
ns-3 Training

A tutorial on the traffic control module in ns-3

June 2018

Objectives of this tutorial

- To provide an overview of traffic control module in ns-3
 - Understand the architecture of traffic control in ns-3
 - Learn different queue disciplines (queue discs or qdiscs)
 - Walk through a simple example
 - Introduce how to write new queue discs in ns-3
 - Learn about writing test cases for new queue discs
 - Introduce AQM Evaluation Suite based on RFC 7928
 - Learn about the ongoing work in traffic control module
- Credits
 - Stefano Avallone (maintainer of traffic control module in ns-3) for sharing his presentation slides.

Outline of the presentation

- Introduction to traffic control layer
- Overview of traffic control layer in ns-3
- Introduction to queue disciplines
- Different types of queue disciplines
- List of queue disciplines in ns-3
- Walk through the example programs
- How to add a new queue disc in ns-3?
- Sample test cases for new queue disc
- Overview of AQM Evaluation Suite for ns-3
- Overview of ongoing work

Introduction to traffic control layer

Introduction to traffic control layer

- Sits between the NetDevices (L2) and network protocol (IP), and intercepts:
 - outgoing packets flowing downwards (IP to NetDevice)
 - incoming packets flowing upwards (NetDevice to IP)
- Processes packets and performs actions such as:
 - scheduling, dropping, marking, policing, etc
- traffic control layer in ns-3:
 - processes outgoing packets only

Overview of traffic control layer in ns-3

Overview of traffic control layer in ns-3

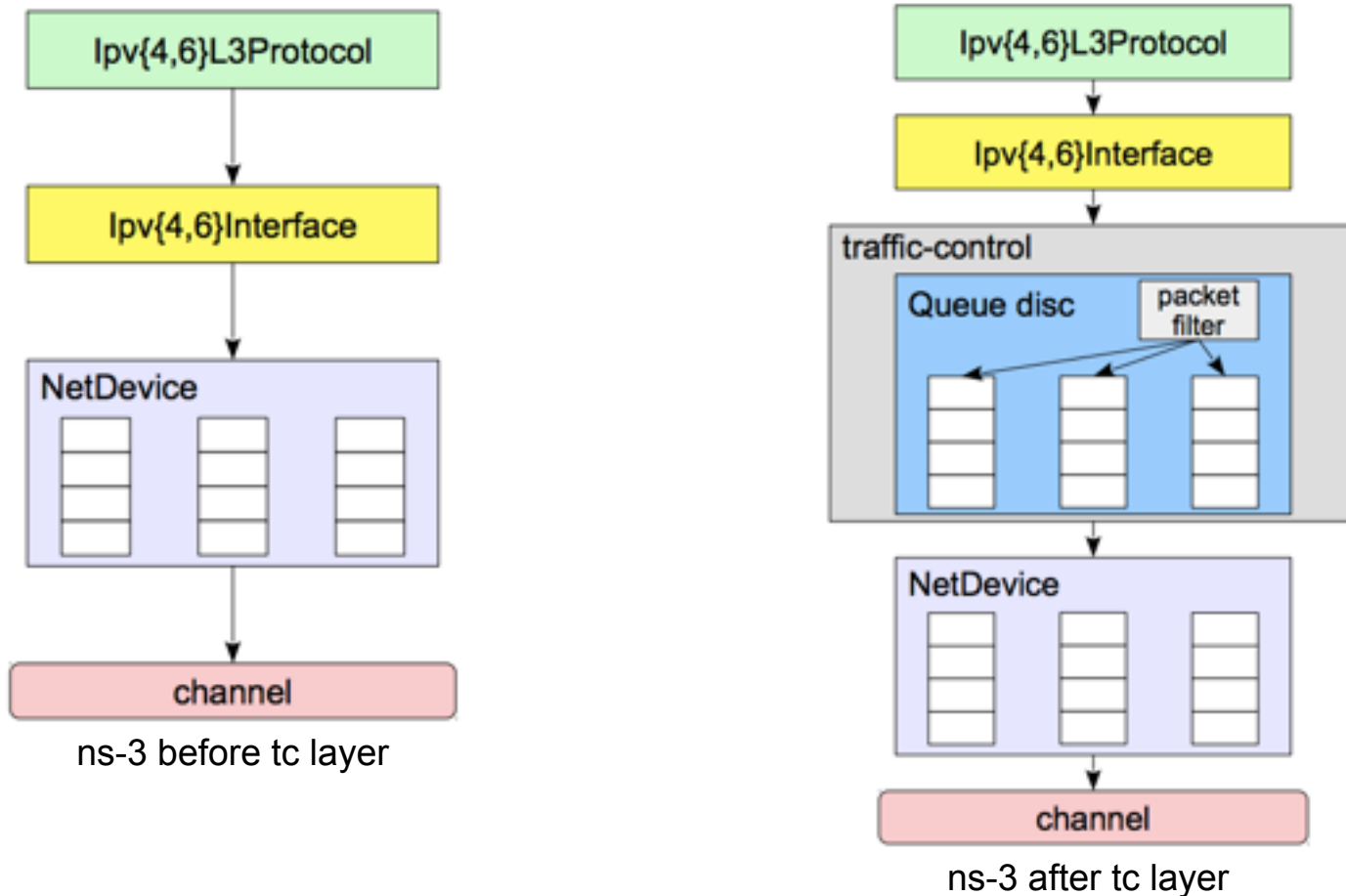


Image source: Stefano Avallone's presentation slides, ns-3 training, June 2017

Overview of traffic control layer in ns-3

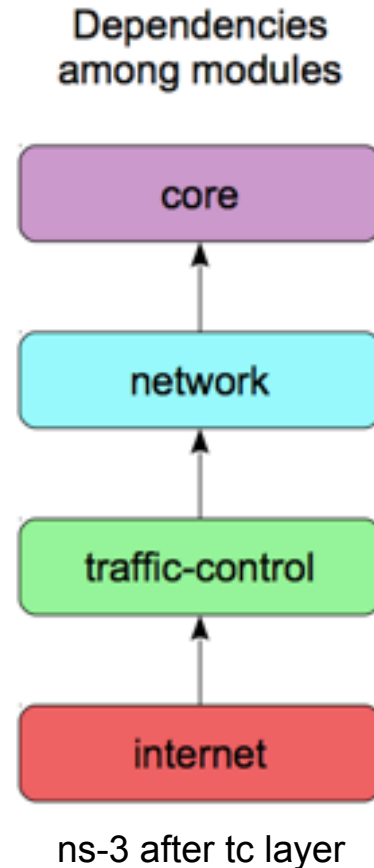
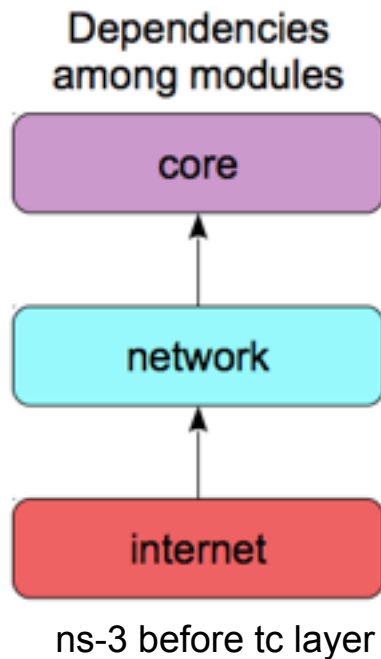


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Overview of traffic control layer in ns-3

- An aggregated object `TrafficControlLayer` is used by IPv{4,6} interfaces to send down the packets, instead of calling `NetDevice::Send()`
- After the packet is processed, `TrafficControlLayer` calls the `Send()` method on the `NetDevice`.
- After enqueueing a packet into one of its queues, the `NetDevice` has to stop the corresponding `NetDeviceQueue` if that queue cannot store another packet
 - by calling `NetDeviceQueue::Stop()`
- After dequeuing a packet from a queue, the `NetDevice` has to wake the corresponding `NetDeviceQueue` if there is room for another packet in that queue
 - by calling `NetDeviceQueue::WakeUp()`

Overview of traffic control layer in ns-3

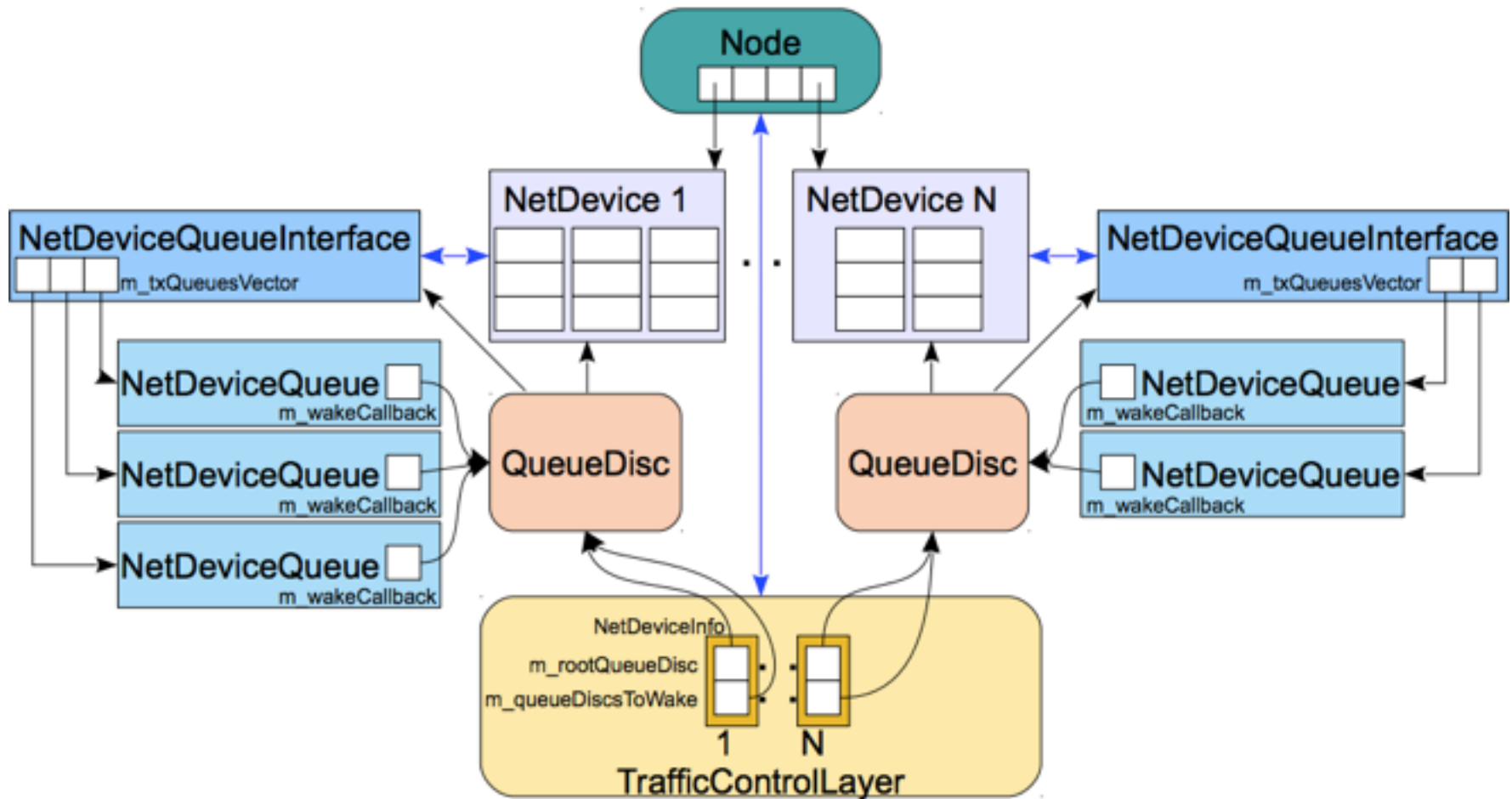


Image source: Stefano Avallone's presentation slides, ns-3 training, June 2017

Introduction to queue disciplines

Introduction to queue disciplines

- ns-3 term: queue discs, Linux term: qdiscs
- Packets received by the Traffic Control Layer for transmission to a NetDevice can be passed to a queue disc to perform scheduling and policing.
- A NetDevice can have a single root queue disc installed
- Not mandatory to install a queue disc on NetDevice (e.g., loopback NetDevice).
- If a NetDevice does not have a queue disc, traffic control layer sends packets directly to the NetDevice.
- A queue disc may contain: queues, classes, filters

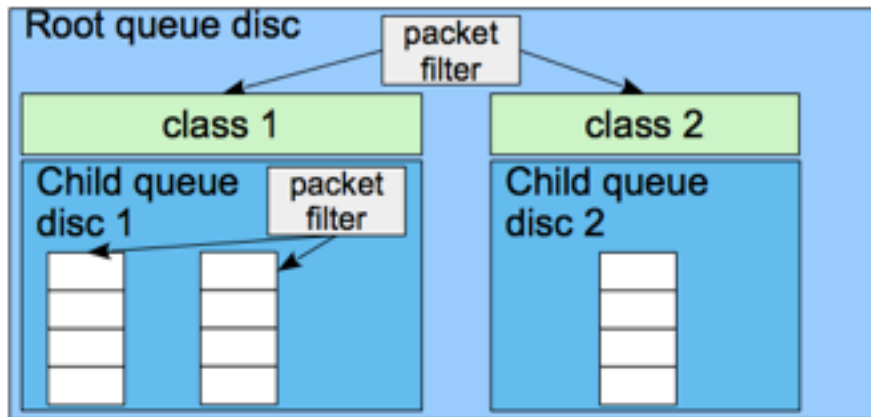
Introduction to queue disciplines

- Traffic control layer requests the queue disc to enqueue a packet, and then run i.e., to dequeue a pre-determined number of packets or dequeue packets until the NetDevice stops the queue disc.
- NetDevice shall wake the queue disc when it detects that there is room for another packet in its transmission queue.
- Waking a queue disc is equivalent to make it run.
- Every queue disc collects stats about the total number of packets / bytes received, dropped, queued and sent.
- Separate counters are kept for each possible reason to drop a packet e.g., drop due to queue full.
- SoJournTime trace source is available.

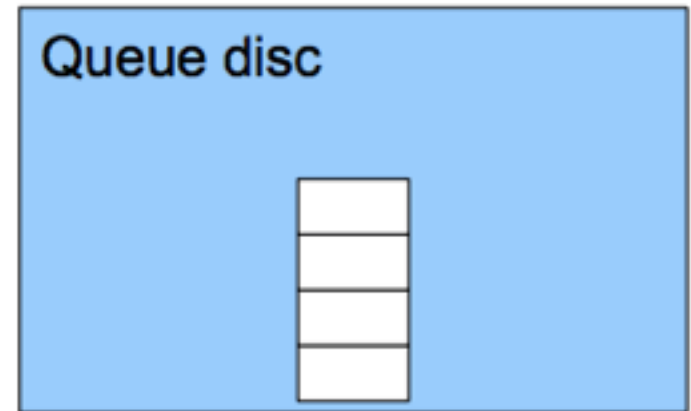
Different types of queue disciplines

Different types of queue disciplines

- Classful queue discs, Classless queue discs, Multi-queue aware queue discs
- Classful queue discs have: a root queue disc and child queue discs



Classful



Classless

Image source: Stefano Avallone's presentation slides, ns-3 training, June 2017

List of queue disciplines in ns-3

List of queue disciplines in ns-3

- pfifo_fast (*default*)
- FIFO
- Token Bucket Fliter (TBF)
- Random Early Detection (RED)
- Adaptive Random Early Detection (ARED)
- Non Linear Random Early Detection (NLRED)
- Feng's Adaptive RED
- Controlled Delay (CoDel)
- Fair Queue CoDel (FQ-CoDel)
- Proportional Integral controller Enhanced (PIE)
- Multi-queue aware queue disc (MQ)

Walk through the example programs:

`examples/traffic-control/`

and

`src/traffic-control/examples`

How to add a new queue disc in ns-3?

Steps to add a new queue disc in ns-3

1. Create new-queue-disc.{h,cc} files for the new queue disc in src/traffic-control/model/
2. Create a class for new queue disc, which is inherited from QueueDisc
3. Some of the following methods may require a specific implementation for the new queue disc:
 - DoEnqueue
 - DoDequeue
 - InitializeParams
4. Make necessary modifications in src/traffic-control/wscript
5. Configure and build ns-3 (resolve errors, if any)
6. Setup an example program for this extension (or use an existing one).
7. Write tests and update the documentation in src/traffic-control/doc/

Sample test cases for new queue disc

Sample test cases for new TCP extension

1. Some of the following test cases are very commonly used across different queue discs
 - Enqueue
 - Dequeue
 - Setting of attributes
 - Byte mode / packet mode functionality
2. Some queue discs need exclusive test cases, such as in the case of FQ-CoDel
 - the working of internal classifier
3. ECN functionality on queue discs can be tested too
 - marking an already marked packet

Presentation on AQM Evaluation Suite

Presented at WNS3-2017

Overview of the ongoing work

Ongoing work

SFQ
DRR

BLUE
PI
REM

DualQ Coupled AQM

ECN Support
for
all queue discs

Thank you!