# RoGUE: RDMA over Generic Unconverged Ethernet

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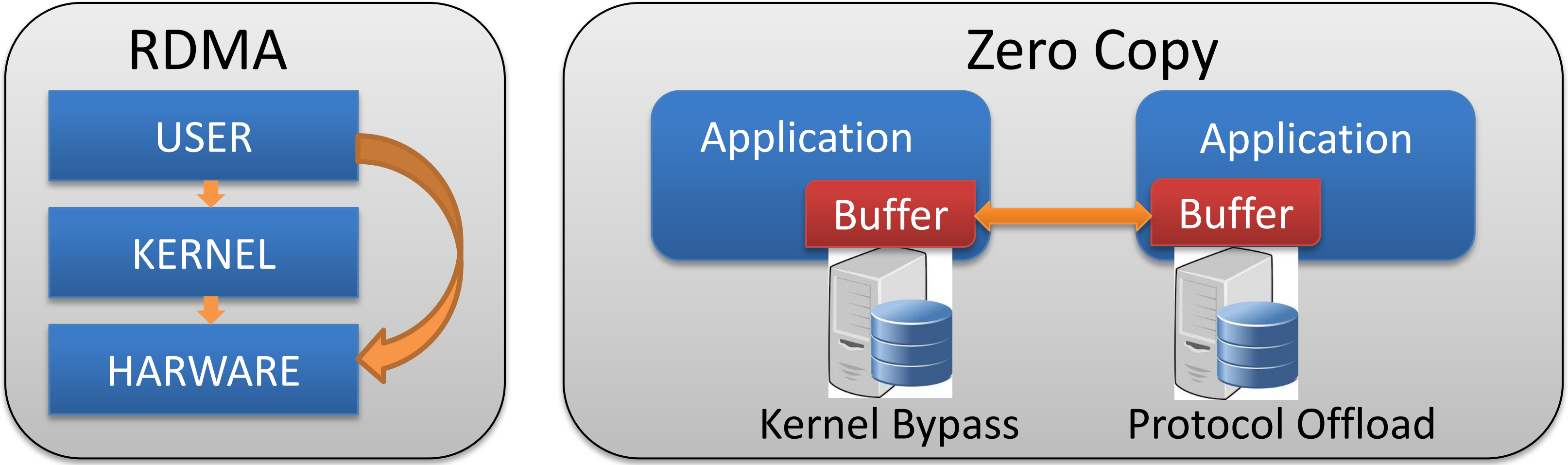
# RDMA Overview



RDMA

USER

KERNEL

HARWARE

Zero Copy

Application

Buffer

Application

Buffer

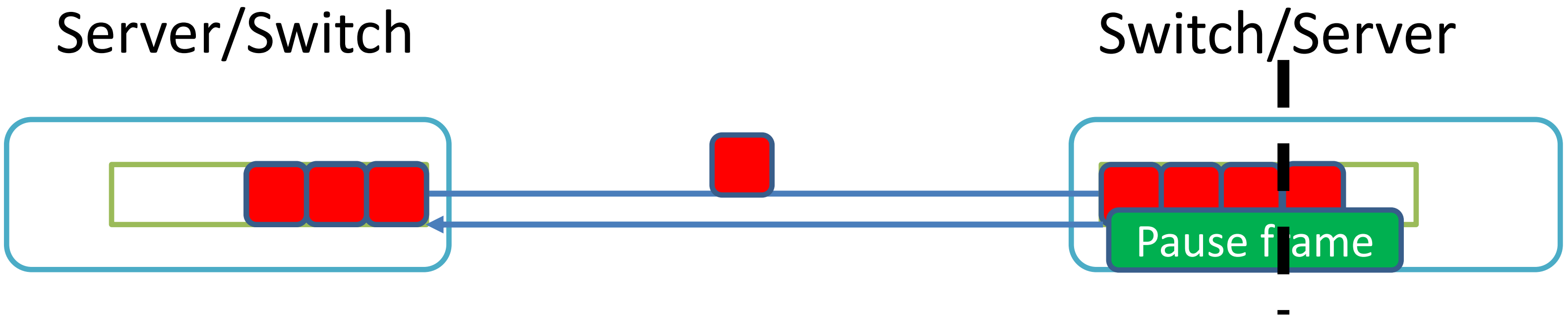
Kernel Bypass

Protocol Offload

Low Latency, High throughput, Low CPU utilization

- RoCE: a protocol that provides RDMA over a lossless Ethernet network

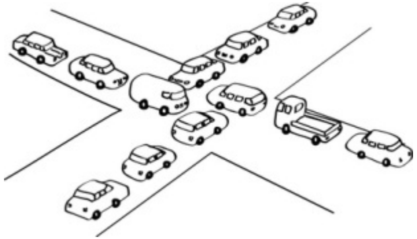
# Priority Flow Control



RoCE assumes Ethernet network to be lossless – achieved by enabling Priority Flow Control (PFC).

# Motivation

- Data center providers are reluctant to enable PFC
  - Instead, isolate RDMA traffic and TCP traffic
- RDMA has not seen the uptake it deserves



HOL Blocking

Unfairness

# Can we run RDMA over generic Ethernet network without any reliance on PFC ?

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## RoCE + PFC

Congestion Control

No packet drop

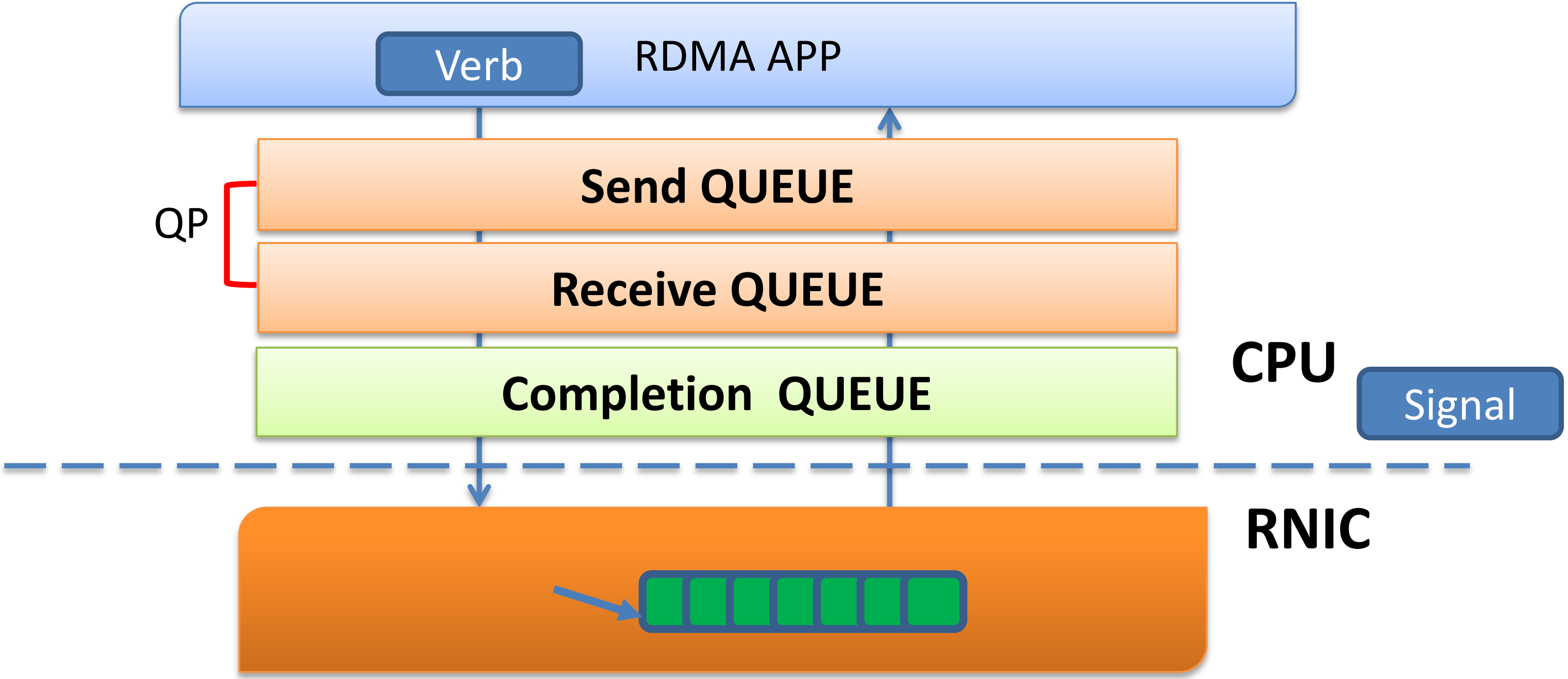
## RoGUE

Congestion Control

Retransmission

yet retain low latency, CPU utilization

# RoCE Overview



Brake the animations

# Where to fix: HW or SW?

## Hardware

Low CPU utilization, Low Latency

It requires to work with NIC vendor

Heterogeneous network hardware with non-standard protocol implementation

Complicates network evolution

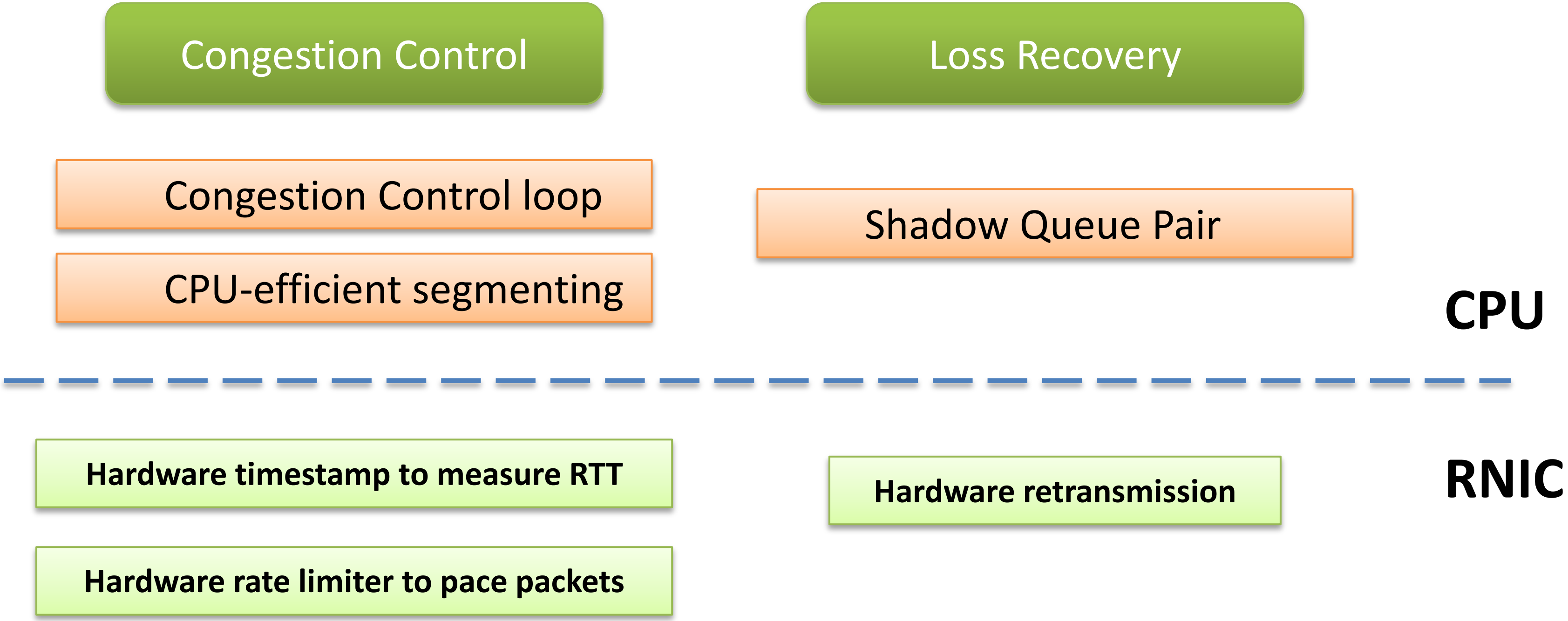
## Software

Easy to implement

Packet level congestion signals are unavailable

High CPU utilization if per-packet operations

# RoGUE Overview



Congestion Control

Congestion Control loop

CPU-efficient segmenting

Hardware timestamp to measure RTT

Hardware rate limiter to pace packets

Loss Recovery

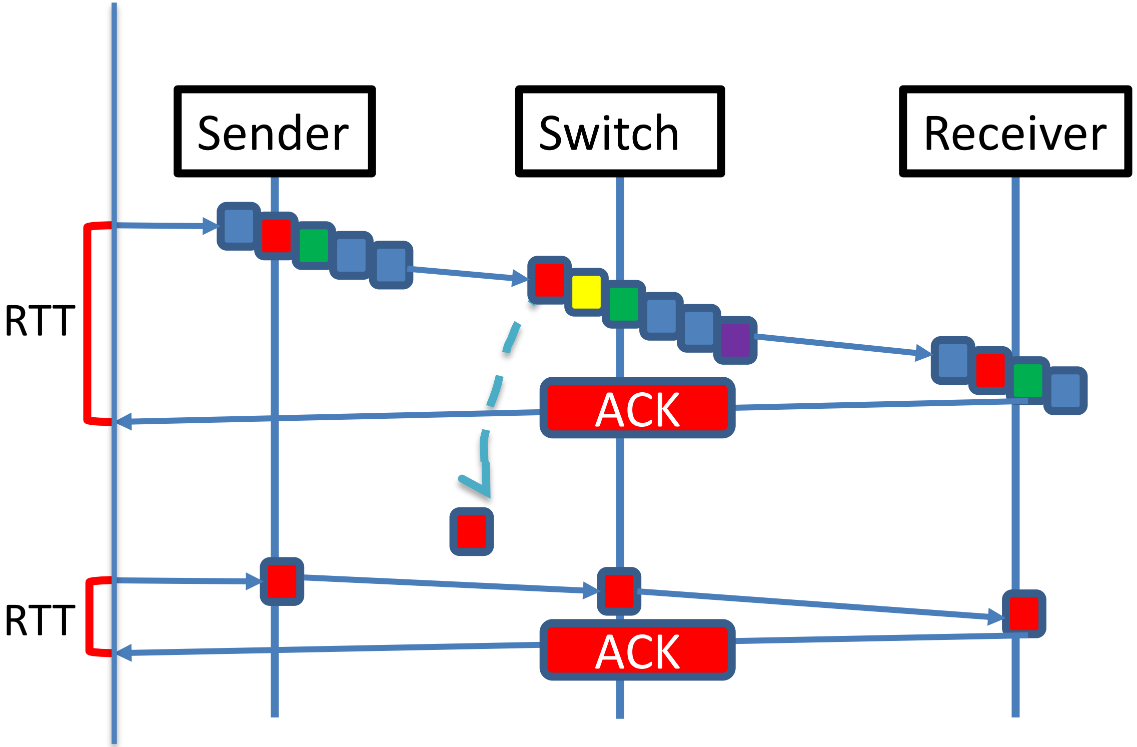
Shadow Queue Pair

Hardware retransmission

CPU

RNIC

# Congestion Signal

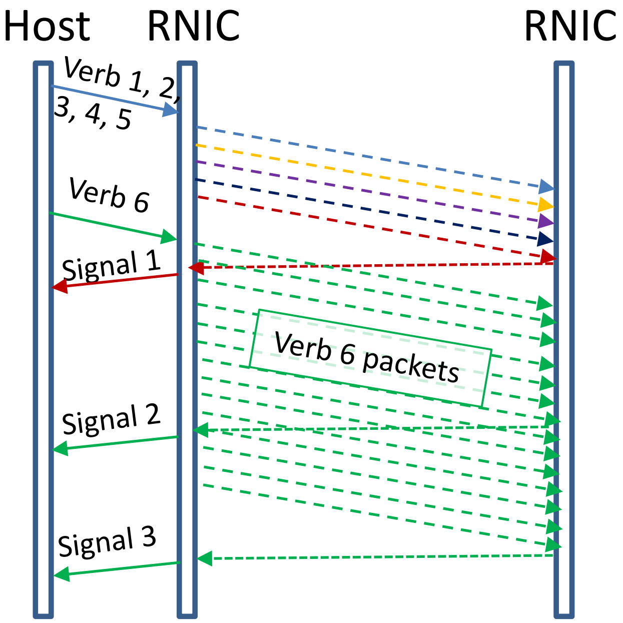


- RTT is high, the queue builds up, reduce the sending rate
- RTT is low, network is idle, increase the sending rate

🟦 🟨 🟪 🟥 🟩 Packets from different flows

# CPU Efficient Segmenting

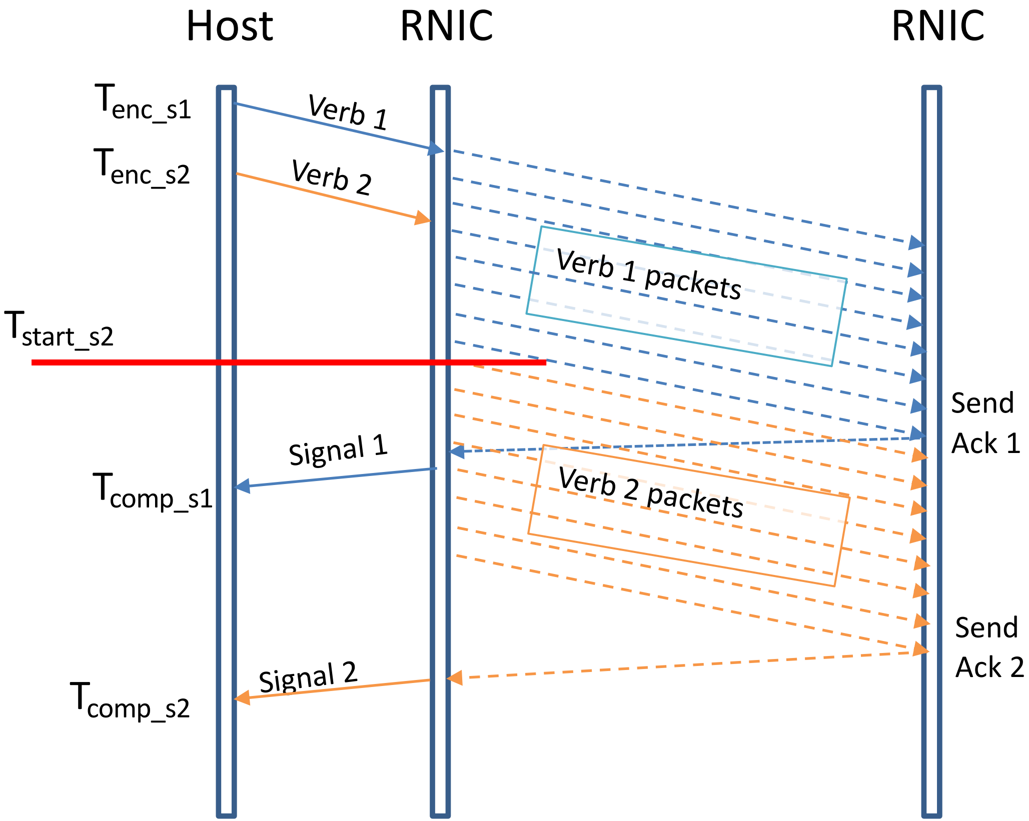
- Two key questions
  - How large a verb should RoGUE send?
  - How often should the RNIC signaled?



- Small Verb (< 64KB)
  - signal every 64KB
  - CPU utilization (< 20%)

- Large Verb (>= 64KB)
  - chunk, and signal every 64KB.
  - CPU utilization (< 10%)

# RTT measurement



$T_{start\_si}$ =max(
Verb i enqueued,
last packet of Verb i-1 goes out of NIC)

$RTT_i = T_{comp\_si} - T_{start\_si} -$ bytes/rate_limit

RTT is measured by Hardware timestamp.

# Congestion Response

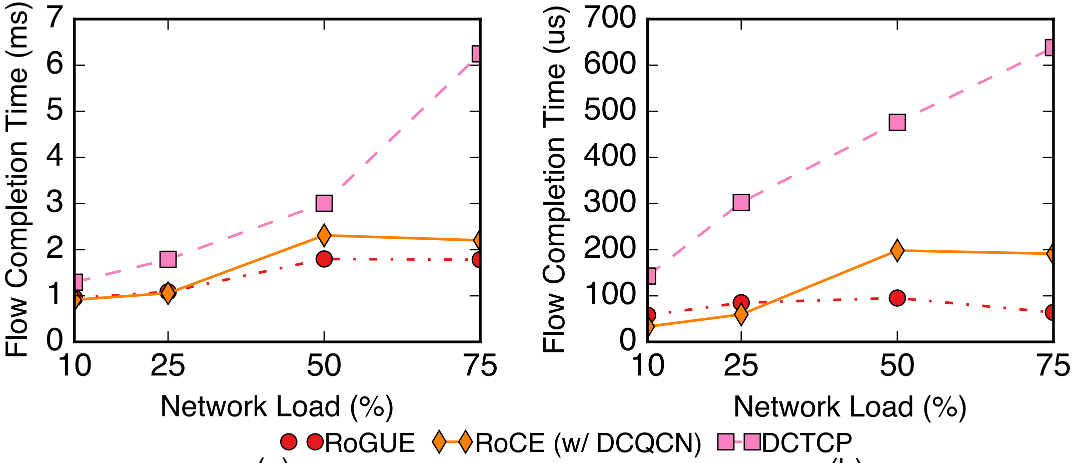
- Similar to TCP Vegas, and Timely
- If congestion window >= 64KB, window-based + rate limiter
- If congestion window < 64KB, rate limiter only
- Rate limiter is offloaded to RNIC

# Evaluation

- Mellanox ConnectX-3 Pro 10Gbps RNICs, DCQCN
- Baselines: DCTCP, DCQCN

# Evaluation-Cluster Experiments

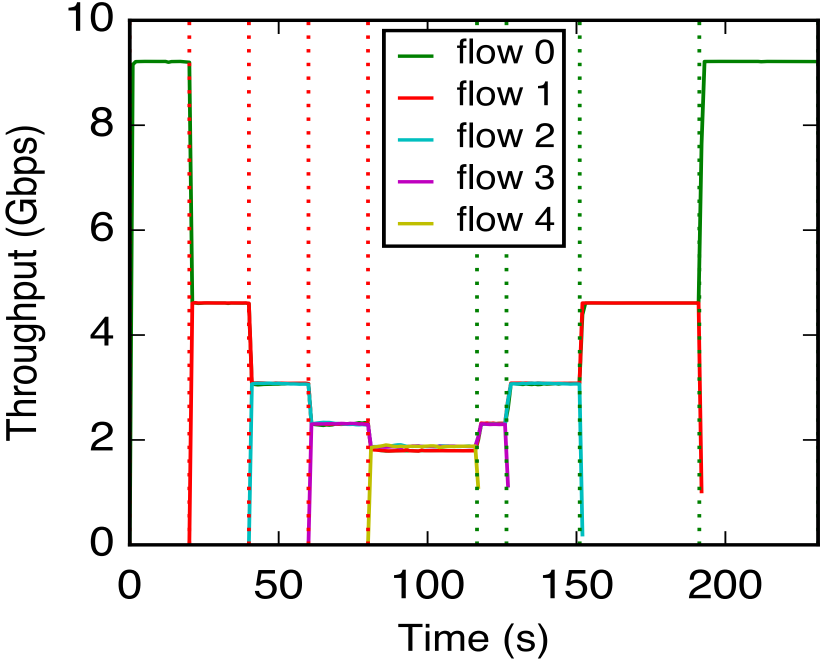
- Each of 16 hosts generates 1MB RPC for random destinations and send 1KB RPC once every ten 1MB RPC



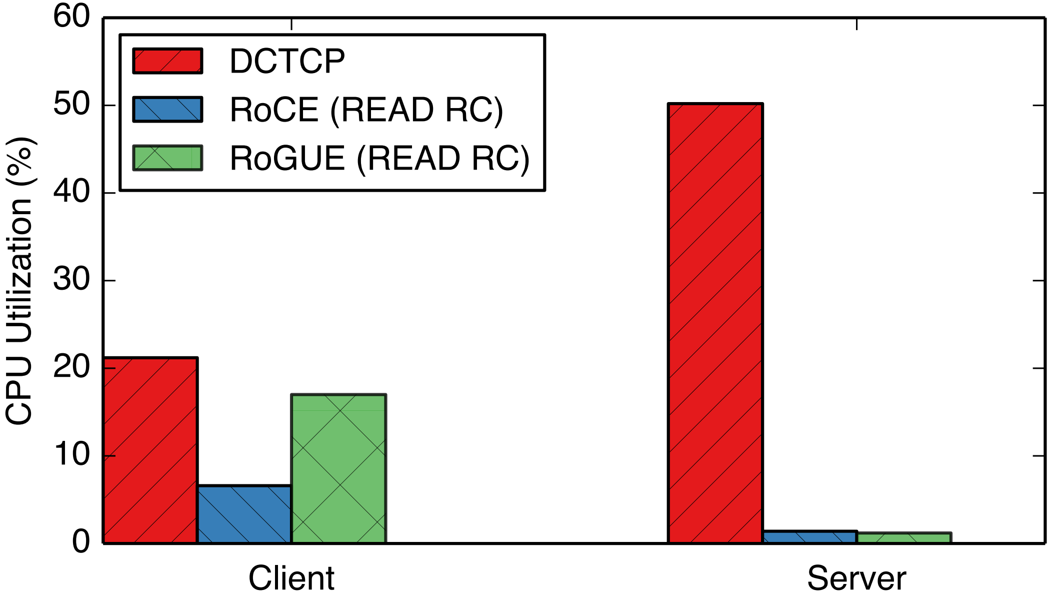
(a)
Large RPCs (1MB) - Median FCT

(b)
Small RPCs (1KB) - 90th %ile FCT

# Evaluation-Congestion Response



# Evaluation-CPU Utilization



# Summary

- It is possible to support RoCE without relying on PFC
- Judicious division of labor between SW and HW to do the congestion control and retransmission, yet retain a low CPU utilization
- RoGUE supports RC and UC transport types of CC
- Evaluation results validate that RoGUE has competitive performance with native RoCE