Latency Guarantee with Stateless Fair Queuing (C-SCORE)

draft-joung-detnet-stateless-fair-queuing-02

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IETF 119, Mar. 2024
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• Categories of C-SCORE, according to the taxonomy [Taxonomy]
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• Understanding C-SCORE (with an example starting from E-CQF)
C-SCORE’s categories [Taxonomy]

Rate based
- C-SCORE
  - ATS
  - DRR

Time based
- CQF var.
  - TAS var.
  - EDF

Flow level
- L/r
- ΣL/R
- ΣB/R

Granularity
- In-time
  - Work conserving
    - WC
    - Non WC
  - On-time
    - Non-Periodic
    - Periodic

Class level
- TAS var.
- CQF var.
  - EDF

service order
- C-SCORE
  - DRR

C-SCORE
Revisit: Suitability of the solutions for DetNet services

Latency
- Tight
- Loose

Periodicity
- Strict
- Sporadic

Burst size
- Large
- Small

Loss tolerance
- No
- Yes

Scale
- Large
- Small

Statistical MUX gain

Flow level
- Flow state unnecessary

Class level
- Work conserving
- Non work conserving

Granularity
- Rate based
- Time based

Flow level
- L/r
- ΣL/R

Class level
- ΣB/R

Flow state unnecessary

Work conserving
- WC
- Non WC

Non work conserving
- In-time
- On-time

Rate based
- C-Score
- ATS
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Time based
- CQF var.
- TAS var.
- EDF

Flow state unnecessary

Simple admission control. Can handle large number of dynamic flows.

Simple E2E latency calculation.

Can minimize the effect of other flows’ bursts.

Flow state unnecessary

Less buffer required. Less jitter

Naturally fits to periodic services.

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C-Score

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Strengths of C-SCORE (1/3) : Simple admission control

- The admission & reservation process depends only on the service rates to the flows.
  - while others require to consider the burst sizes of all the flows.
Strengths of C-SCORE (2/3): Flow isolation

• The E2E latency of p’s flow is bounded [Kaur] by

$$\frac{B - L}{r} + \sum_{h=0}^{H} \left( \frac{L_{\text{max}_h}}{R_h} + \frac{L}{r} \right).$$

• B, L, r are flow specific, which can be controlled according to requirement
  • Latency bound can be adjusted with r, the service rate.
• E2E latency bound guaranteed to a flow upon its admission, alters minimally as other flows join or leave.

A near perfect flow isolation

Can minimize the effect of other flows’ bursts.

Flow state unnecessary

C-SCORE needs no flow state in core nodes.

Flow level

Granularity

Class level

Can minimize the effect of other flows’ bursts.

Flow state unnecessary

C-SCORE needs no flow state in core nodes.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Max Packet Length of the flow</td>
</tr>
<tr>
<td>B</td>
<td>Max burst of the flow</td>
</tr>
<tr>
<td>r</td>
<td>Service rate of the flow</td>
</tr>
<tr>
<td>L_{\text{max}_h}</td>
<td>Max Packet Length at node h</td>
</tr>
<tr>
<td>R_h</td>
<td>Link capacity of h</td>
</tr>
</tbody>
</table>

Symbol | Definition |
|--------|------------|
Strengths of C-SCORE (3/3): Statistical MUX gain

Jitter VC & CJVS [Stoica] are non-work conserving stateless fair queuing schemes. The four schemes below have the identical E2E latency bound of 0.32ms.

Small average latency.
Small observed max latency.
More room to best-effort traffic.

[FIGURE 20. Comparison of E2E latency distributions of 7-hop C type flows. Utilization is 90%. C-SCORE with PIFO queue with $d_s(p) =$ service latency. The order of boxplots is the same as the order in the legend.] [Joung]
Considerations for ECQF

• In the above example, there are only three DetNet classes, three different E2E latency bounds.

• A slot length is determined by the sum of max burst sizes (or packet lengths if Max Burst=Packet) of all the flows in the same class, in the most congested link in a network. Other classes’ slot lengths are also dependent on this length.

• Thus, when more flows are admitted later, then all the slot lengths have to be increased. Or the initial slot lengths have to be large enough to accommodate the future flow admissions.
Solution: Flow level E-CQF

- Allocate “thicker” pipes to the flows with higher service rates. \(\rightarrow\) Their slot times are smaller.
- The E2E latency bound is still \(\sim (H+1) \times \text{slot time}\).
- The E2E latency bounds can be allocated to flows exactly as they want by adjusting the service rate.
- Even when more flows are admitted, there is no change in the slot time, thus unaltered latency bound.
- Still, there can be wasted bandwidth due to various packet sizes.

A single box’s area equals to the max packet length. A slot time is \(\frac{\text{max packet length}}{\text{service rate}}\) of the flow.

“A single box’s area equals to the max packet length. A slot time is \(\frac{\text{max packet length}}{\text{service rate}}\) of the flow.”
A better solution: Flow level, variable sized slot scheduler

- No wasted bandwidth.
- The precise and fair service differentiation among flows.
- The flow isolation property is preserved.
- The E2E latency bound is still \( (H+1) \times (\text{max packet length/service rate}) \).

A slot time depends on the packet length, which has to served in the slot.
We already have it: C-SCORE (Flow level, variable sized slot scheduler, but work conserving)

- No wasted bandwidth.
- The precise and fair service differentiation among flows.
- The flow isolation property is preserved.
- One difference: Work conserving. A packet can be served even before its slot starts.
- The E2E latency bound, without preemption, is ~ $H \times \{(\text{max packet length/service rate}) + (\text{max packet length within the node/link capacity})\}$. 

The slot end time is call Finish Time (FT) in C-SCORE.
Thank you

• Please take a look at


• Comments and Questions are welcome!


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