Timeslot Queueing and Forwarding (TQF)

draft-peng-detnet-packet-timeslot-mechanism-12

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Main Updates (10 -> 12)

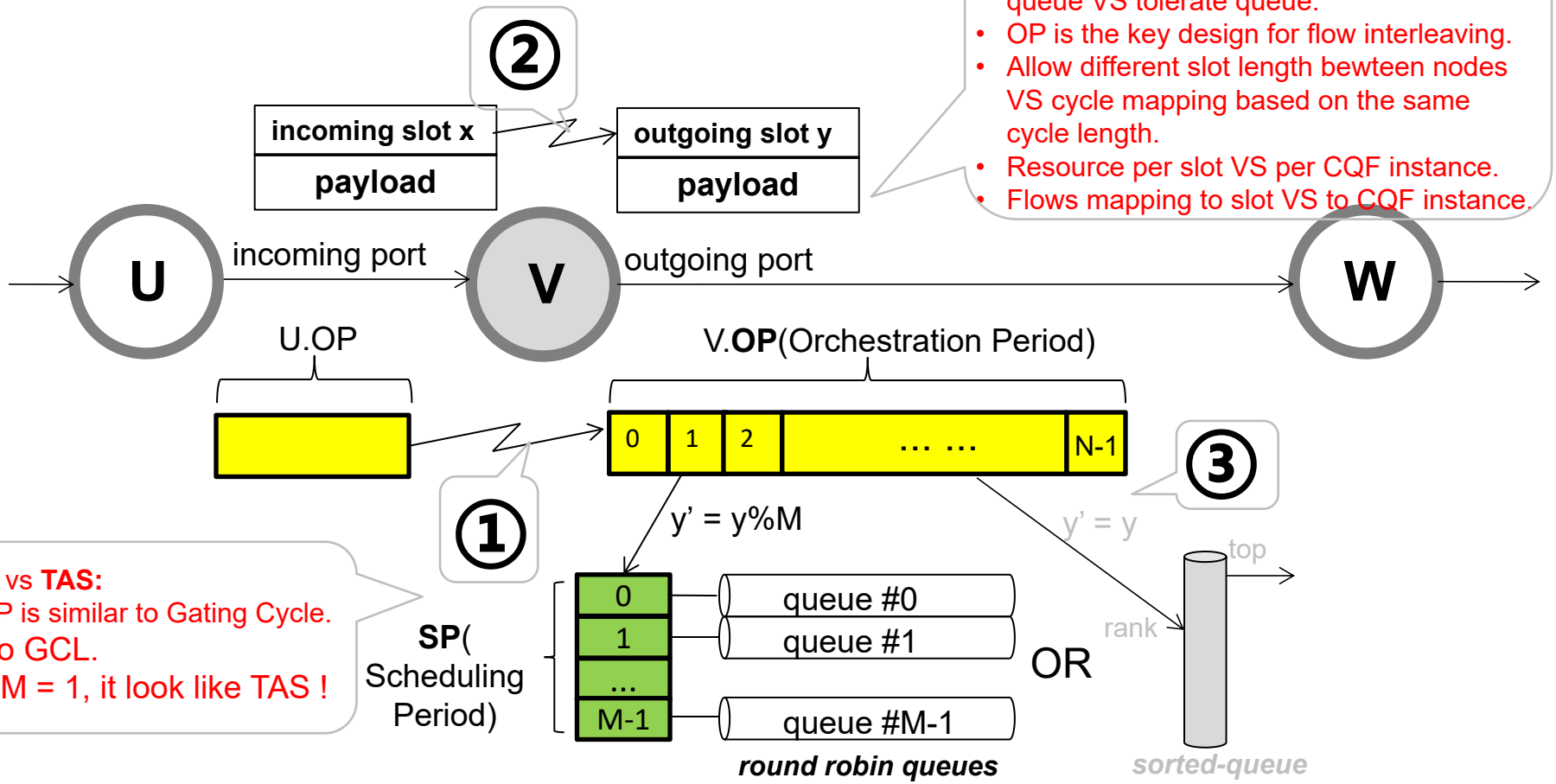
- Editorial modifications to make the text clearer.

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:**
- SP is similar to round robin bins, timeslot queue VS tolerate queue.
- OP is the key design for flow interleaving.
- Allow different slot length bewteen 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.
- If M = 1, it look like TAS !

Evaluation on Grid RT

- The OPL (Orchestration Period Length) 5 ms and timeslot length 100 us are choosed
- 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 vedio flows.

Timeslot	**Burst Resource**	**Allowed Admited Flows**
#0~#9	1000 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 vedio 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

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.

Mapping to Which Category ?

Suitable Categories for DetNet (draft-taxonomy-03, section 6)	**Mapping result of TQF**
6.1. Right-bounded category 6.2. **Flow level periodic bounded category** 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	It maps to **Flow level periodic bounded category**, based on the functional characteristics.

Handling Status of All Received Comments

[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!