Timeslot Queueing and Forwarding (TQF)

draft-peng-detnet-packet-timeslot-mechanism-13

Shaofu Peng	ZTE
Peng Liu	China Mobile
Kashinath. Basu	Oxford Brookes University
Aihua Liu	ZTE
Dong Yang	Beijing Jiaotong University
Guoyu Peng	Beijing University of Posts and Telecommunications
Junfeng Zhao	CAICT

IETF-124 Nov 2025

Main Updates (12 -> 13)

- Editorial modifications to make the text clearer.

Processed Comments

- A comment raised by Florian in the last IETF 123 meeting, about the number of queues in TAS and TQF. Further discussed in the maillist with the following clarifications:
  - All 8 traffic classes queues in TAS can certainly controlled by GCL, however, only one of them is dedicated for higher priority Scheduled Traffic (ST). The allocated slots for non-ST queues in GCL are not really allocated to them, and will lose slots once new ST flows need to be set up.
  - During non-ST queues OPEN state, other mechanism such as ATS further decides which non-ST queue can actually send packets.
  - All M queues in TQF are dedicated for higher priority DetNet flows.
  - Improvements summary of TQF:
    - Multiple Orchestration Period instance.
    - Scheduling Period mapped by Orchestration Period.
    - Slot based queue can be instantiated as RR or PIFO.
    - Queueing delay can be controlled by timeslot offset.
    - Time asynchronous, i.e., BTM, BOM and ETM

Actions

- According to Chairs’ instructions, we checked the category, and sent the implementation status to the mailist.
  - **Category**

    6.1. Right-bounded category
    6.2. **Flow level periodic bounded category** **<--- TQF**
    6.3. Class level periodic bounded category
    6.4. Flow level non-periodic bounded category
    6.5. Class level non-periodic bounded category
    6.6. Flow level rate based unbounded category
    6.7. Flow level Rate based left-bounded category

  - **Implementations**
    - TQF has been implemented in ZTE Corporation's router ZXR10 M6000-SE V6, with the developed ASIC module.
    - Interoperability test between TQF and SP on the CENI (a round-trip distance of 3000 kilometers). TQF timeslot resources is arranged based on the worst cast latency of SP, to absorb the jitter caused by SP on the border node. The jitter tested is within 20us.

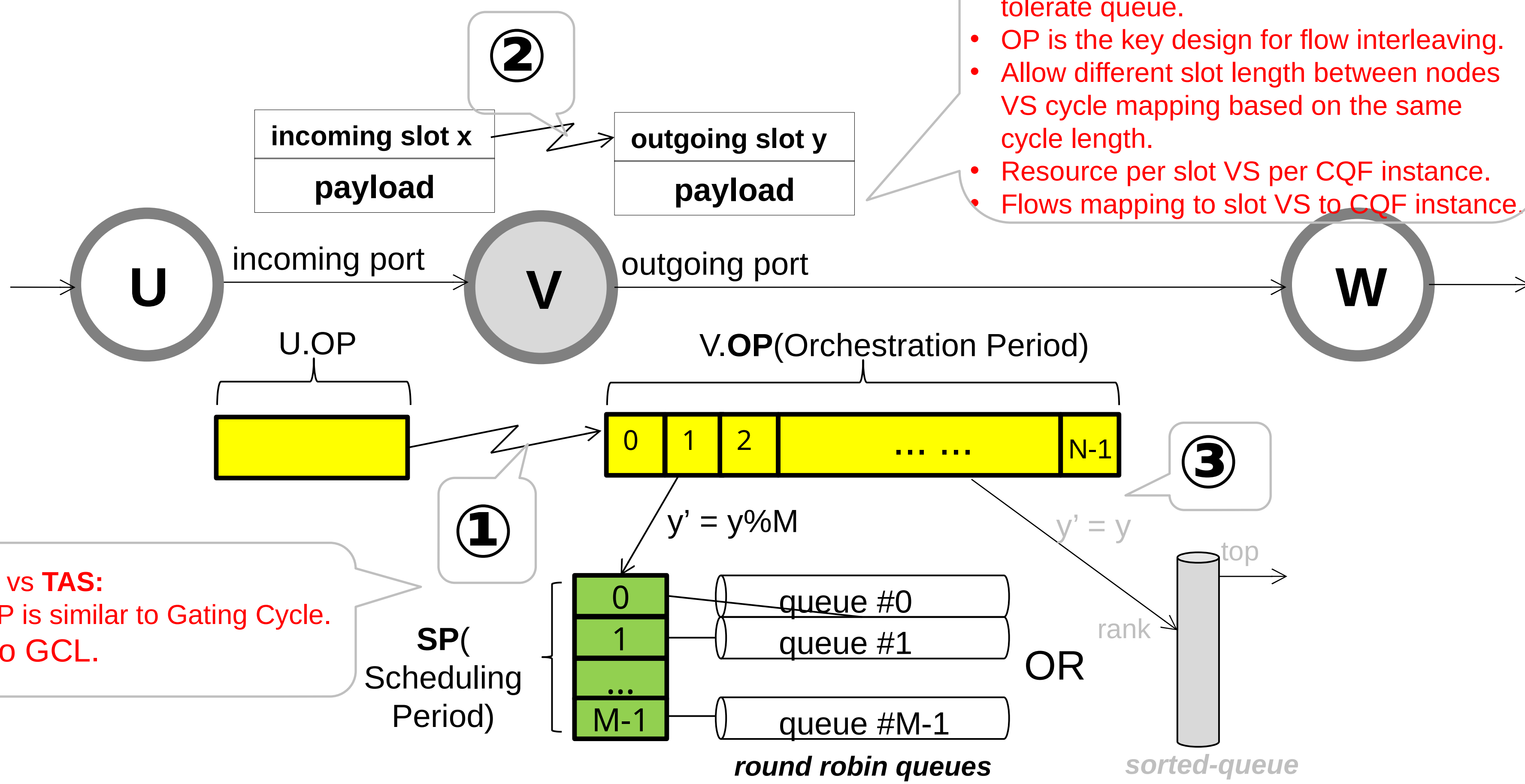
TQF Overview

Target: Flow periodically access designated time slots in the orchestration period, and achieves flow interleaving based on time slot allocation, to avoid congestion.

① Setup BTM (base timeslot mapping)@OP between the adjacent nodes.
② Setup FTM (forwarding timeslot mapping)@OP for each flow.
③ Insert packets to the queue@SP based on outgoing timeslot id.

TQF vs **CQF:**

- If SP with round robin, timeslot queue VS tolerate queue.
- OP is the key design for flow interleaving.
- Allow different slot length between nodes VS cycle mapping based on the same cycle length.
- Resource per slot VS per CQF instance.
- Flows mapping to slot VS to CQF instance.



TQF vs **TAS:**

- OP is similar to Gating Cycle.
- No GCL.

Evaluation on Grid RT

- The OPL (Orchestration Period Length) 5 ms and timeslot length 100 us are selected.
- A possible timeslot resource table:
  - Principle: ensuring that the offset between the incoming timeslot and the reserved outgoing timeslot is less than the per-hop latency bound of each type of flow , e.g., 700us for audio and CC flows, 1400us for video flows.

Timeslot	**Burst Resource**	**Allowed Admited Flows**
#0~#9	100 Kbits	for 60 CC/Audio/Vedio (round-1). For example, 40 CC + 2 Audio in #0, 20 CC + 26 Audio in #1, 26 Audio + 4 Vedio in #2, etc.
#10~#20	1000 Kbits	for 60 Audio/Vedio (round-2)
#21~#30	1000 Kbits	for 60 Audio/Vedio (round-3)
#31~#40	1000 Kbits	for 60 Audio/Vedio (round-4)
#41~#49	1000 Kbits	for 60 Vedio (round-5)

- E2E bounded latency = the sum of bounded latency per-hop. E.g., for the video flow of path Src2-2-3-6-5-8-7-Dst3, it is 7*1000 us if each hop get the same offset 1 ms..
- E2E bounded jitter is 200 us (100*2). Or 0 with the help of time deviation (E).

Evaluation on Ring-mesh RT

- A TQF instance OPL-5ms with timeslot length 100us, both for ring and core networks.
- In the ring network, assuming that each node generates a local flow-set at the same time. A possible timeslot resource table:

Timeslot	Burst Resource	Allowed Admited Flows
#0~#9	100 Kbits per slot	CC, Audio (round-1), Video (round-1) of 7 flow-sets
#10~#20	100 Kbits per slot	Audio (round-2), Video (round-2) of 7 flow-sets
#21~#30	100 Kbits per slot	Audio (round-3), Video (round-3) of 7 flow-sets
#31~#40	100 Kbits per slot	Audio (round-4), Video (round-4) of 7 flow-sets
#41~#49	100 Kbits per slot	Video (round-5) of 7 flow-sets

- In the core network, the bottleneck link will carry 70 flow-sets. A possible timeslot resource table:

Timeslot	Burst Resource	Allowed Admited Flows
#0~#9	1 Mbits per slot	CC, Audio (round-1), Video (round-1) of 70 flow-sets
#10~#20	1 Mbits per slot	Audio (round-2), Video (round-2) of 70 flow-sets
#21~#30	1 Mbits per slot	Audio (round-3), Video (round-3) of 70 flow-sets
#31~#40	1 Mbits per slot	Audio (round-4), Video (round-4) of 70 flow-sets
#41~#49	1 Mbits per slot	Video (round-5) of 70 flow-sets

- E2E bounded delay for CC is 3.8 ms (100*14 + 600*4), for Audio is 5 ms (1100*2 + 700*4),for Video is 8.8 ms (1800*2 + 1300*4).
- E2E bounded jitter is 200 us (100*2). Or 0 with the help of time deviation (E).

Functional Characteristics Analysis

Taxonomy with Functional Characteristics (draft-taxonomy-03, section 5)	**Functional Characteristics of TQF mechanism**
5.1 Periodicity • If a solution has a set of consecutive time slots that is repeated periodically, • and the time slots are assigned to packets based on a predefined rule. then the solution is periodic.	**It is periodic:** • There is an Orchestration Periold (OP) containing multiple time slots. • A flow is assigned repeatly to a particular set of timeslots in that OP.
5.2. Traffic Granularity • Flow level: Each packet is controlled based on its specific flow. • Flow aggregate level: Flows are grouped by shared characteristics like TSpec, RSpec, or routing path. • Class level: Flows are further grouped by similar RSpec, regardless of specific path or TSpec.	**It is flow level:** • A time slot (and the corresponding FTM) is assigned per flow for interleaving. • i.e., FTM is flow specific. It represents the in/out slot mapping relationship. • TQF extends TAS's single Scheduling Traffic queue to multiple slot queues which can be allocated to each flow.
5.3. Time Bounds • **Bounded: A packet's transmission completion is allowed after a minimum time bound and before a maximum time bound.** • **Left-bounded: A packet's transmission completion is allowed after a minimum time bound.** • **Right-bounded: A packet's transmission completion is allowed before a maximum time bound.**	**It is bounded:** • **The transmission completion time is within the outgoing timeslot, i.e., after the beginning of the slot and before the end of the slot.**

History of Comments and Responses

[Q1] suggest not to use PIFO because there is no router or hardware switch that can support it. (from gengxuesong, IETF117)
[A] It depends how you implement the data plane, same viewpoint as Dean Bogdonovic.

[Q2] This is a single draft describing TCP/IP. Two layers that should be separated from each other...... (from Toerless, IETF118)
[A] Split into two documents: draft-peng-detnet-packet-timeslot-mechanism-10, and draft-peng-detnet-tqf-controller-plane-00.

[Q4] Please include a summary of the discussion from the other working groups where you are presenting this work. (from Lou, IETF120)
[A] Initiated discussion in 6MAN WG for data encapsulation, no comments received yet.

Other issues in interim meetings have been clarified, see:
https://datatracker.ietf.org/meeting/interim-2023-detnet-06/session/detnet

Discussion on the differences between TQF and CSQF, some comparison is added in the introduction:

https://mailarchive.ietf.org/arch/msg/detnet/EB4NLP4vmzJ4UqxLwBSx5HjOOik/
https://mailarchive.ietf.org/arch/msg/detnet/7jhcA8m56RSwQVL8l2XxVlckvfs/

Next step

- WG adoption ?
- Any questions/comments ?

Thank you!