Segment Routing (SR) Based Bounded Latency

draft-chen-detnet-sr-based-bounded-latency-00

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Motivation

- Achieving end-to-end bounded latency is one of the goals of DetNet.
- Time-based scheduling is one of the ways to achieve bounded latency and zero congestion loss.
    - It can provide fine grained and accurate latency control.
- Segment Routing is a source routing technology without per-flow states m aintained at intermediate nodes;
    - Scale to large number of flows;
- This draft combines Segment Routing and Time-based scheduling to imple ment bounded latency.
    - It can provide **scalable** fine-grained and accurate latency control.
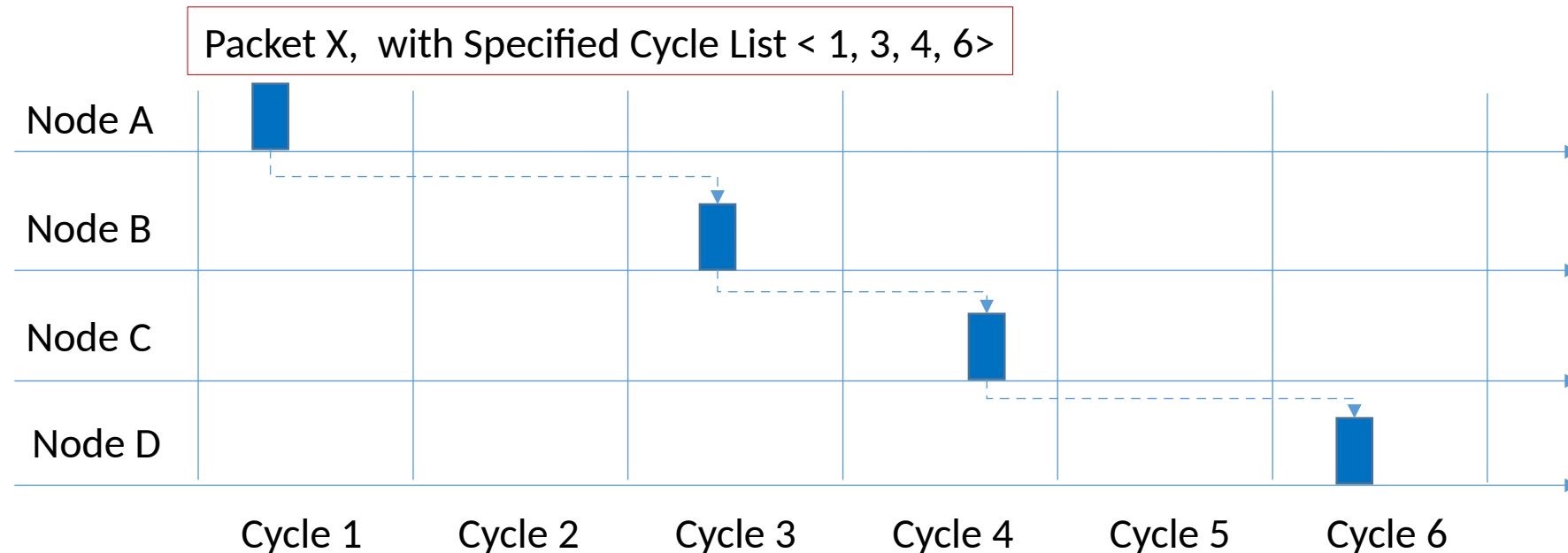
One Example of Time-based QoS: IEEE TSN CQF

- CQF: Cyclic Queuing and Forwarding (802.1Qch)
  - The sending time of an interface is divided into a series of equal time intervals with the duration of T, each time interval is called a "cycle";
  - CQF assumes that a packet is transmitted from an upstream node in a cycle and the packet must be received at the downstream node in the same cycle, and it must be transmitted out in the next cycle to the nexthop downstream node.
  - The critical traffic is transmitted and queued for transmission along a path in a cyclic manner;
  - With above: E2E Jitter <= 2T, E2E Delay <= (N+1) * T, where N is the hops of the path.
  - Suitable for small networks, where link delay is trivial, and processing delay and jitter is small. Otherwise, more bandwidth has to be reserved as a guard band for each cycle, and the effective bandwidth for critical services will be greatly reduced.

Node A

Node B

Node C

Node D

Cycle 1 | Cycle 2 | Cycle 3 | Cycle 4
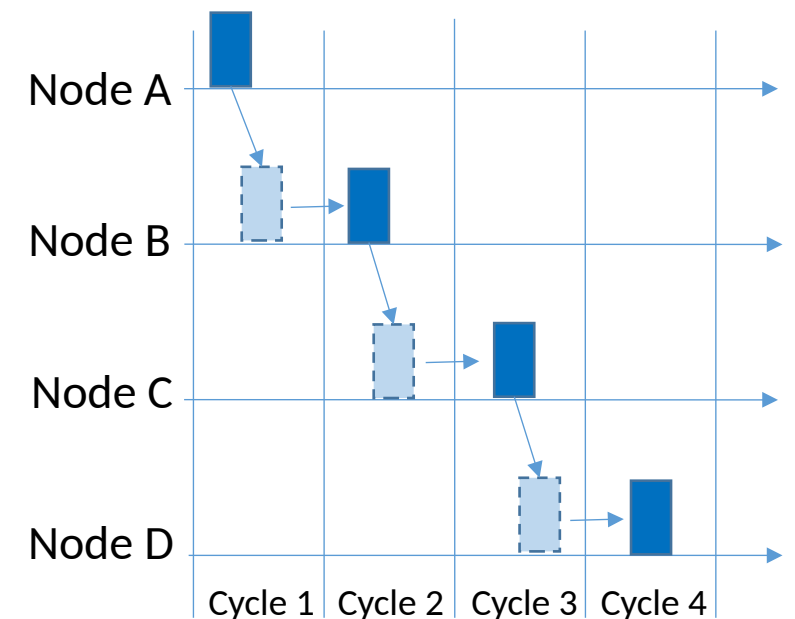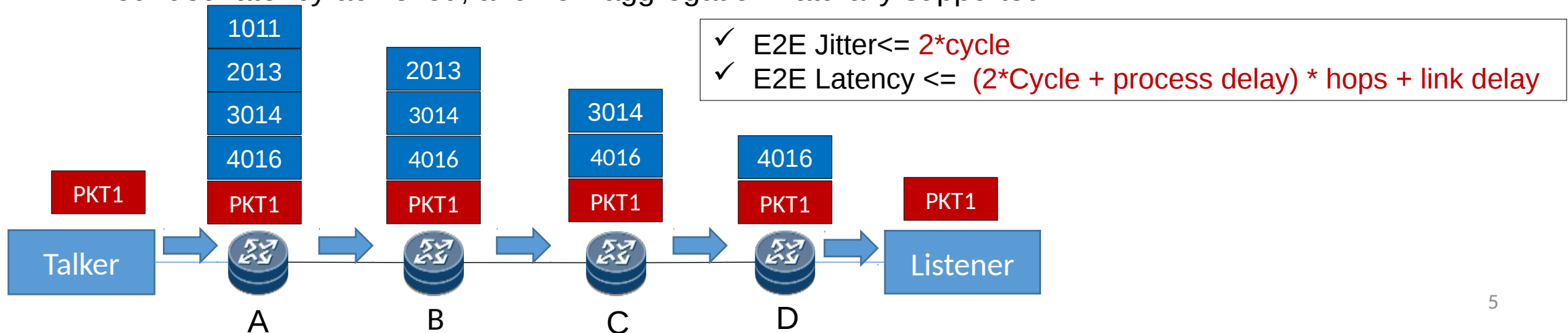
Cycle Specified Queuing and Forwarding(CSQF)

- CSQF improves on CQF by explicitly specifying the sending cycles at every node along the path.

- Relieves the limitation that the sending and receiving have to be done in the same cycle.

- For CSQF, the cycle to use depends on traffic planning and path calculation. The path calculation will consider the available cycle resources, bandwidth, and delay constraints (link delay, processing delay, etc.).

Packet X, with Specified Cycle List < 1, 3, 4, 6>

Node A

Node B

Node C

Node D

Cycle 1   Cycle 2   Cycle 3   Cycle 4   Cycle 5   Cycle 6

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Segment Routing Enables CSQF (SR-CSQF)

- Defines a new segment: Cycle Segment, which has two meanings:
  - Identify an interface/link, just like an adjacency segment; and
  - Identify a cycle of the interface/link.
  - E.g., 1011 identifies cycle 1 of interface 1 at node A, 2013 identifies cycle 3 of interface 1 at node B…
- To specify to which interface and in which cycle a packet should be transmitted, it just needs to attach a Cycle Segment to the packet.
- By attaching a list of Cycle Segments to a packet, it can not only implement the explicit route , but also specify the sending cycle at each node along the path without maintaining per-flow states at the intermediate and egress nodes.
  - Bounded latency achieved, and flow aggregation naturally supported.

1011
2013
3014
4016
PKT1

2013
3014
4016
PKT1

3014
4016
PKT1

4016
PKT1

PKT1

PKT1

✓ E2E Jitter<= 2*cycle
✓ E2E Latency <= (2*Cycle + process delay) * hops + link delay

Talker

A   B   C   D

Listener

Virtual Resource Reservation (VRR)

- An essential component of DetNet is Traffic Engineering (TE)
  - Dedicated resources are reserved for the exclusive use of DetNet flows.
- RSVP-TE/SRP can be used for explicit resources reservation
  - Per-flow states have to be maintained at the intermediate nodes;
- SR-CSQF is based on Segment Routing
  - The time interval allocation/cycle information is embedded in the SIDs;
  - It ensures that a node can schedule different packets without conflict and forward the packets at the proper time interval.
- The resource reservation is implemented and guaranteed by the controller.
  - The controller knows the network topology and available reserved resource for DetNet flows;
  - The controller maintains the status (e.g., cycle occupation) of all "established" flows at each node;
  - The controller decides whether a new flow can be accepted; if so, returns the Cycle Segment list for the new flow.

Next Steps

- Solicit more reviews/comments, refine the draft accordingly.
- Define SR extensions in support of Cycle Segment.
- Consider "SR + non-Time-based QoS" mechanism.

Thanks