HyStart++: Modified Slow Start for TCP

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HyStart Recap

- Slow Start can overshoot ideal send rate and cause massive packet loss

- HyStart: Exit slow start early based on Delay Increase algorithm
  - Inter-Packet Arrival algorithm does not perform well due to ACK compression

- Delay Increase algorithm works well but has false positives
  - Latency fluctuations on wireless links
  - Transient queue buildup
HyStart “Delay Increase” algorithm

• Keep track of minimum observed RTT in each round in slow start

• For rounds where cwnd is at or higher than MIN_SSTHRESH and N_RTT_SAMPLE RTT samples have been obtained
  Eta = clamp(MIN_ETA, lastRoundMinRTT / 8, MAX_ETA)
  if (currentRoundMinRTT >= (lastRoundMinRTT + Eta))
    ssthresh = cwnd
    exit slow start

• MIN_SSTHRESH = 16, MIN_ETA = 4 msec, MAX_ETA = 16 msec, N_RTT_SAMPLE = 8
HyStart++

- HyStart “Delay Increase” for only the initial slow start
- Compensate for premature slow start exit
  - Congestion Avoidance algorithm can take time to ramp up
- Use Limited Slow Start (RFC3742) until next congestion signal

- For each arriving ACK in LSS, where N is the number of previously unacknowledged bytes acknowledged in the arriving ACK:
  \[
  K = \frac{cwnd}{LSS\_DIVISOR \times ssthresh}
  \]
  \[
  cwnd = \max(cwnd + \frac{N}{K}, CA\_cwnd())
  \]
- \(LSS\_DIVISOR = 0.25\)
Test framework & Metrics

• A/B test framework using emulated WAN environment

• Test parameters
  • Latency
  • bottleneck buffer size
  • Bandwidth
  • artificial random loss

• Metrics
  • Goodput
  • Retransmitted bytes %
  • Fast retransmits
  • Timeouts
  • Loss recovery success rate
Results

• 100 Mbps bandwidth, BDP size bottleneck buffer

• For large RTT flows (100 msec)
  • Up to 39% improvement in average and P90 goodput for short flows
  • Up to 14% improvement in average and P90 goodput for long flows

• No noticeable improvement for small RTT flows (50 msec, 25 msec)

• Across all tests
  • Number of bytes retransmitted reduced by 50%
  • Number of RTOs reduced by 36%
  • Loss recovery success rate improves 43.48% -> 52%

• Awaiting results from production A/B test
  • Preliminary numbers show 20% reduction in retransmissions – not scoped
Status & Next Steps

• HyStart++ is deployed on by default for all connections
  • Windows 10 May 2019 Update onwards
  • Windows Server 2019 1903 version onwards

• Draft Status
  • draft-balasubramanian-tcpm-hystartplusplus-01 posted

• More A/B tests, please suggest interesting test cases

• Future: compare HyStart++, BBR STARTUP phase, and Paced Chirping

• Adopt document in tcpm