Rotating Priority Queues
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• Idea:
  – Approximate a sorted scheduler queue (e.g., EDF, WFQ) by FIFO queues
  – FIFO queues are periodically rearranged (“rotated”)

  – Here: Approximate Earliest-Deadline-First with FIFO queue
Rotating-Priority-Queues (RPQ)

Design Principles:

- $P$ priority sets.
- $P + 1$ FIFO queues with labels.
- Relabel queues every $\Delta$ time units.
- One delay bound for each priority set: $d_p = p \cdot \Delta$. 
**Experimental Setup**

- Single 155 Mbps switch.
- Three connection groups *Low, Medium, High Delay.*

<table>
<thead>
<tr>
<th>Index</th>
<th>Delay Bound</th>
<th>Burst Size</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>(d_j)</td>
<td>(B_j) (r_j)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(j)</td>
<td>(1)</td>
<td>12 ms</td>
<td>4,000 cells</td>
</tr>
<tr>
<td>(Low)</td>
<td>1</td>
<td>12 ms</td>
<td>4,000 cells</td>
</tr>
<tr>
<td>(Medium)</td>
<td>2</td>
<td>24 ms</td>
<td>2,000 cells</td>
</tr>
<tr>
<td>(High)</td>
<td>3</td>
<td>36 ms</td>
<td>4,000 cells</td>
</tr>
</tbody>
</table>
Evaluation

EDF

SP
Evaluation of RPQ

RPQ ($\Delta = 12\, ms; \, 6\, \text{FIFOs}$)  

RPQ ($\Delta = 6\, ms; \, 12\, \text{FIFOs}$)  

RPQ ($\Delta = 4\, ms; \, 18\, \text{FIFOs}$)  

RPQ ($\Delta = 3\, ms; \, 24\, \text{FIFOs}$)
Rotating Anomaly

- For $\Delta \to 0$: $RPQ = EDF$
- For $\Delta \to \infty$: $RPQ = SP$
- For $\Delta$ small: $RPQ$ is worse than $SP$
- Why?
Rotation Anomaly

Arrival scenario:

At $T-\epsilon$: Arrival of 3 packets from priority 2 with $d_2 = 2\Delta$

At $T+\epsilon$: Arrival of 1 packet from priority 1 with $d_1 = \Delta$

delay bounds:
- priority 1: $\Delta$
- priority 2: $2\Delta$

- Observation: Rotation can put packets with a later deadline ahead ("deadline inversion")
- Can rotation anomaly be avoided?
Rotating-Priority-Queues\(^+\) (RPQ\(^+\))

*Design Principles:*

- \(P\) priority sets.
- \(2P\) FIFO queues with labels.
- Relabel queues every \(\Delta\) time units.
- One delay bound for each priority set: \(d_p = p \cdot \Delta\).
RPQ$^+$ Scheduler

1. Red: 3
   - Next slot: 3
   - Current slot: 3

2. Blue: 2
   - Next slot: 2
   - Current slot: 2

3. Black: 1
   - Next slot: 1
   - Current slot: 1
RPQ^+ Queue Rotation

Before rotation.

Step 1: "Concatenation"

Step 2: "Promotion"
Implementing RPQ$^+$ in Shared Memory

- No movement of packets.
- Operations independent of queued packets.
Evaluation of $\text{RPQ}^+$

$\text{RPQ}^+ \ (\Delta = 12 \text{ms}; \ 6 \ \text{FIFOs})$  $\text{RPQ}^+ \ (\Delta = 6 \text{ms}; \ 12 \ \text{FIFOs})$

$\text{RPQ}^+ \ (\Delta = 4 \text{ms}; \ 18 \ \text{FIFOs})$  $\text{RPQ}^+ \ (\Delta = 3 \text{ms}; \ 24 \ \text{FIFOs})$
Summary of Evaluation

- Compare volume of the schedulable regions:
  \[
  \frac{V^\Sigma(\Delta)}{V_\infty} \cdot 100\%
  \]
Summary of RPQ⁺

- For $\Delta \to 0$: $RPQ^+ = EDF$
- For $\Delta \to \infty$: $RPQ^+ = SP$
- For $\Delta$ small: $RPQ^+$ always better than $SP$
- No rotation anomaly.