ItswTCM: A New Aggregate Marker to Improve Fairness in DiffServ

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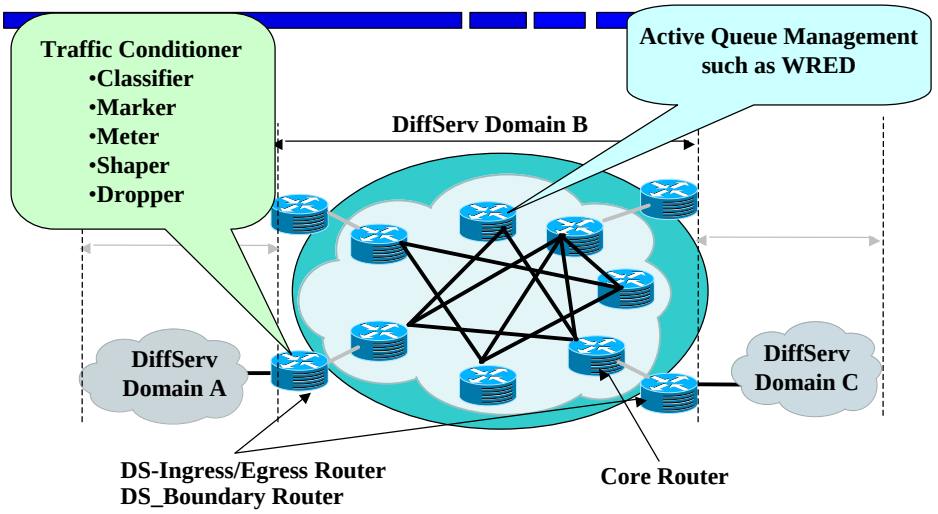
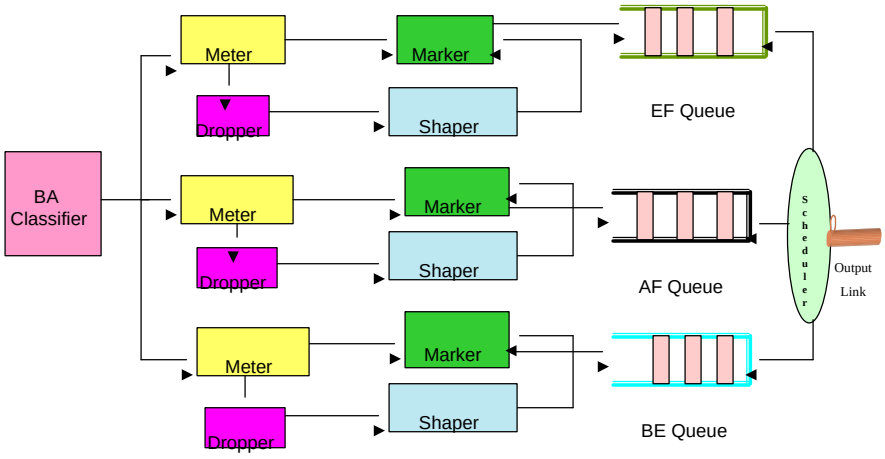
DiffServ

- Provides statistical guarantees to a few pre-defined per hop behavior
  - Expedited Forwarding
  - Assured Forwarding
  - Best Effort
- Edge routers and core routers
  - Complex tasks such as administration, control, traffic classification, traffic monitoring, traffic *marking*, etc are pushed to the *edge routers*.
  - *Core router* implements active queue management such as RIO.

Differentiated Service Network



Traffic conditioning at edge router



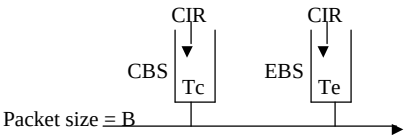
Unfairness in DiffServ

- Excess core bandwidth is shared among flows instead of aggregates.
- DiffServ tends to favor small service subscribers.
- Causes of unfairness:
  - Nature of TCP congestion control
  - Service rate is ensured by green packets; excess network bandwidth is acquired by *yellow* and *red* packets.
  - Marking yellow and red packets *without considering their service profile* leads to unfairness among traffic aggregates.

Markers

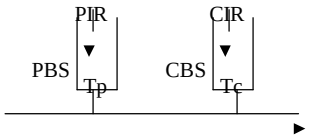
- Token bucket
  - Single rate three color marker (srTCM) – RFC 2697
  - Two rate three color marker (trTCM) – RFC 2698
- Average rate estimators
  - Time sliding window (TSW)
  - Time sliding window three color marker (tswTCM) – RFC 2859

srTCM (RFC 2697)



- If Tc(t) - B >= 0, the packet is GREEN and Tc is decremented by B, else
- if Te(t) - B >= 0, the packets is YELLOW and Te is decremented by B, else
- the packet is RED and neither Tc nor Te is decremented.

trTCM (RFC 2698)



- If Tp(t)-B < 0, the packet is red, else

  If Tc(t)-B < 0, the packet is yellow and Tp is decremented by B,

  else

  The packet is green and both Tp and Tc are decremented by B.

tswTCM Marking (RFC 2859)

- Marking based on measured throughput of the traffic stream against CIR and PIR
- Mark *green* if sending rate <= CTR
- Mark *yellow* the portion of the traffic between CTR and PIR
- Mark *RED* the portion of traffic > PIR

tswTCM Marking Algorithm

avg-rate = Estimated Avg Traffic Sending Rate
if (avg-rate <= CIR)
    the packet is marked as green;
else if (avg-rate <= PIR) AND (avg-rate > CIR)

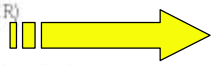
$$\text{calculate } P0 = \frac{(\text{avg-rate} - \text{CIR})}{\text{avg-rate}}$$

with probability P0 the packet is marked as yellow;
with probability (1-P0) the packet is marked as green;
else

$$\text{calculate } P1 = \frac{(\text{avg-rate} - \text{PIR})}{\text{avg-rate}}$$

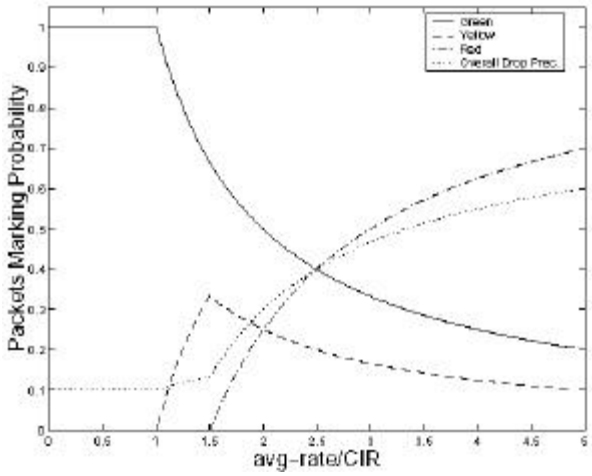
$$\text{calculate } P2 = \frac{(\text{PIR} - \text{CIR})}{\text{avg-rate}}$$

with probability P1 the packet is marked as red;
with probability P2 the packet is marked as yellow;
with probability (1-(P1+P2)) the packet is marked as green;



- Yellow packet marking probability is proportional to excess bandwidth of the aggregate rather than the CIR of the aggregate
- Encourages aggressive senders
- Small service subscribers or an aggregate with more flows usually wins.

Marking Probability of tswTCM



Objectives of this study

- Develop a new aggregate based traffic marker to improve the fairness excess bandwidth sharing among aggregates in a DiffServ network.
- Comparison of fairness of different traffic markers using ns.

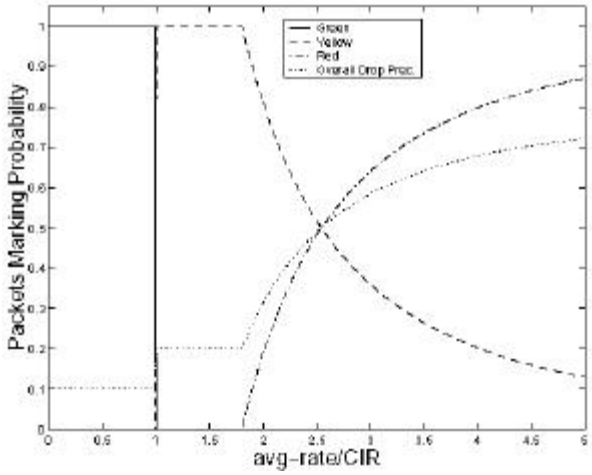
Proposed ItswTCM Algorithm

avg-rate = Estimated Avg Traffic Sending Rate
c = a constant (c> 1)
if (avg-rate <= CIR)
    the packet is marked as green;
else if (avg-rate <= c* CIR)
    the packet is marked as yellow;
else
    calculate $P = \left(\frac{c^* CIR}{avg\text{-}rate}\right)^2$
    with probability P the packet is marked as yellow;
    with probability 1-P the packet is marked as red;

- Probability of marking yellow packets is proportional to their CIR
- avg-rate > CIR implies that the network has excess network bandwidth; it is not very critical whether the throughput is realized by green or yellow packets.

Because *yellow* packets help in acquiring the excess network bandwidth, allow an aggregate to inject yellow packets in proportion to their CIR

Marking Probability of ItswTCM

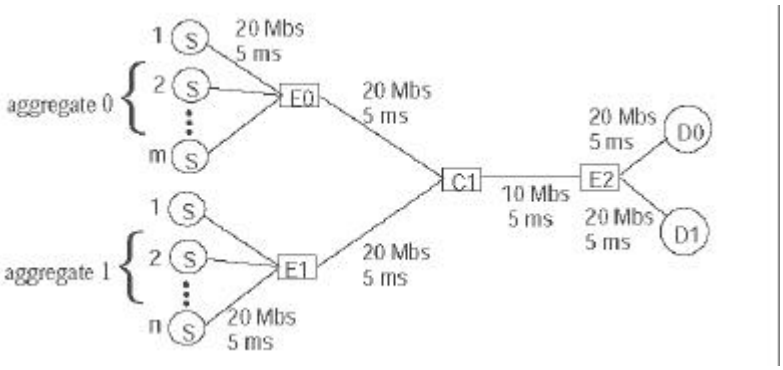


Advantages of ItswTCM

- Provides a strong incentive for sources to obey their service contracts
- Will help to protect TCP-friendly traffic from UDP-like traffic

Simulation Topology

- NS-2 Network Simulator
- Aggregate 1 has a fixed CIR of 1Mbps
- Aggregate 0 varies its CIR from 1Mbps to 8Mbps



Fairness Index

$$FI = \frac{(\sum_i x_i)^2}{N * \sum_i {x_i}^2}$$

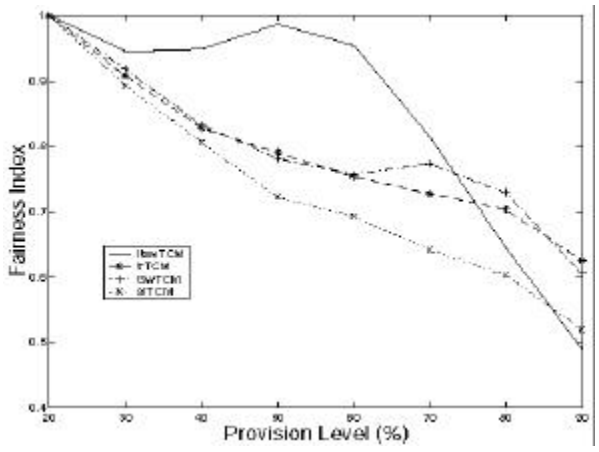
excess bandwidth obtained by aggregate *i*

x_i = ----------

CIR of aggregate *i*

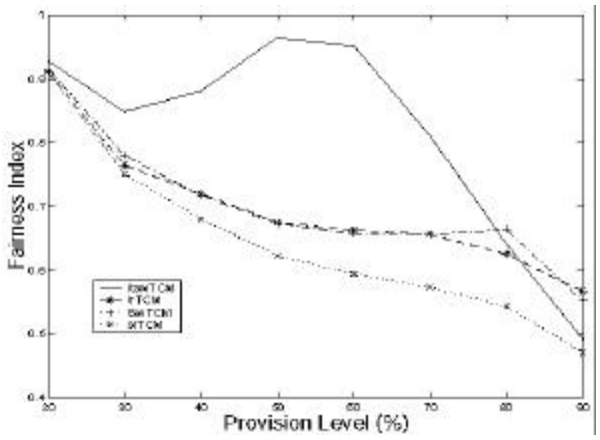
Fairness Index versus Provision Level

Case 1 (Small and large subscribers emit the same number of flows):
aggregate 0 (16 flows) and aggregate 1 (16 flows)



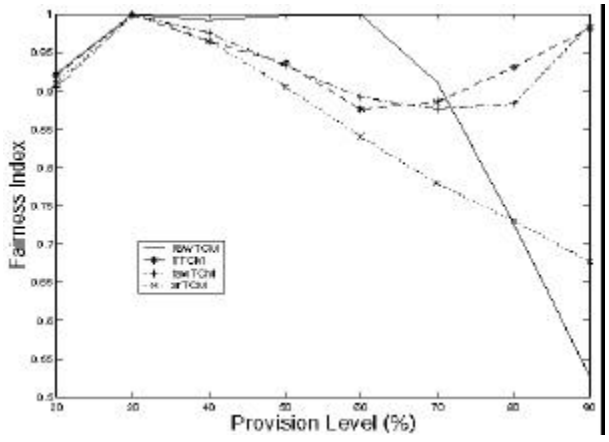
Fairness Index versus Provision Level

Case 2 (Small subscriber emits large number of flows):
aggregate 0 (16 flows) and aggregate 1 (32 flows)

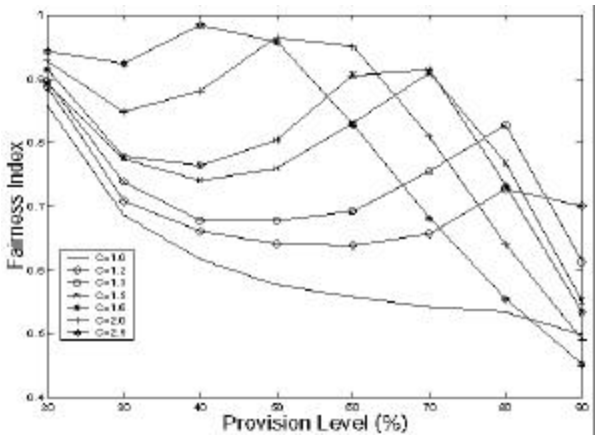


Fairness Index versus Provision Level

Case 3 (Large subscriber emits large number of flows):
aggregate 0 (32 flows) and aggregate 1 (16 flows)



Effect of *c* on ItswTCM



As *c* decreases:

- the fair sharing region moves from low to high provision level
- the fairness level also decreases.

Contributions of this study

- Proposed an Improved Time Sliding Window based Three Color Marker (ItswTCM), which improves the proportional fair sharing of excess network bandwidth among aggregates.
- Fairness of our scheme is better when the network is properly provisioned.

Conclusion

- Proposed a new aggregate based three color marker
- The proposed ItswTCM has better fairness than srTCM, trTCM, and tswTCM for a large range of network provisioning level (20% - 70%)
- ItswTCM is not as sensitive to the number of flows in an aggregate as the other three markers
- Yellow packets play a significant role in achieving fairness. It is important to inject the right amount of yellow traffic into network.
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