Palermo Congestion Control
Sender Side

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Alejandro Popovsky <apopov@palermo.edu>
Gustavo Muzzillo <gmuzzi@palermo.edu>
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TCP congestion control
Most common algorithms

• Goals:
  – Maximize throughput
  – Minimize losses

• Based on loss detection

• Reno / Cubic
TCP congestion control

Most common algorithms PROBLEMS

Cubic vs Cubic inflight data
First Cubic connection bloats buffer, and gets most of the capacity till several recovery rounds

Cubic vs Cubic round trip times
Buffer bloat effects

• Increased latency for connections sharing the bottleneck with long transmissions.

• Huge effect on transaction-oriented connections: web pages, requests-responses, etc.

• Affecting other users’ connections and also same user’s connections.
Bottleneck Sharing

Individual connection share of Capacity = Individual connection percentage of queue occupation

=> Little incentives for buffer bloat prevention
Traditional Latency aware congestion control

• Examples: LEDBAT, VEGAS, VENO, TCP-LP, ...

• Sharing performance: “Less than best effort Congestion Control” (LBE)

• Alternatives to LBE: adaptive behavior
Goal: estimate the share of the joint available capacity

Proposed variable:

Proportional rate (Ra) response to In-flight size (Ca) variations

\[ Xa = \left( \frac{\Delta Ra}{\Delta Ca} \right) \left( \frac{Ca}{Ra} \right) \]
Estimating Bottleneck share with $X_a$

Exclusive user of bottleneck:
- $\text{In-Flight size} < \text{BDP} \Rightarrow X_a = 1$
- $\text{In-Flight size} > \text{BDP} \Rightarrow X_a = 0$

Shared bottleneck:
- $X_a \approx (1 - \text{share of capacity})$

In-Flight size < BDP

Smaller BDP

Big share of capacity

Small share of capacity

Share of joint available capacity
Palermo Algorithm

- Maintain:
  - Optimize throughput
  - Minimize loss

- Add:
  - Minimize latency
  - Fair sharing

- Adaptive behavior:
  - Buffer bloat prevention if possible
  - Else revert to regular congestión control
Palermo Receiver Congestion Control

• Developed in 2016, presented IETF 95.

• Opportunity observed in CABASE IXP’s:
  – Flow controlled traffic without dynamic receive window (DRS), sometimes gets same throughput as congestión controlled traffic, but with smaller latency.

• Thoroughly tested in University of Palermo proxies for incoming traffic.
Palermo Receiver Side Performance

- Average Round trip time
- Average Throughput

Palermo versus DRS receiver window control. Measurements at university proxy, averaging over several Centos mirrors.
Palermo Receiver Side Performance

Measurements at university proxy, Downloading from major newspapers during peak hours (in parallel to large downloads)

54% improvement
Receiver vs Sender Congestion Control

• Receiver side:
  – Optimize incoming traffic.
  – Current limitation uncertainties
    Application, Flow ctrl, or sender cwnd.
  – Round trip time measurements unaccuracy.
  – Need to slow sender in order to gain control

• Sender Side
  – Optimize outgoing traffic
  – Better knowledge of current limitation
  – Better measurements of round trip times

• Both sides
  – Need to wait for adaptations to show effects in feedback variable Xa
• Available capacity not jointly reached
  => regular cwnd growth

• Available capacity jointly reached
  (number of conns sharing the bottleneck: unknown)
  – but having a small percentage => regular growth
  – but having 100% or high percentage => oscillate

• Adaptation criteria:
  – algorithm obtains a latency that grows with the number of sharing conns. So no gain is achievable when conns count exceed a limit, so revert to regular aggressive (reno-cubic) congestion control.
TCP congestion control
Palermo sender Architecture

• Developed for Linux Kernels 5.9, and above.

• Independent Dynamic Kernel Module (LKM, DMKS)

• Tested for X86_64 architecture extendable to other architectures like ARM, PPC, etc.
Test Objectives

- Check throughput maximization when connection alone at the bottleneck
- Check bufferbloat prevention when sharing bottleneck with well behaved connections
- Check fair sharing of bottleneck capacity when sharing bottleneck with well behaved connections.
- Check performance when sharing bottleneck with bad-behaved (traditional) connections.
- Compare with state-of-the-art competing algorithms (BBR)
- Check large scale deployment in datacenters.
Testbench Infrastructures

TestBench 1

References
- Red 1: 10.0.4.0/24
- Red 2: 10.0.5.0/24
- Red 3: 10.0.6.0/24

Netem Queuing Limits
Testbench Infrastructures (cont.)

TestBench 2

References
- Red 1: 10.0.4.0/24
- Red 2: 10.0.5.0/24
- Red 3: 10.0.6.0/24

AQMS Limits
CUBIC vs CUBIC tests

Cubic vs Cubic inflight data

First Cubic connection bloats buffer, and gets most of the capacity till several loss-recovery rounds

Cubic vs Cubic round trip times
BBR vs BBR tests

4 conexiones BBR

Bbr vs Bbr inflight data

BBR vs BBR round trip times
Palermo vs Palermo test results

Palermo vs Palermo inflight data

Palermo vs Palermo round trip times
Palermo vs Cubic test results

Palermo vs Cubic inflight data

Palermo vs Cubic round trip times
Palermo vs BBR test results

Palermo vs bbr inflight data

Palermo vs bbr round trip times
CUBIC vs BBR test results

Cubic vs bbr inflight data

Cubic vs bbr round trip times
Conclusions and Future Work

• Proposed algorithm:
  – As a valid option for being used by organization's servers to improve their performance on outgoing traffic.

• Next:
  – Explore robustness and variants
  – Upcoming publication
  – Large scale tests in datacenters
  – Proposal for Kernel std distribution

For more information, or source code:
https://www.palermo.edu/ingenieria/ingenieria-telecomunicaciones/control-de-congestion-palermo.html
apopov@palermo.edu