A framework to determine the optimal loss rate of RED queue for next generation Internet routers

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Queue Management

- **Passive**
  - No preventive packet drop until buffer reaches a threshold when packets are dropped with probability of one.
  - Examples:
    - Tail Drop
    - Drop from Front
    - Pushout

- **Active**
  - Preventive random packet drop
  - Example: Random Early Detection
  - Suggested by IETF (RFC 2309)
Random Early Detection (RED)

- **Uses**
  - four parameters: min\(_{th}\), max\(_{th}\), max\(_p\), w
  - average queue size (avg) is calculated using a weighted averaging
  - Drop probability, \( p = \max_p \frac{avg - min_{th}}{max_{th} - min_{th}} \)

- **Solves**
  - Global synchronization problem
  - Avoids bias against bursty traffic
**RED Algorithm**

For Each Packet Arrival

Calculate the average queue size avg

If Min_Threshold ≤ avg < Max_Threshold

Calculate probability p

with probability p:

Mark the arriving packet

else if Max_Threshold ≤ avg

Mark the arriving packet
Average and Instantaneous Queue Lengths

$K_h = \text{max}_th,$

$K_l = \text{min}_th$
Value of $\text{max}_p$

- **$\text{max}_p$ is too small:**
  - RED is insufficient to notify senders,
    - Tail drop will dominate
- **$\text{max}_p$ is too large:**
  - Low link utilization

- **Open Question:** What is the optimum value of $\text{max}_p$?
Problem statement

- **Value of max_p suggested in previous research**
  - Takes into account only the packet drop rate, but does not take into account the traffic pattern.

- **Open question:**
  - What is the optimum value of max_p?
  - What is the relationship between max_p and the other three parameters?
Objectives

\[ p = \max_p \frac{\text{avg} - \min_{th}}{\max_{th} - \min_{th}} \]

- Develop a model for \( \max_p \) which is related to:
  - TCP connection parameters and
  - RED configuration parameters
- The \( \max_p \) suggested by our model:
  - Results in packet drops being due to active drops
  - Eliminates tail drops (passive drops)
  - Results in high link utilization
  - No global synchronization
- Previous value of \( \max_p \) in literature
  - Eliminates passive drops
  - But, results in low utilization of the link bandwidth for TCP traffic.
Change in instantaneous queue depends on the difference between incoming and outgoing traffic rates to the queue.

- Incoming traffic rate depends on the size of the TCP congestion window and the round trip time.
- Model for \( cwnd \) has been developed in previous research.

\[
\frac{(NC)^2 (K_h - K_l)(1 + \frac{K_l}{2K_l})^2}{(\mu \tau)^2 K_h} \leq \max_p \leq \frac{(NC)^2 (K_h - K_l)(1 + \frac{K_l}{2K_l})^2}{(\mu \tau)^2 K_l}
\]

- \( N \)= Number of connections
- \( C \)= constant depending of the TCP settings.
- \( \mu \)= Service rate of RED queue
- \( \tau \)= RTT in terms of calculation interval of average queue length.
Simulation Configuration

Serv 0 → RED: 1ms, 100 Mbps
Serv 1 → RED: 5ms, 100 Mbps
Serv 2 → RED: 31ms, 100 Mbps
Client → RED: 5ms, 10 Mbps
w=0.07

$K^0_l = 6, K^0_h = 20$

$K^0_l = 6, K^0_h = 140$
TCP Load – Typical RED parameters

- No global synchronization.
- This is expected.
Packet drop - Typical RED parameters

- No passive drops
- All drops due to active drops
- This is expected
Link utilization - Typical RED parameters

Typical RED parameters

- *Good* link utilization
$K_i^0 = 6, K_h^0 = 140$

$max_p = 0.1$
$K^0_l = 6, K^0_h = 140$

$\text{max}_p = 0.1$

- Active packet drops taking place
$K_i^0 = 6, K_n^0 = 140$

$\max_p = 0.1$

*Poor link utilization*
$K^0_l = 6, K^0_h = 140$

max_p = 0.96
$K_i^0 = 6, K_h^0 = 140$

max_p = 0.96

- All drops are active packet drops
$K^0_l = 6, K^0_h = 140$

$\text{max}_p = 0.96$

*Good* link utilization
Conclusions

- We have proposed a model to calculate $\max_p$ for RED.
- Network engineers can use this value to optimize the performance of routers using RED.
Further Information

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Thank you!
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Thank you!