

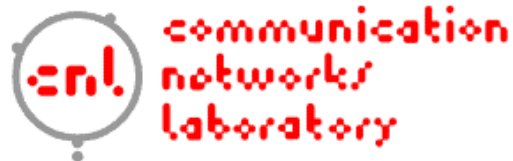


# Effect of Transfer File Size on TCP-ADaLR Performance: a Simulation Study

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# Roadmap

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- Introduction
- Overview of TCP
- Background and related work
- TCP with adaptive delay and loss response (TCP-ADaLR) algorithm
- Simulation scenarios and performance evaluation
- Conclusions



# Introduction

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- File transfer protocol **FTP**:
  - is the primary protocol used for file transfers
  - relies on the transmission control protocol **TCP** for reliable transport
- Current Internet trend:
  - growth in **IP** communications
  - increasing demand in multimedia and data applications
- Transmission control protocol:
  - provides reliable byte-stream transport for most Internet applications such as **FTP**
  - carries up to **90%** of Internet traffic

IP: Internet Protocol

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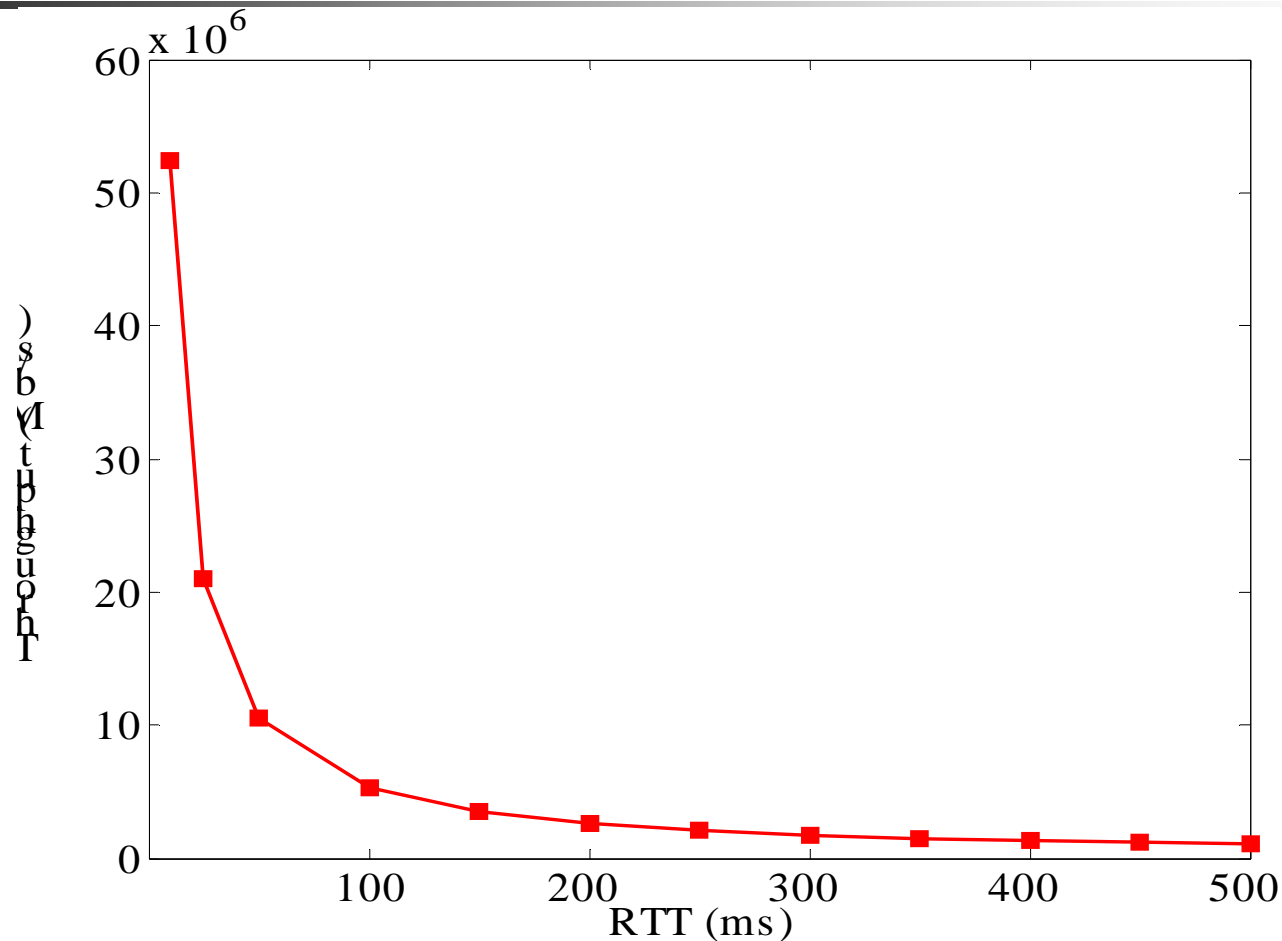
# Overview of TCP

- Transmission control protocol **TCP**:
  - employs acknowledgement **ACK** mechanism for flow and congestion control
  - increases the congestion window **cwnd** size based on the value of receiver's advertised window **rwnd** and the number of segments or bytes acknowledged
  - performs poorly in the presence of large propagation delays
- Large bandwidth-delay product:
  - is the product of the link capacity and the RTT
  - characterizes networks with large propagation delays

RTT: round trip time



# Overview of TCP



Achievable throughput is inversely proportional with RTT and, hence, links with larger RTTs are underutilized

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## Related work

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- **HighSpeed TCP (HSTCP) and scalable TCP :**
  - proposed for large bandwidth-delay product networks
  - adjust the **cwnd** adaptively based on the current **cwnd** when:
    - ACKs are received
    - TCP segments are lost
  - have **cwnd** adjustment parameters that are specifically optimized for Gigabit Ethernet wide area networks
- **User Datagram Protocol UDP:**
  - proposed for accelerating large file transfers in networks with large RTTs
  - is an unreliable connectionless protocol



## Related work

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- **Reliable blast UDP (RBUDP):**
  - employs **TCP** for exchanging control information
  - employs **UDP** for transferring data
  - requires a priori knowledge of the rate of the bottleneck link between the sender and receiver
- **Simple available bandwidth utilization library (SABUL)** combines:
  - **UDP** with rate-based control
  - **TCP-like** window-based control



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# TCP-ADaLR: TCP with adaptive delay and loss response



- End-to-end solution for improving TCP performance:
  - mitigates the effect of large propagation delays, error losses, and the limited TCP **rwnd** on TCP throughput
  - introduces modifications only at the TCP sender
    - **scaling component  $\rho$**
    - **adaptive cwnd increase mechanism**
    - **adaptive rwnd increase mechanism**
    - **loss recovery mechanism**
- **TCP-ADaLR** modifications are applicable to:
  - TCP SACK
  - TCP NewReno

# TCP-ADaLR: TCP with adaptive delay and loss response



- Improves TCP performance by taking the effect of RTT on the window increments:
  - computes **scaling component  $\rho$**  from measured RTT
  - adjusts the **cwnd** and **rwnd** based on the value of **scaling component  $\rho$**
- Allows faster transmission of additional segments in the presence and absence of losses
- Limits the number of retransmissions in order to prevent a large number of unnecessary retransmissions

RTT: round trip time

*cwnd*: congestion window

rwnd: receiver's advertised window



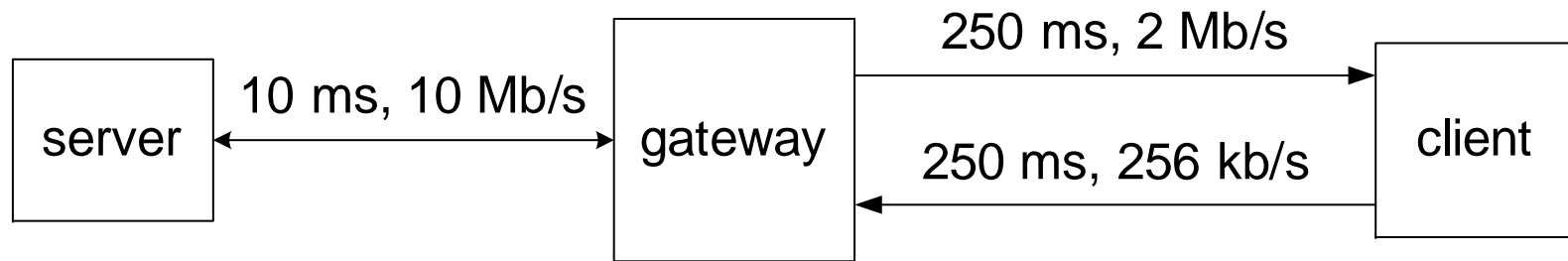
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# Network topology



- Propagation delays are **one-way**
- Ethernet link between the gateway and the server is **full-duplex** with a **data rate of 10 Mb/s**
- Link between the gateway and the client is asymmetric with **data rates of 2 Mb/s downlink** and **256 kb/s uplink**
- Links are **lossless**

# Simulation scenarios and performance metrics



- Simulation scenarios:
  - 50 MB file download for various link propagation delays 10 ms, 25 ms, 50 ms, 100 ms, 200 ms, 250 ms, 300 ms, 350 ms, 400 ms, 450 ms, and 500 ms
  - FTP file download for various file sizes 500 kB, 50 MB, 100 MB, 200 MB, 300 MB, 400 MB, and 500 MB
- Performance metrics:
  - FTP download response time
  - TCP throughput
  - link throughput and utilization



# TCP simulation parameters

TCP Parameter	Value
Initial RTO	3.0 s
Minimum RTO	1.0 s
Maximum RTO	64.0 s
Timer granularity	0.5 s
Persistent timeout	1.0 s
Maximum ACK delay	0.0 s
Maximum ACK segment	1
Duplicate ACK threshold	3
Sender maximum segment size (SMSS)	1,460 bytes
Slow start initial count	2
Receiver's advertised window ( <i>rwnd</i> )	65,535 bytes
Retransmission threshold	6
RTT gain	0.125
RTT deviation gain	0.25
RTT deviation coefficient	4



# FTP file application parameters

Attribute	Value
File inter-request time (s)	18,000
File inter-request time distribution	constant
File size (MB)	50
File size distribution	constant
Simulated time (hours)	5

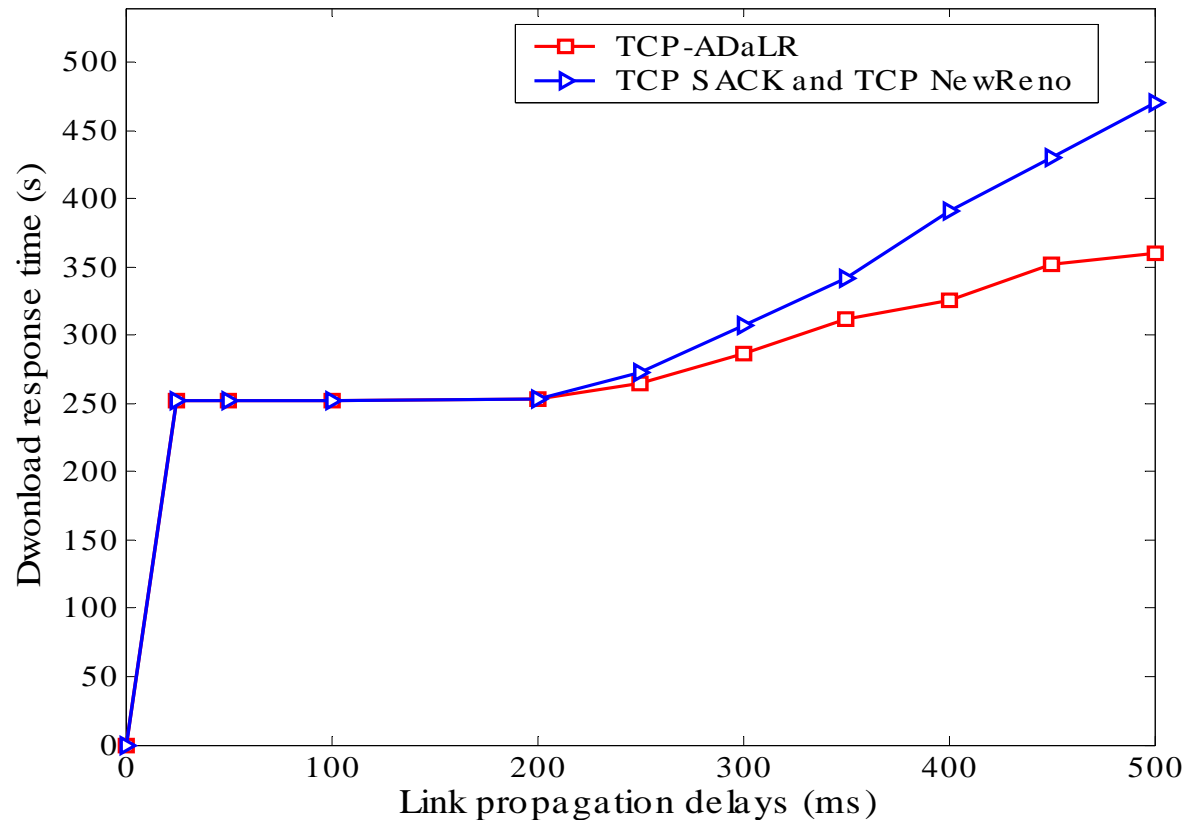


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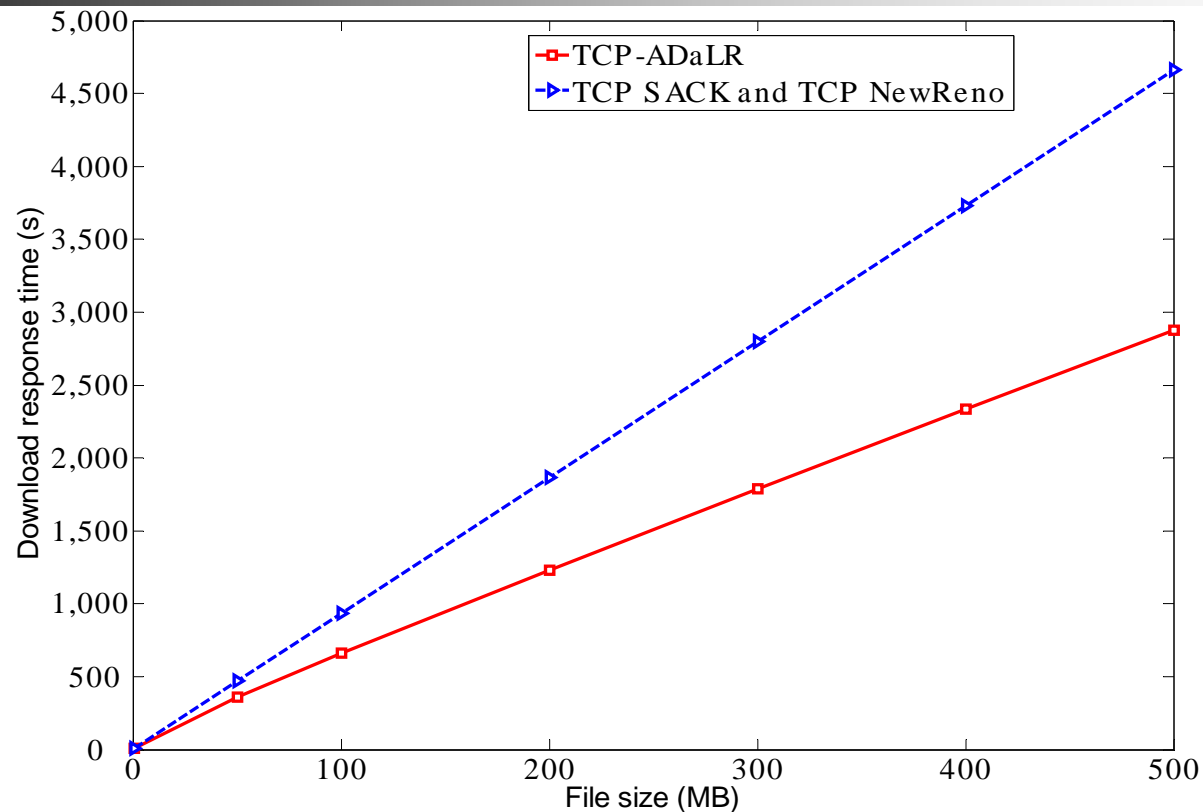
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# Scenario with various link propagation delays: download response time



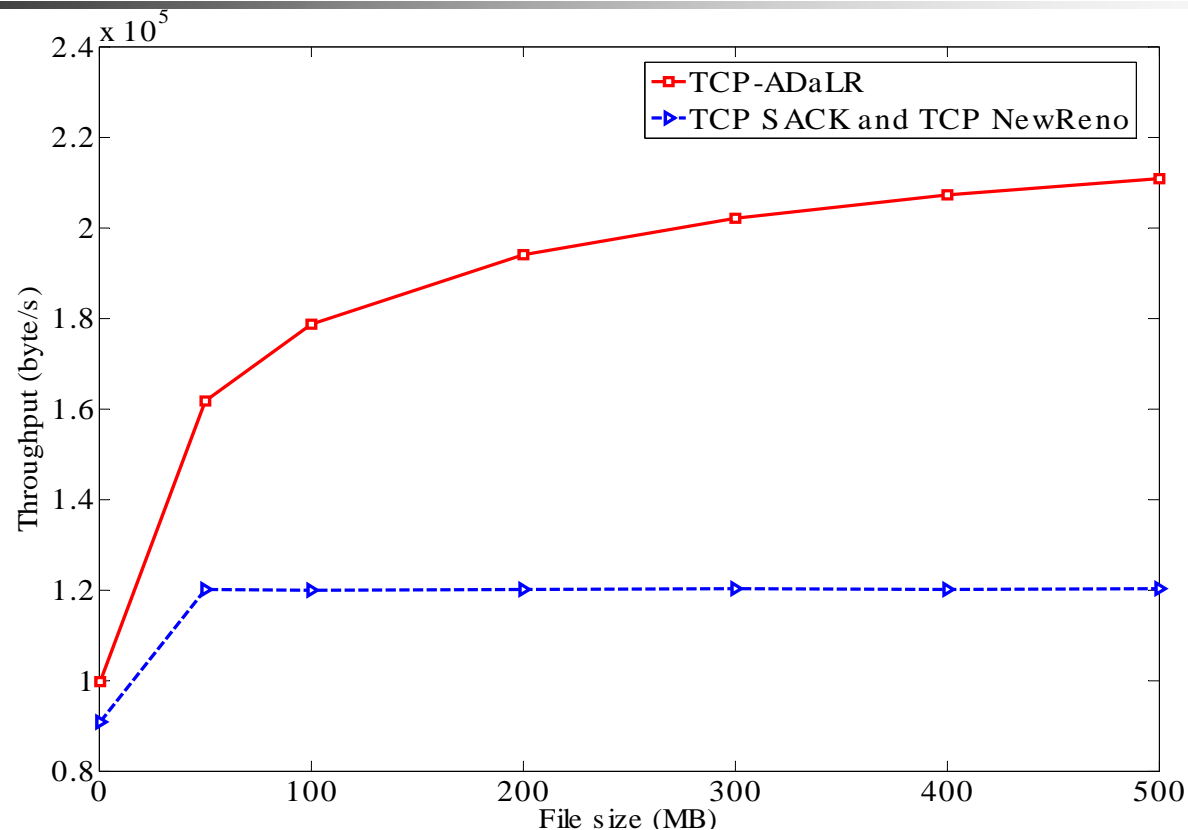
- TCP-ADaLR, TCP SACK, and TCP NewReno exhibit comparable performance for RTTs < 200 ms
- TCP-ADaLR exhibits 5.5%–75% shorter download response time than TCP SACK and TCP NewReno for RTTs > 200 ms

# Scenario with various FTP file sizes: download response time



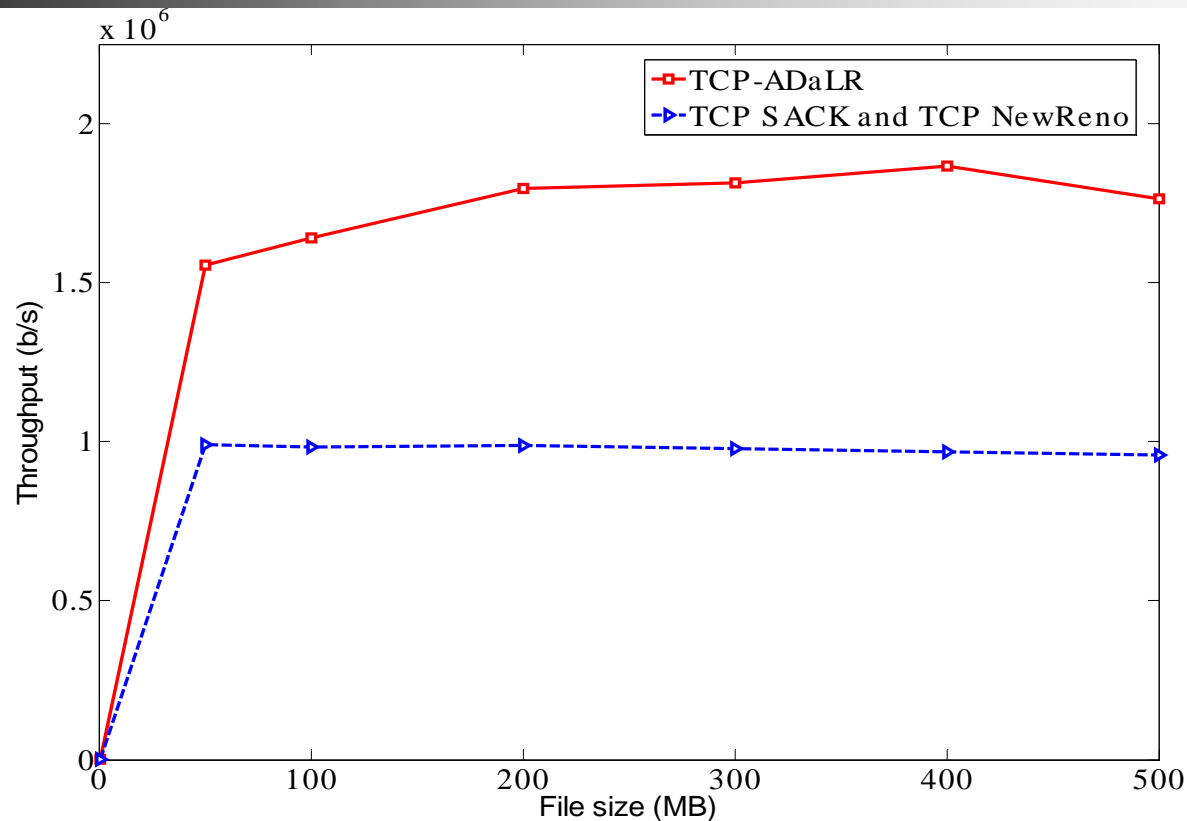
- As file size increases, FTP file download response time increases for TCP-ADaLR TCP SACK, and TCP NewReno connections
- TCP-ADaLR shows 9%–38% shorter download response times than TCP SACK, and TCP NewReno

# Scenario with various FTP file sizes: TCP throughput



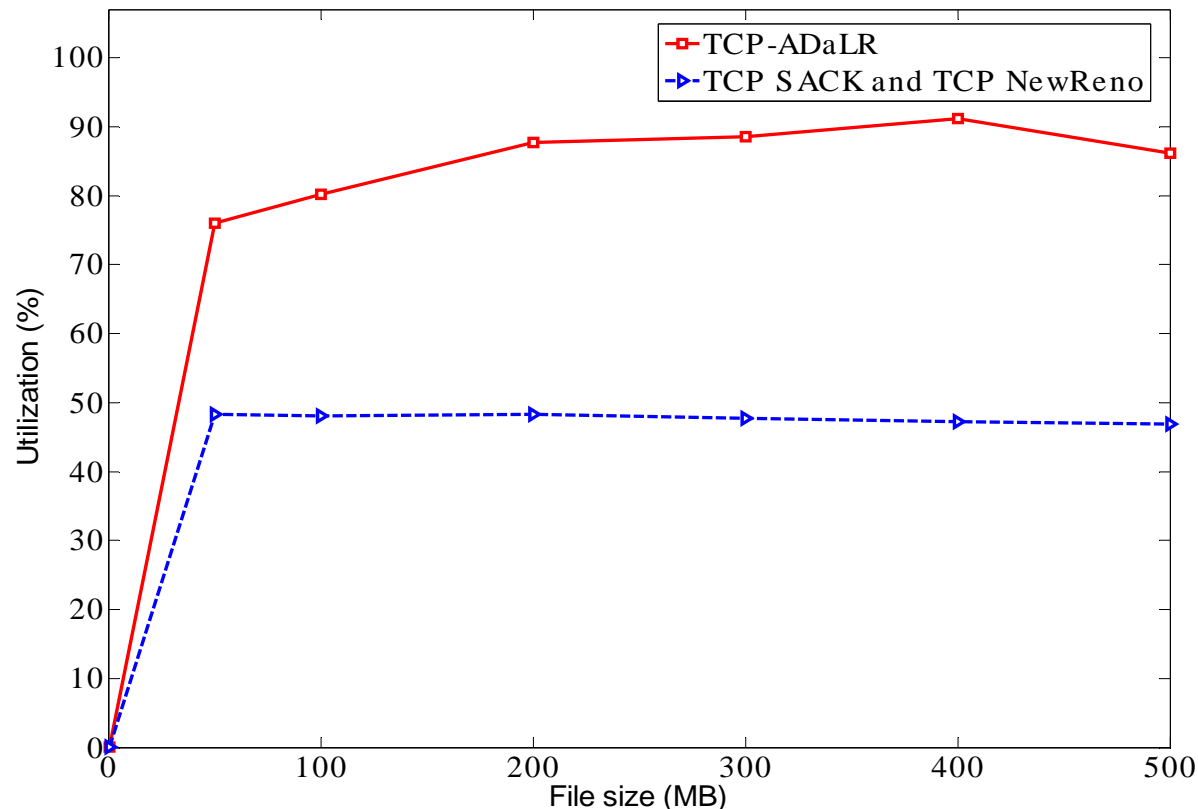
- As file size increases, **TCP-ADaLR** shows **9%–75%** higher TCP throughput compared to TCP SACK, and TCP NewReno
- TCP throughput of TCP SACK and TCP NewReno remains unchanged when the transfer file size exceeds 50 MB

# Scenario with various FTP file sizes: link throughput



- As file size increases, **TCP-ADaLR** exhibits up to **81%** higher link throughput than TCP SACK, and TCP NewReno
- For TCP SACK and TCP NewReno, the value of **rwnd** limits the throughput to  $\sim 1$  Mb/s

# Scenario with various FTP file sizes: link utilization



- As file size increases, **TCP-ADaLR** exhibits **57%-90%** higher link utilization than TCP SACK, and TCP NewReno
- For TCP SACK and TCP NewReno, the value of **rwnd** limits the throughput to  $\sim 50\%$  of the available 2 Mb/s link capacity

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# Conclusions

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- **TCP-ADaLR** algorithm improved TCP performance for transfers of small to moderate and large files in high latency lossless networks
- **TCP-ADaLR** utilized link capacities better, accelerated file transfers, and exhibited higher TCP throughput than TCP SACK and TCP NewReno
- Deployment of **TCP-ADaLR** in existing networks requires modifications only at the TCP sender, with minimal processing and memory overhead
- Simulation results indicate that **TCP-ADaLR** is a viable option for large file transfers in existing networks that employ TCP as the transport layer protocol



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