A Better-Than-Best-Effort Service for Continuous Media UDP Flows

Mark Parris
Kevin Jeffay
F. Donelson Smith
Jan Borgersen

Department of Computer Science
University of North Carolina at Chapel Hill

http://www.cs.unc.edu/Research/dirt

Queue Management and Congestion Avoidance

- Braden, et al. recommend:
  - Implement some form of active queue management in routers.
    - Avoid full queues, reduce latency, reduce packet dropping, avoid lock-out phenomena
  - Continue research into mechanisms to deal with unresponsive or aggressive flows.
- Floyd & Fall:
  - mechanisms to identify “misbehaving flows”
- To date, focus was on supporting TCP
- How can we do better than best-effort for multimedia in this framework?

Active Queue Management

RED

- Random Early Detection (RED) (Floyd, et al.)
  - Multiple modes based on threshold values
  - Probabilistic and forced drops
    - avoid consecutive drops
    - drops proportional to bandwidth utilization
  - Weighted average accommodates bursty nature of traffic

Active Queue Management

FRED

- Flow-based RED (Lin & Morris)
  - Drops are proportional to bandwidth used
  - Logical queues for each flow
  - Unresponsive flows are identified and penalized

- Each flow has access to an equal share of the queue
  - dynamically calculated based on current queue size & number of active flows
Active Queue Management
Drop Preference Management (DPM)

- Goals:
  » maintain most properties of RED
  » constrain non-responsive flows
  » given these constraints, improve multimedia performance
    – lower latency

- Design:
  » Multimedia flows are tracked in logical queues
  » Fixed portion of the queue shared between these flows
  » Staleness test
  » Delete and advance drop policy
  » Continue to apply RED policies

DPM data flow

- DPM is an extension to RED for selected flows
- All packets remain in a single queue (order is maintained between flows)

Delete and Advance

- Tagged flows use delete and advance instead of standard drops.
- First packet for the flow is discarded and subsequent packets for that flow are advanced.
- Depth of packets from all other flows is maintained (or decreased).
- Freshest packets arrive at receiver

Research Questions

- Does it work?
  » Performance of TCP
  » Performance of Multimedia
  » Effect of unresponsive traffic

- What’s the overhead?
  » CPU cycles
  » State

- What settings offer optimal performance?
  » Sensitivity of average calculation
  » Threshold values
  » Queue length
  » Other drop policies?
Empirical Evaluation
Experimental Setup

- Senders transmit a mix of TCP, real-time and non-real-time UDP traffic
- Delay introduced at receivers to produce large delay-bandwidth product
- 10 Mbps link bottleneck

Experimental Results
TCP Throughput

<table>
<thead>
<tr>
<th>Time (secs.)</th>
<th>FIFO</th>
<th>RED</th>
<th>DPM</th>
<th>FRED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1200</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>3</td>
<td>1100</td>
<td>110</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>5</td>
<td>1000</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>900</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>9</td>
<td>800</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>11</td>
<td>700</td>
<td>70</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>13</td>
<td>600</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>15</td>
<td>500</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>17</td>
<td>400</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>19</td>
<td>300</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>21</td>
<td>200</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>23</td>
<td>100</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>25</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Experimental Results
UDP Latency

<table>
<thead>
<tr>
<th>Time (secs.)</th>
<th>FRED</th>
<th>DPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>20</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>30</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>40</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>50</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

Conclusions

- DPM offers comparable TCP performance to FRED or RED
- DPM maintains less state than FRED
- DPM offers lower latency to multimedia applications