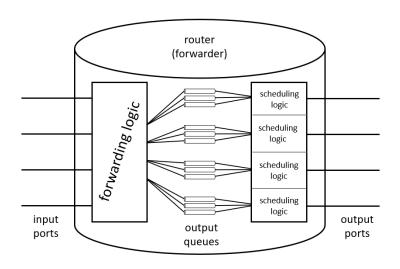
Scheduling is not queuing

DetNet interim
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What does a router (forwarder) do?



Forwarders perform 2 distinct per-packet and per-router* functions:

- Forwarding selecting to which output port a packet should be sent
- Scheduling selecting from which output queue
 the next packet to be forwarded should

be selected

Scheduling is therefore often called called queuing

^{*} They may also perform per-flow **or** per-router functions, which are already handled well enough

How has this changed?

When Segment Routing (or Traffic Engineering) is used forwarding is *more* than simply *selecting* the correct output port It involves *deciding* **where** the packet should be forwarded

When TSN/DetNet is used (i.e., when the network elements are synchronized) scheduling is more than simply selecting from which queue to forward It involves deciding when to send any given packet

Such generalized scheduling may not involve any queues at all Instead, it may employ any mechanism that strives to send each packet at the *right time*

Where in the IETF?

The right time has both control plane and user plane aspects

- control (or management) plane calculate the right time per packet per router
- user (forwarding) plane schedule each packet, optimally before its right time
 and is hop-by-hop and not end-to-end
- Such scheduling is hence unambiguously work for the RTG area and **not** the TSV area
- even disregarding my proposal for combining scheduling with Segment Routing

If not queues - then what?

A single queue is a First In First Out data structure
the packets in a queue are implicitly sorted by time of arrival
Multiple queues add a priority that is independent of time aspects

There are many alternatives to queue data structures, such as

- the stack a Last In First Out data structure
- the sorted list a linear data structure ordered by some field
- the min (max) heap a tree data structure in which every parent node is < (>) its child nodes

In particular, draft-stein-srtsn proposes using

- a stack of local deadlines in each packet
- a sorted list or min heap data structure in the router rather than queues!

What can be done with a non-queue?

There are several *known* ways of using a sorted list or min heap to reduce end-to-end propagation delay, for example :

- Longest In System
 - insert the packet's birth time into the header
 - create sorted list or min heap based on birth times
 - forward packets with earlier birth times before packets with later times
 this is suboptimal since a longer in system packet
 with a loose delay budget
 will be sent before a younger packet with a tight budget
- Earliest Deadline First
 - insert packet's deadline into the header
 - create sorted list or min heap based on deadline
 - forward packets with earlier deadlines before packets with later deadlines this is suboptimal since an EDF packet already be near its destination

will be sent before a later packet far from its destination

What is stack-based scheduling?

With the stack-based approach

- insert a stack of local deadlines
 (with an entry for each router along the path) into the header
- create sorted list or min heap based on local deadline
- forward earlier deadline packets before packets with later times

This method has multiple advantages

- the stack is inserted by the ingress router
 which has its clock sync'ed to all the other routers
 so that the local deadlines are directly comparable
- it can be optimized even for relatively large networks
- its configuration can be easily and rapidly distributed
- new flows can be dynamically added or removed
- it lowers average latency as compared to standard queueing
- ratio of missed deadlines can be tuned

What is **SR**TSN?

If we are already using a stack why not reuse Segment Routing's stack too?

In such case a single joint optimization

- selects a path with appropriate immutable delay
- calculates delay offsets for each router along that path

With SRTSN each time sensitive packet carries a stack with both

- forwarding (segment routing) instructions and
- scheduling (local deadline) instructions
 each stack entry

Summary

With synchronized forwarding elements

- scheduling means releasing packets at the right time
- queues are not optimal data structures for scheduling so scheduling is not queuing
- optimal scheduling involves
 - hop-by-hop and not end-to-end mechanisms
 - a sophisticated control or management plane and is thus unambiguously work for RTG not TSV
- inserting a stack of local deadlines into packet headers conveys multiple advantages
- combining deadline stacks with forwarding stacks is even better

Thanks for listening!

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