PIE: A lightweight latency control to address the bufferbloat problem

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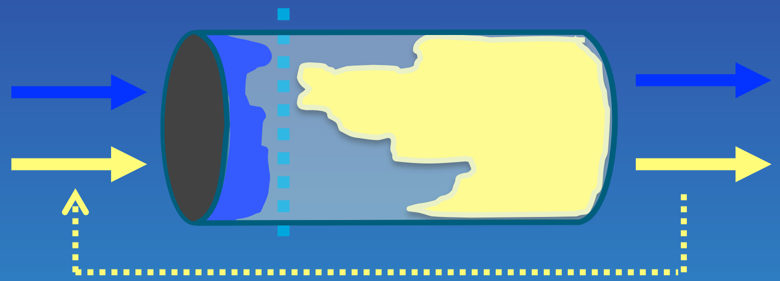
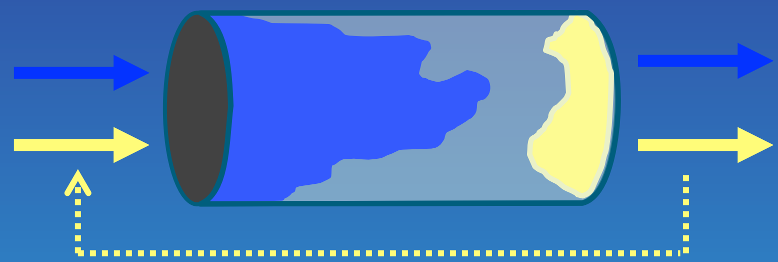
November 5, 2013, IETF 88

Current Design



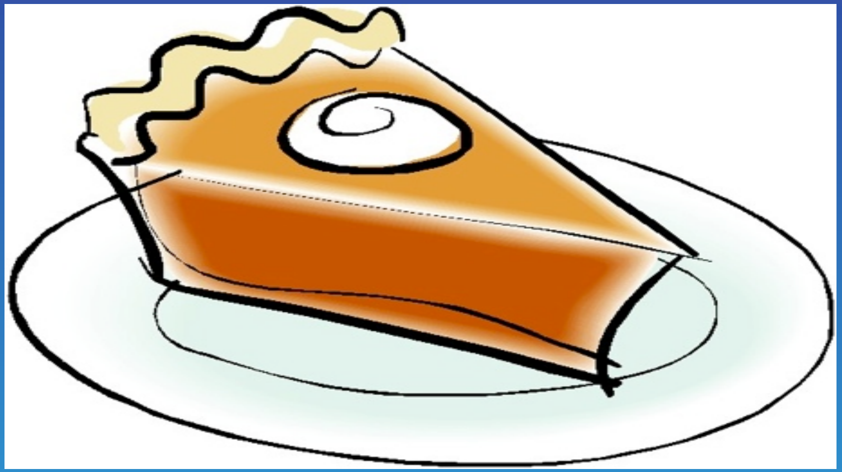
- Large TCP flows occupy most buffer
- Feedback signals are sent when buffer occupancy is big
- Average delay is consistently long
- Little room left for sudden burst

Future Goal



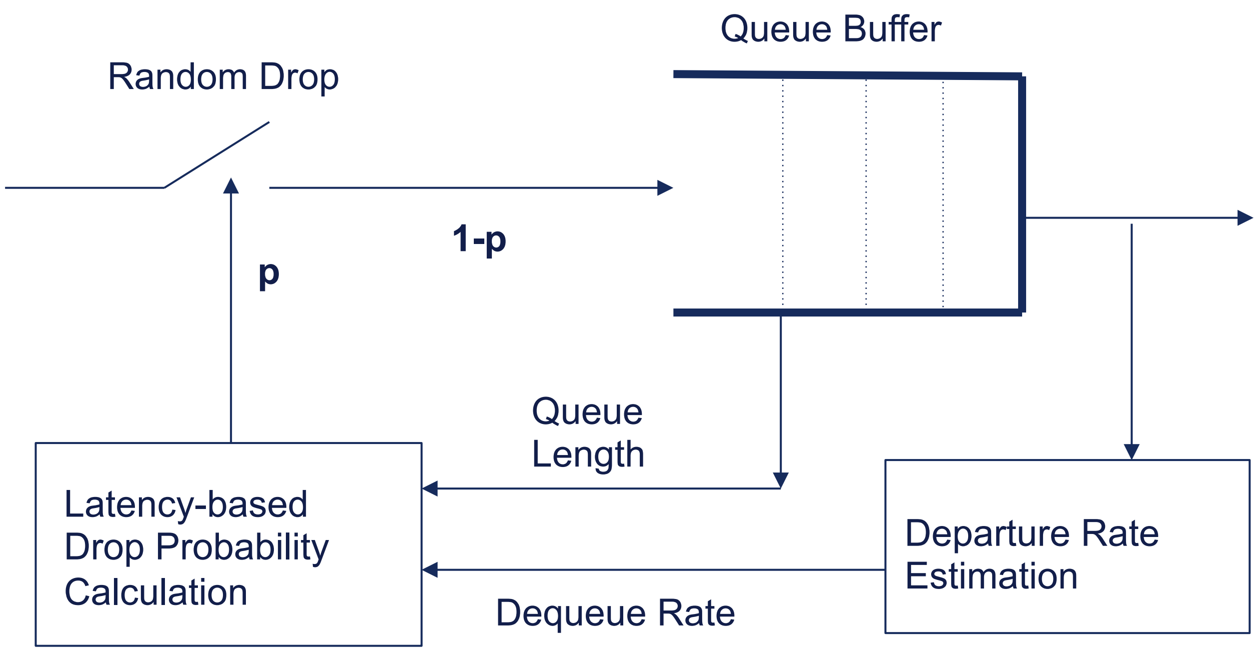
- Large TCP flows occupy small buffer
- Feedback signals are sent early
- Average delay is kept low
- Much room left for sudden burst

Solution Maybe



As Easy As PIE!

The block diagram of PIE



The design of PIE

a and b are chosen via control analysis

- Upon every packet arrival
  - randomly drop a packet based on drop_prob calculated below
- Every T_{update} interval
  - estimated_delay, est_del = queue_length/depart_rate
  - drop_prob += a*(est_del – target_delay) + b* (est_del – est_del_old)
  - est_del_old = est_del;
  - depart_count = 0;
- In a measurement cycle
  - Upon a packet's departure: depart_count += deque_packet_size;
  - if dq_count > deq_threshold then
  - depart_rate = deqart_count/(now-start);
  - dq_count = 0; start = now;

PIE Work Update

- Actively participate in the DOCSIS 3.1 AQM working group with colleagues from Arris, Broadcom, CableLabs, Cisco, Comcast Cable, Huawei, Intel, ST Micro, Timer Warner Cable, etc.
- Weekly meetings from April, 2013 – Now: discuss evaluation scenarios, design trade offs, application impacts, etc. taking into the considerations from MSOs, system and silicon vendors
- The working group has chosen a single queue based design instead of multi-queue based design such as FQ
  - design complexity does not justify the performance gain
- The working group has chosen PIE as the required, default-on AQM scheme for Cable Modems per DOCSIS 3.1 spec (vendors can implement additional AQM schemes)
  - Implementation simplicity, convergence performance, and readiness for future applications

Variant of PIE in DOCSIS

- Departure rate estimation
  - directly use MAC layer's information, i.e. Peak Traffic Rate and Max Sustained Traffic Rate directly into the algorithm
- Several constants in the PIE algorithm has been customized to fit the cable networks
- Improved handling of the single TCP flow case
  - extended drop probability calculation to better handle low drop probability scenarios
  - inclusion of detecting burst before protecting

Thank you.