Dynamic threshold Control of RED for establishing fairness among thousands of TCP connections

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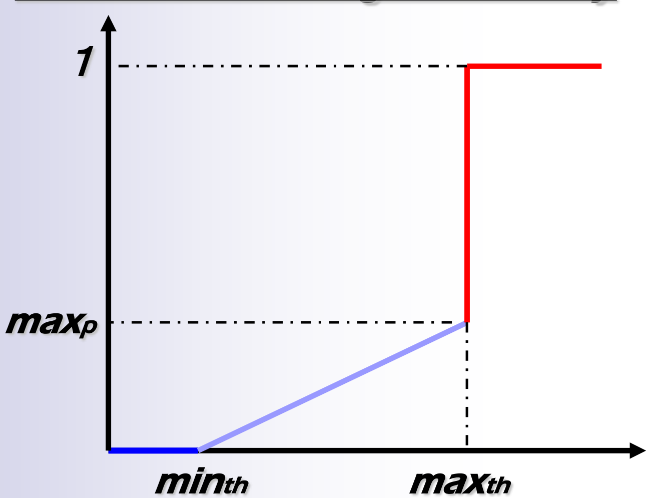
Backgrounds

- ***Internet Router Buffer***
  - Tail-Drop Router
    - Simple, easy implementation
    - Discard arriving packets when buffer is full
      - Bursty packet loss
    - Poor performance
      - Throughput
      - fairness among connections
- ***RED (Random Early Detection)***
  - Discard incoming packets with a certain probability

RED (Random Early Detection)

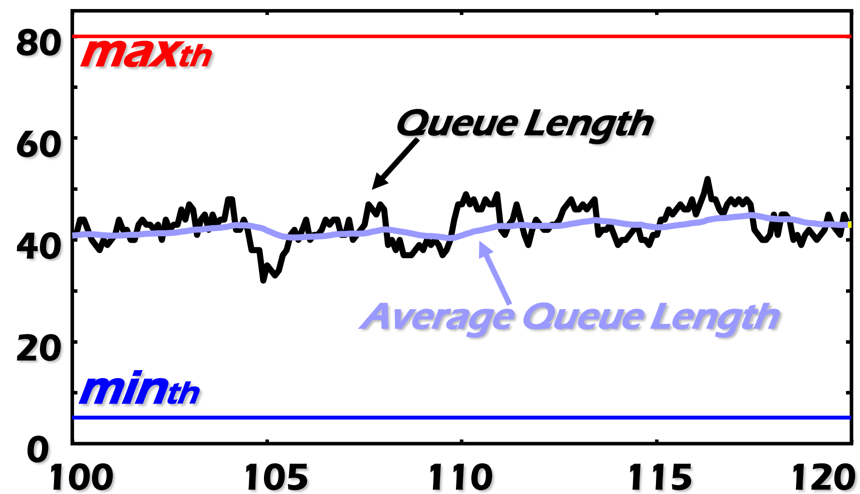
- Probability is changed according to average queue length
- Avoid buffer overflow, keep queue length low

Packet Discarding Probability



Average Queue Length [packets]

Queue Length [packets]



Time [sec]

Researches on RED

- *Achieve better performance than Tail-Drop*
  - Throughput, Fairness among connections
- *Difficult to set control parameters*
  - Depends on network condition, # of active connections, …

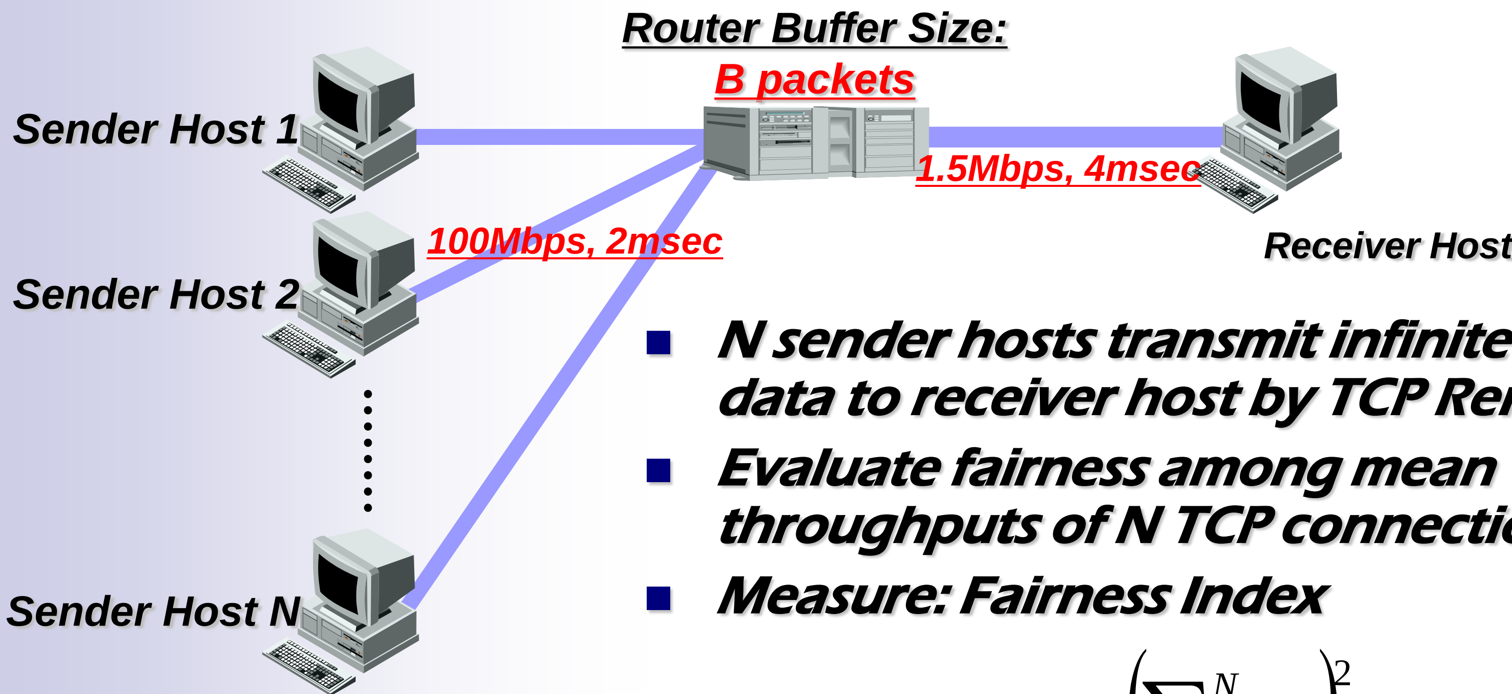
Researches on RED (2)

- *Many enhanced algorithm have been proposed*
  - Introducing new control parameters
  - Parameter setting problem remains
- *Focus only on throughput*
- *Small number of connections*

Objectives

- ***Evaluate fairness of RED with many connections***
  - Compare with Tail-Drop
- ***Propose new algorithm of RED***
  - Set threshold values dynamically
  - Easy parameter setting
  - Provide good fairness

Network Model

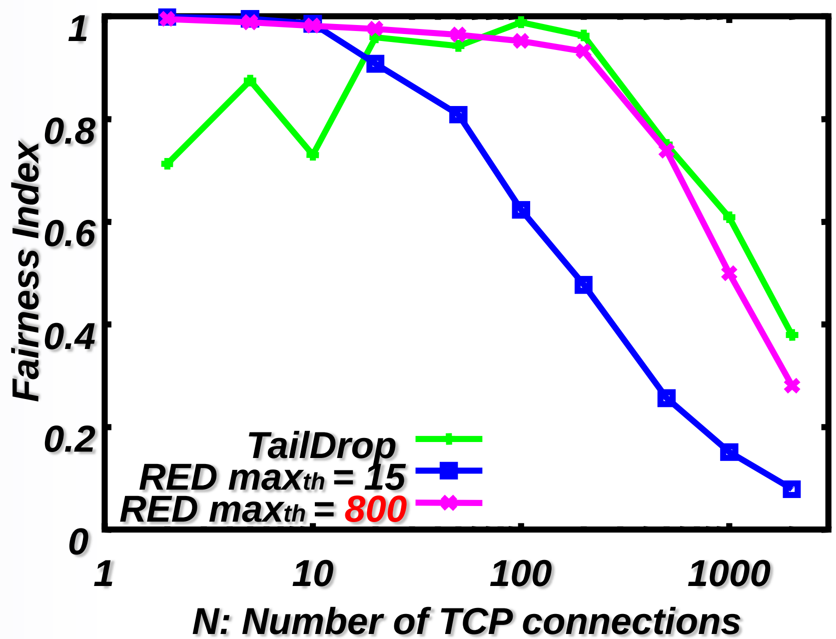


- *N sender hosts transmit infinite size of data to receiver host by TCP Reno*
- *Evaluate fairness among mean throughputs of N TCP connections*
- *Measure: Fairness Index*

$$f = \frac{\left(\sum_{i=1}^{N} x_i\right)^2}{N \sum_{i=1}^{N} x_i^2}$$

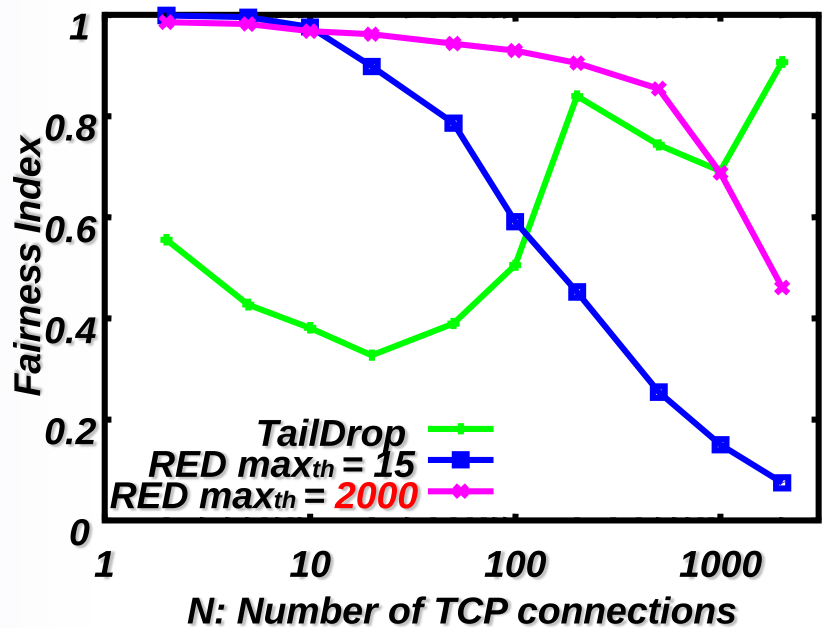
  - 0 (unfair) < *f* < 1 (completely fair)

Evaluation Result (1): B=1000 [packets]



- *Tail-Drop shows degrades fairness when N is small*
- *Recommended parameter set of RED shows bad fairness especially when N is large*
- *RED with appropriate parameters shows good fairness regardless of N*

Evaluation Result (2): B=10000 [packets]

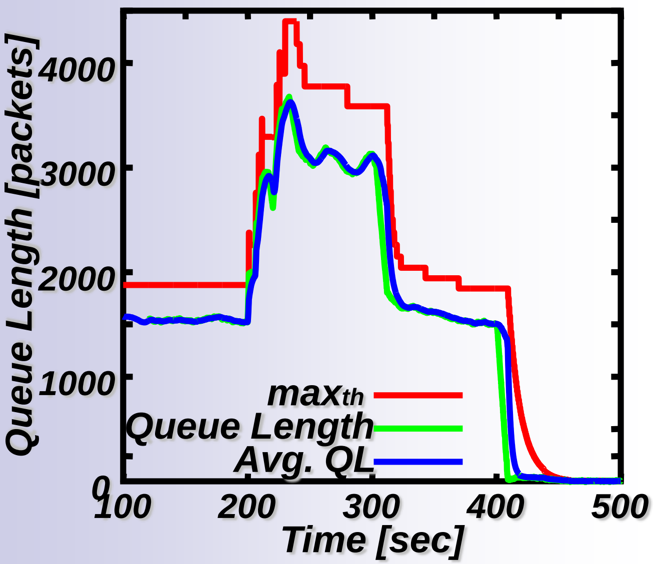


- Tail-Drop and RED with recommended parameter set cannot provide fairness
- Best setting of RED changes according to network condition

Fairness of RED

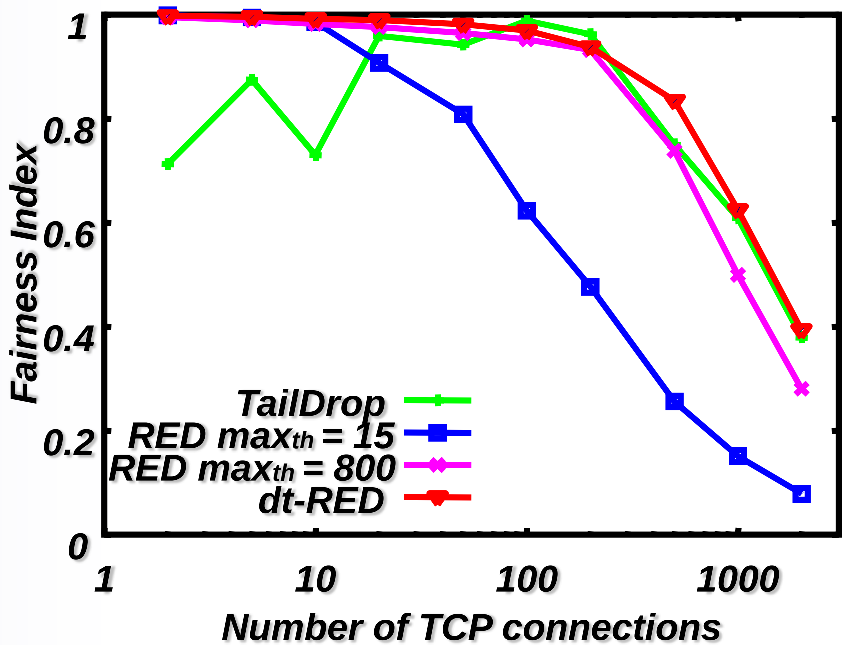
- *Recommended parameter set cannot provide fairness when N is large*
  - When average queue length becomes max_{th}, RED discards incoming packets **in burst** as Tail-Drop
- *Threshold value (max_{th}) should be set carefully to keep fairness*
- *Appropriate value will be changed by various factors*
  - Bandwidth, Buffer size, # of connections, delay, …
- ***Static parameter setting is impossible***

Proposed Algorithm: dt-RED



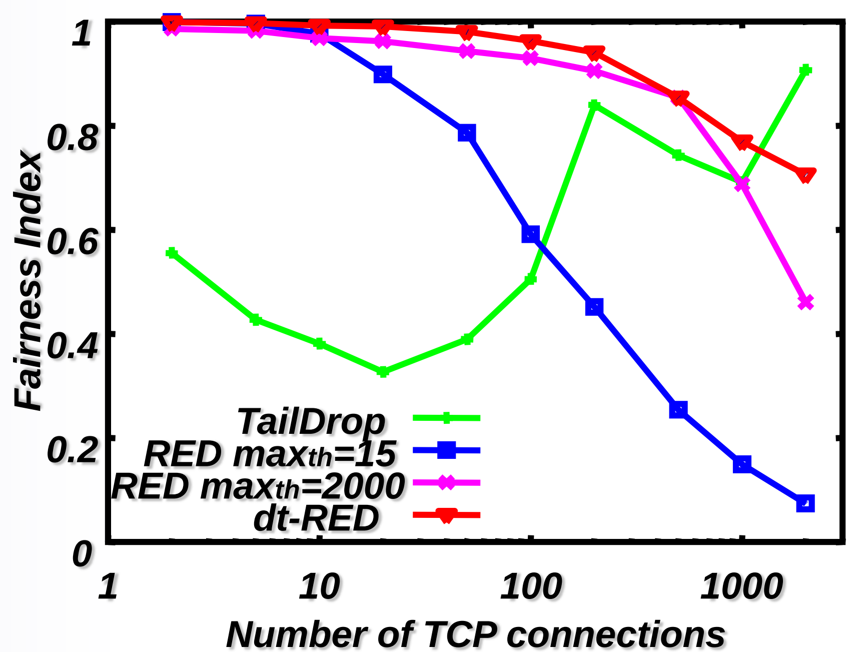
- *Observe average queue length at regular intervals*
- *Change threshold values (max_{th}, min_{th}) according to the average queue length*
- *Keep average queue length between max_{th} and min_{th}*
- *Avoid bursty packet losses at the RED router buffer*

Evaluation Result (3): B=1000 [packets]



- ***dt-RED can provide the best fairness among all algorithms***

Evaluation Result (4): B=1000 [packets]



- *dt-RED shows good fairness regardless of the number of connections and buffer size*

Characteristics of dt-RED

- *Always provide the same fairness as original RED with best parameter set*
  - Automatically set threshold values appropriately
- *Show good performance with one parameter set, regardless of network condition*
  - Remove the difficulty of parameter setting in original RED

Conclusion

- *Fairness of RED algorithm is largely dependent on control parameters*
- *Static parameter setting is difficult*
- *dt-RED can set parameters appropriately according to dynamic change of network condition*