Controlled Delay (CoDel) Queue Discipline

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Overview

- CoDel is the first AQM algorithm to use ‘Queue Delay’ as a metric of congestion
  - The main idea is to minimize the impact of ‘Bufferbloat’
  - It has lesser knobs than other AQM algorithms
  - CoDel algorithm is described in RFC 8289
  - Implemented in the Linux kernel
- Flow Queue CoDel (FQ-CoDel) queue discipline
  - A popular variant of CoDel implemented in the Linux kernel
  - Used as a default queue discipline in many operating systems
  - FQ-CoDel is described in RFC 8290
- CoDel - BLUE Alternate (COBALT) queue discipline
  - Improvement over CoDel, implemented as a part of CAKE queue disc in Linux

Working of CoDel

- CoDel operates during the ‘dequeue’ time
  - Note: CoDel runs on the ‘output port’, during the ‘dequeue’ time!
- CoDel operates ‘on departure of every packet’
  - Hence, there is no periodic time interval in which CoDel is invoked.
  - If packets do not arrive (hence, do not depart), CoDel algorithm is not invoked
- Two phases in CoDel algorithm
  - Dropping and Non-dropping
- CoDel decides whether the outgoing packet should be dequeued or dropped
  - Two main components of CoDel
    - Calculation of ‘instantaneous queue delay’
    - Decision making logic (whether to dequeue or drop the outgoing packet)

Working of CoDel (contd ...)

- Two configurable parameters in CoDel algorithm
  - target (default: 5 ms) [Note: this is same as ‘target queue delay’ in Adaptive RED]
  - interval (default: 100ms) [Note: assumption is average RTT in Internet is 100ms]
- Algorithm:
  - Attach an ‘timestamp’ when the packet is enqueued (to indicate enqueue_time)
  - Calculate current queue delay (cur_qdelay) for every outgoing packet:

$$\text{cur\_qdelay} = \text{dequeue\_time} - \text{enqueue\_time} \qquad \text{Eq. (1)}$$

  - When cur_qdelay > target for the first time, start the ‘interval’ timer
  - Enter dropping phase, only if cur_qdelay > target for the entire ‘interval’
  - Otherwise, stay in non-dropping phase because it was a short burst.
    - Reset ‘interval’ timer and wait for cur_qdelay > target again

Working of CoDel (contd …)

- On entering the dropping phase
  - Drop the outgoing packet
  - Increment ‘count’ (indicates number of packets dropped in ‘this’ dropping phase)
  - Calculate time to drop the next packet using the Control Law:

$$\text{next\_drop\_time} = \text{current\_time} + \text{interval}/\text{sqrt}(\text{count}) \qquad \text{Eq. (2)}$$

- While in dropping phase
  - Continue to Drop packets using Eq. (2) till cur_qdelay > target
  - When cur_qdelay < target, exit the dropping phase
  - Reset the value of count to 0
  - Enter non-dropping phase

Working of CoDel (contd ...)

- Example: CoDel's working in the dropping phase

  Assume:

  - current_time = 1000ms and count = 1, then

    next_drop_time = current_time + interval/sqrt(count) Eq. (2)

    next_drop_time = 1000ms + 100ms/sqrt(1)

    next_drop_time = 1100ms

  - Assume that the second packet is dropped at 1100ms (current time), then

    next_drop_time = 1100ms + 100ms/sqrt(2)

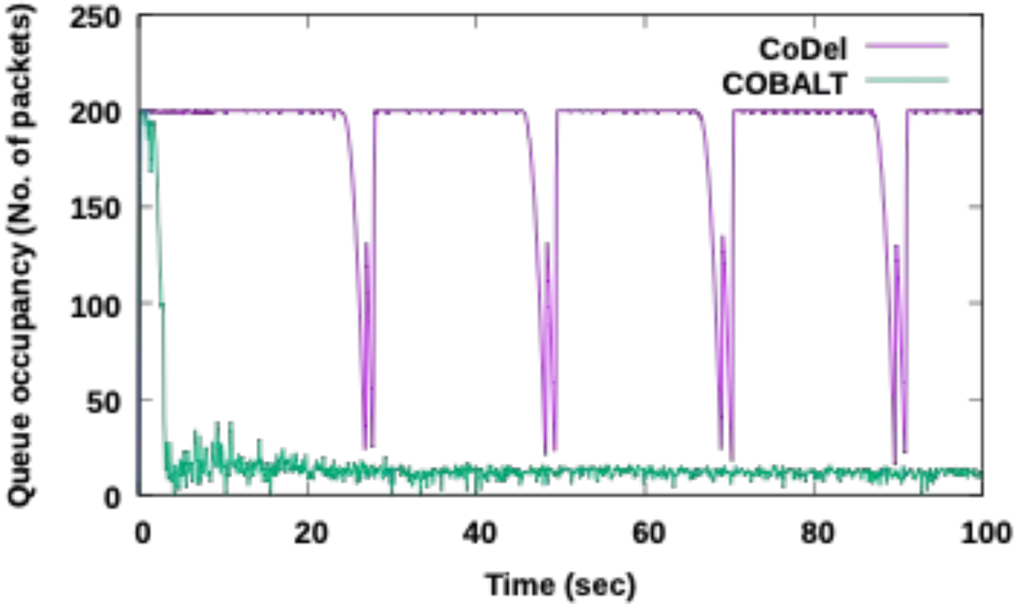
    next_drop_time = 1100ms + 71ms = 1171ms

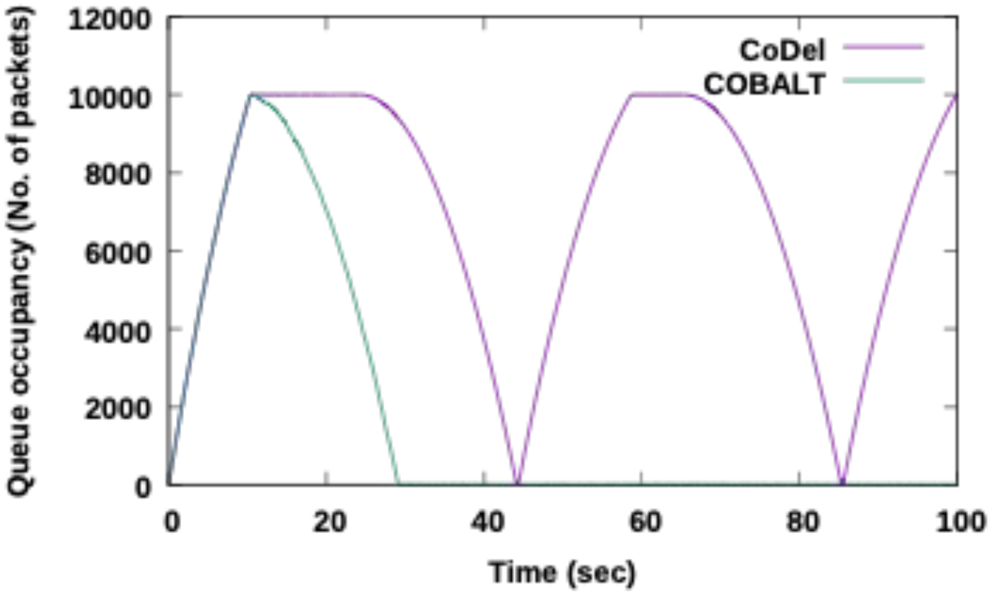
  - The gap between packet drops reduces if CoDel stays longer in dropping phase:

    Example: 1000, 1100, 1171, ...

Known problems with CoDel

- Queue control is lost when some of the flows are unresponsive
  - FQ-CoDel isolates flows by providing a separate queue to every flow
  - Flow is identified by: Src IP, Src port, Dst IP, Dst Port, Protocol Number
  - Discards the heuristics obtained from the dropping phase





Palmei J, Gupta S, Imputato P, Morton J, Tahiliani MP, Avallone S, TT D. Design and Evaluation of COBALT Queue Discipline. In 2019 IEEE International Symposium on Local and Metropolitan Area Networks (LANMAN) 2019 July (pp. 1-6). IEEE.

Recommended Reading

RFC 8289: Controlled Delay Active Queue Management

Link: https://datatracker.ietf.org/doc/html/rfc8289

RFC 8290: The Flow Queue CoDel Packet Scheduler and Active Queue Management Algorithm

Link: https://datatracker.ietf.org/doc/html/rfc8290

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