Timeslot Queueing and Forwarding (TQF)

draft-peng-detnet-packet-timeslot-mechanism-04

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Updates

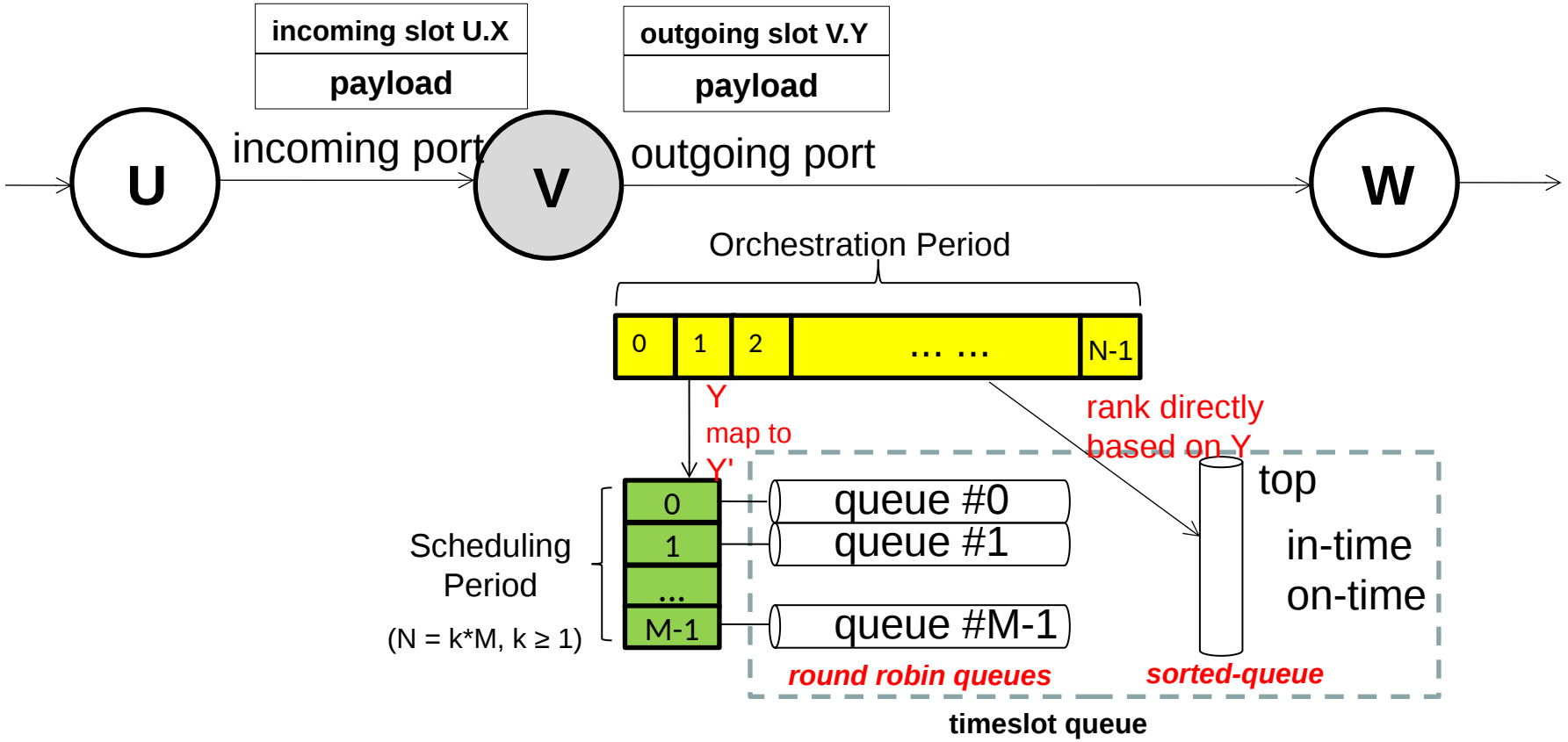
- Supplement PIFO based timeslot scheduling.
- Simplify the timeslot mapping relationship to reduce maintenance and advertisement costs.
- Clarify the forwarding states related with ideal position mantained on the network entry, and the relevant processing based on actual position.
- Fix the latency equation per-hop and E2E.
- Supplement in-time scheduling mode.
- Update the evaluation table.
- Supplement security considerations..

Motivations

- TSN TAS introduces a synchronous TDM method based on gate control list (GCL) rotation cycle (i.e., gating cycle) in Ethernet LAN.
  - The basic idea is to calculate when the packets of the Scheduled Traffic arrive at a certain node, then the node will turn on the green light for it.
  - A gating cycle contains multiple varialbe length timeslots each for specific flow(s). Here, the timeslot is different with the time frame such as SONET/SDH implemented in L1.
  - However, TAS requires time synchronization and has **scalability issues** on GCL calculation, update and installation.

- To meet the large scaling requirements, this document enhance TAS to **introduce timeslot resources to layer-3 and related timeslot scheduling on DetNet Data Plane**.
  - It belongs to TSN mechanism **category “PERIODIC SCHEDULING”**.

Overview of TQF Mechanism

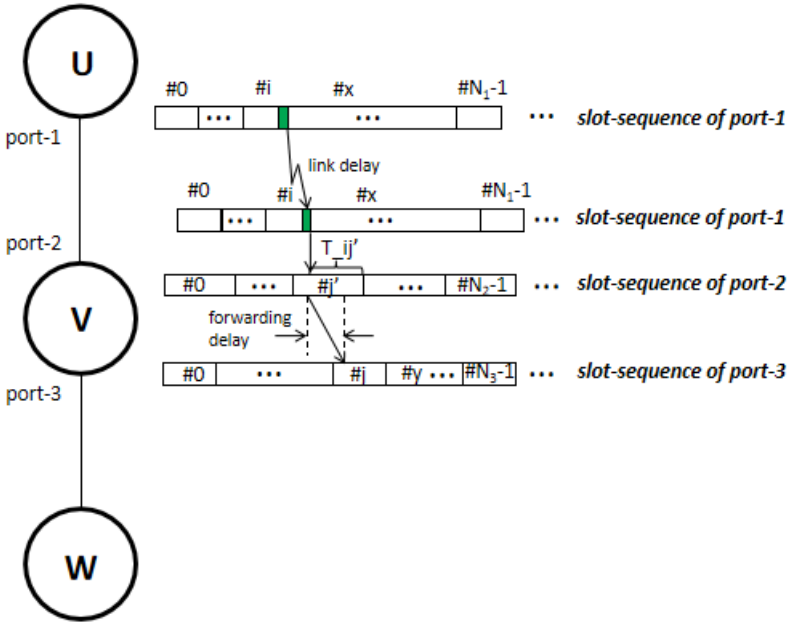


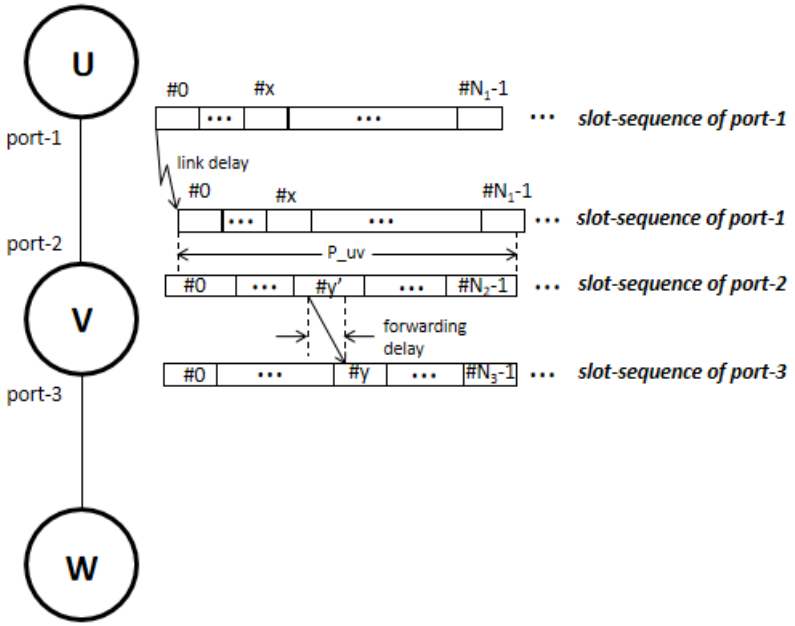
- Decouple the Orchestration Period from the Scheduling Period.
  - **Orchestration Period** includes timeslot resources, euqals to LCM of service burst interval;
  - **Scheduling Period** matches the actual capacity of the device, requiring only a few RR queues or a single sorted-queue.
    - All RR queues have equivalent binary semantic Open/Closed, no other semantics.
- Path calculation based on timeslot resource reservation. Obtain a flexible mapping relationship between the incoming and outgoing timeslots on each node.

Basic Timeslot Mapping (BTM) Between Adjacent Nodes

only signal this few states.

- For an unidirectional link, we may detect a single timeslot maping relationship: “the outgoing timeslot of local node’s outgoing port” -> “the ongoing sending timeslot of downstream node’s incoming port”.
  - Or, may detect the orchestration period offset relationship between adjacent nodes.





- Based on the above detection, we dan deduce trivial BTM: “any outgoing timeslot X of local node’s outgoing port” -> “the ongoing sending timeslot Y of downstream node’s outgoing port”, for the purpose of resource reservation later.

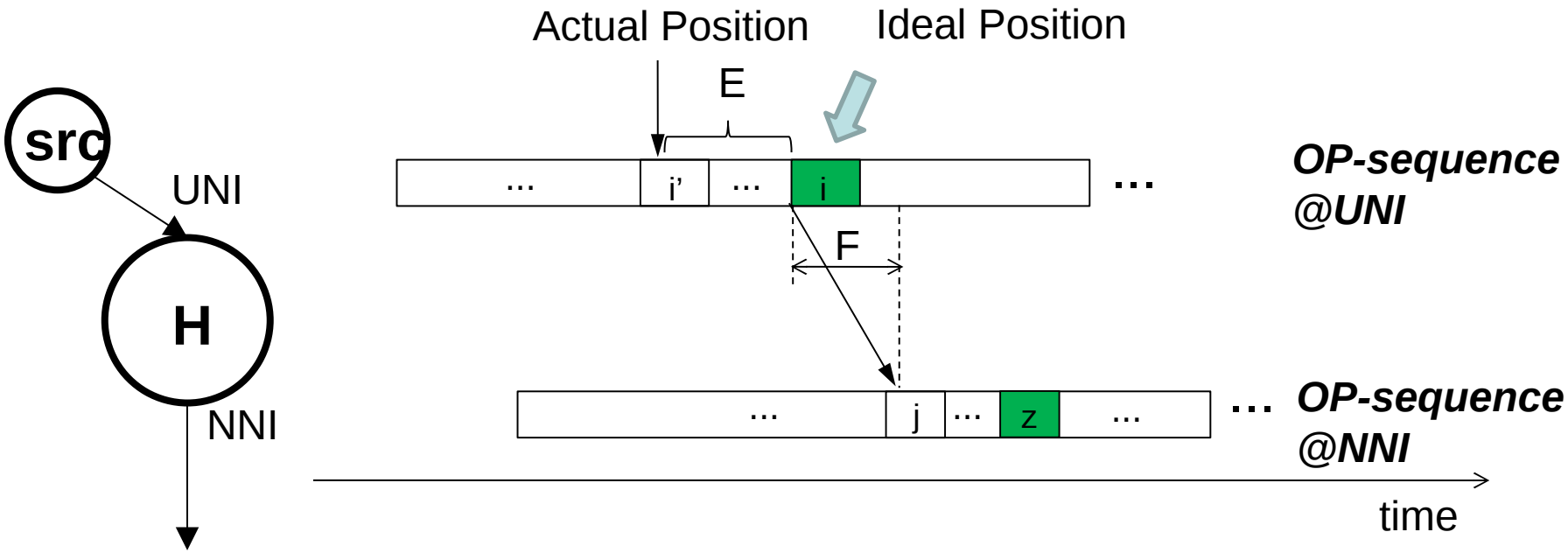
States Related with Ideal Position on the Network Entry

- On the network enry, for each regulated sub-burst of specific flow, the reserved outgoing timeslot of NNI port is based on the ideal incoming timeslot of UNI port.
  - e.g, sates for the flow:

    <OPL, incoming slot i_1, outgoing slot z_1>;

    ... ...

    <OPL, incoming slot i_n, outgoing slot z_n>
  - The network entry should take the closet ideal incoming slot based on the actual position of the regulated packet.



PIFO Based Scheduling

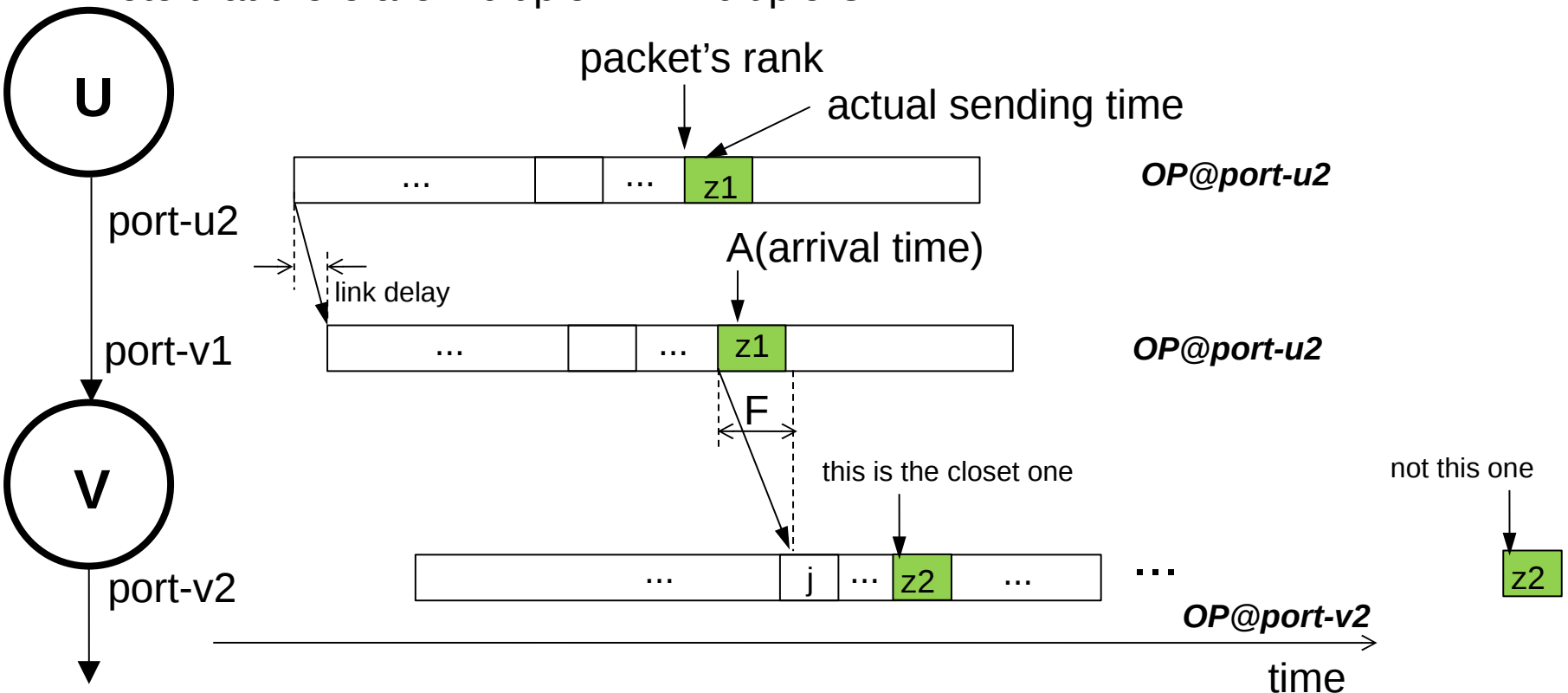
- On-time scheduling mode for low jitter

  In the case of on-time mode, packets should only be permitted to send at the begining of the reserved ougoing timeslot Z. So:

  packet's rank = Z.begin

  where, Z is the one closest to the arrival time.

  Note that there are multiple Z in multiple OP.

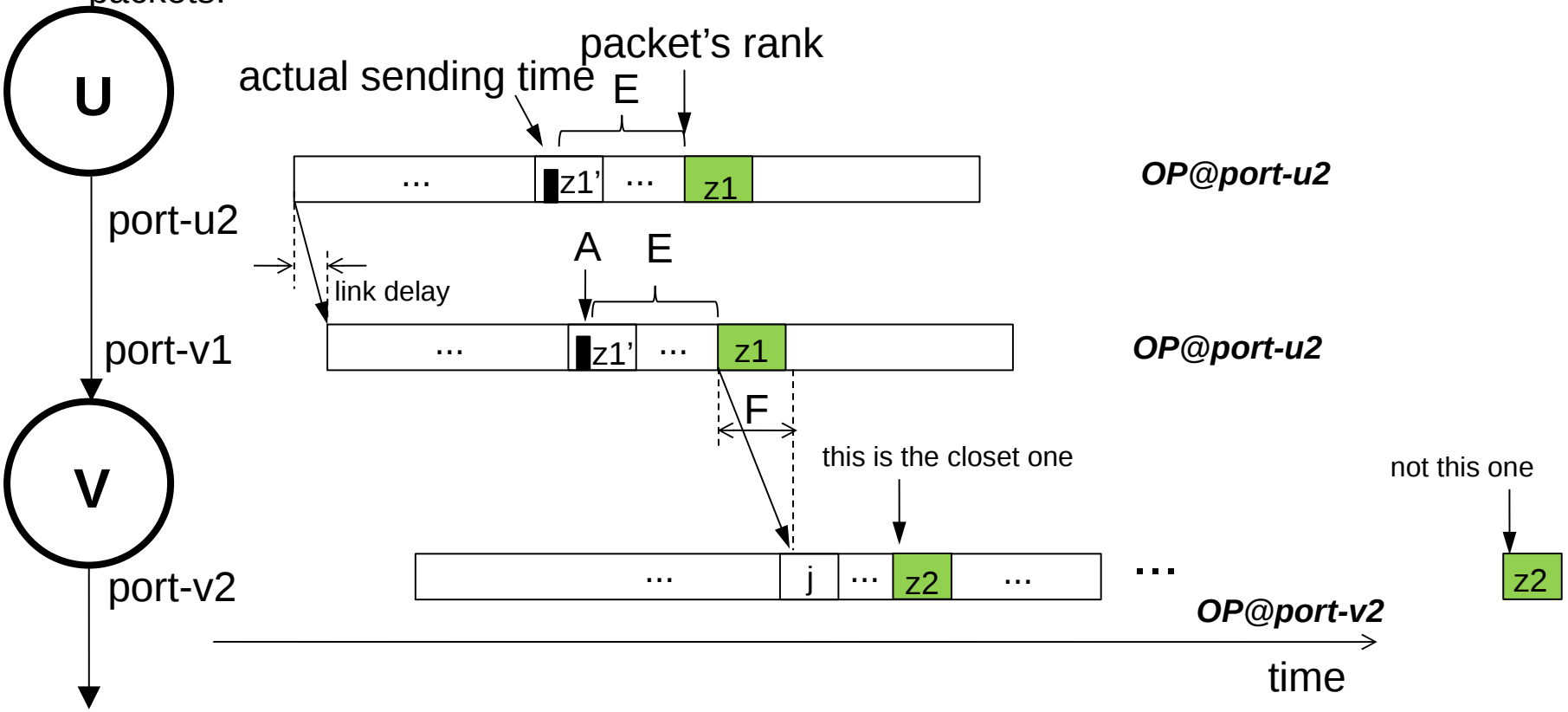


- In-time scheduling mode for low delay

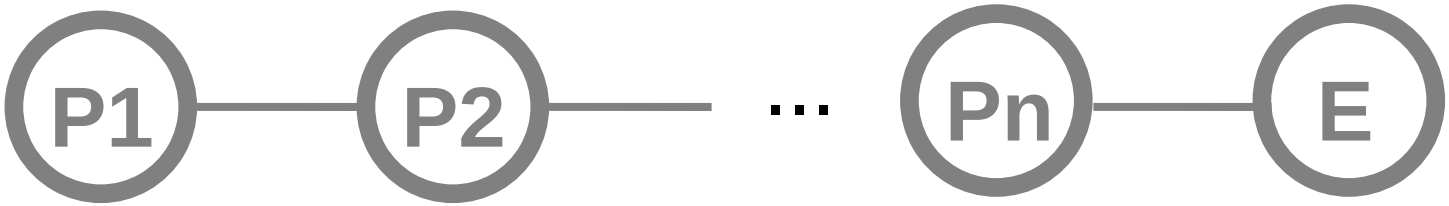
  In the case of in-time mode, packets may be sent before the begining of the reserved ougoing timeslot Z. So:

  packet's rank = Z.begin

  where, Z is the one closest to the "arrival time plus E". E should be carried in the packets.



E2E Latency Equatation



F: intra-node forwarding delay
T: remaining time of the ongoing sending timeslot
o: offset between the outgoing and ongoing timeslot
TL: tmeslot length

- Best E2E latency (liner with hops)

  $\sum_{1 \le i \le n}(F\_i+T\_i+o\_i*TL\_i) \; - \; TL\_n + F\_e$

  It occurs when the packet arrived at the end of the ideal incoming timeslot of UNI port and sent at the head of outgoing timeslot of all NNI port.

- Worst E2E latency (liner with hops)

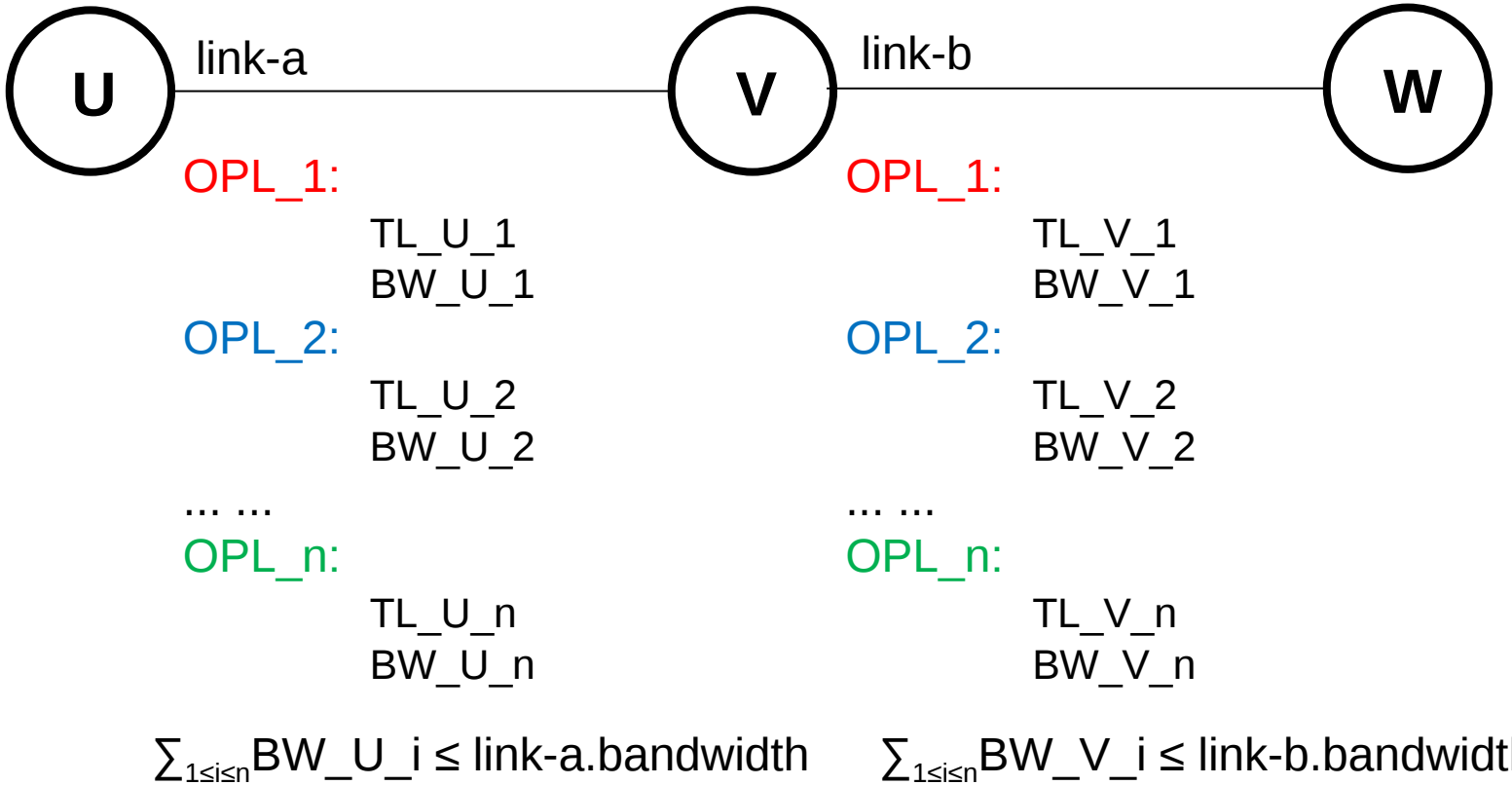
  $\sum_{1 \le i \le n}(F\_i+T\_i+o\_i*TL\_i) \; + TL\_uni + F\_e$

  It occurs when the packet arrived at the head of the ideal incoming timeslot of UNI port and sent at the end of outgoing timeslot of all NNI port.

- Jitter is constant TL_uni + TL_n.

Multiple Orchestration Period Instances

- Multiple orchestration periods may be provided by the network. A TQF enabled link can be configured with multiple TQF scheduling instances each corresponding to specific orchestration period length.
- Interworking between different nodes is based on the same orchestration period instance.



Evaluation

Requirement items	Evaluation	Notes
3.1. Tolerate Time Asynchrony	Yes	No full time synchronization needed, but need frequency sync(3.1.3).
3.2. Support Large Single-hop Propagation Latency	Yes	The timeslot mapping covers any value of link propagation delay.
3.3. Accommodate the Higher Link Speed	Partial	The higher service rate, the more buffer needed for the same timeslot length.
3.4. Be Scalable to The Large Number of Flows and Tolerate High Utilization	Yes	Multiple OPL instance, each for a set of serivce flows, without overprovision. Utilization may reach 100% link bandwidth. The unused bandwidth of the timeslot can be used by best-effot flows. Calculating paths is NP-hard.
3.5. Tolerate Failures of Links or Nodes and Topology Changes	N/A	No relationship with queueing mechanism...
3.6. Prevent Flow Fluctuation	Yes	Flows are permitted based on timeslot reservation, isolated from each other through timeslots.
3.7. Be scalable to a Large Number of Hops with Complex Topology	Yes	E2E latency is liner with hops , from ultra-low to low latency by multiple OPL. E2E jitter is low by on-time mode. Calculating paths may be NP-hard.
3.8 Support Multi-Mechanisms in Single Domain and Multi-Domains	N/A	No relationship with queueing mechanism...

Next step

- The content is basically mature and detailed for implementation, and we would like to request WG adoption.
- Any questions/comments ?

Thank you!