Assessing the Threats Targeting Low Latency Traffic: The case of L4S

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Context: New network requirements

- Low latency (LL) deployment becomes a hot topic, with strong latency requirements. Target e2e latency:
  - $\approx$ 1ms for Factory 4.0 and haptic Internet
- We chose to focus on L4S, an architecture actively discussed at the IETF
- What an attacker can do to harm LL requirements?
  - Some vulnerabilites have been found in precedent work, but how can they be characterized?
- We propose a classification of undesirable flows, and highlight their respective impacts on low latency services
- To that aim, we modified user-space protocols easily to exploit the over-sensitivity of such applications




Low latency: known threats (1/2)

We studied the following undesirable flows and propose to classify them as such:

- **Misbehaving flows**:
  - Protocol manipulations
    e.g.: Hacked ACK [KOT11, SHE05, LAR21], hacked ECN[ELY01, KOT11, LAR20]
  - Abnormal behavior in traffic pattern
    e.g.: Low rate DoS[ZHI20]
- **Unresponsive flows**:
  - Flows not subjected to the congestion control (UDP, VoIP, live streaming ...)
  - Are usually legitimate but can be generated by a malicious user
- **Malformed flows**:
  - Emitting pattern complex to handle
    e.g.: micro-bursts due to radio access point and/or bufferization at different levels in the endpoint's network stack [OLJ20, STE17])

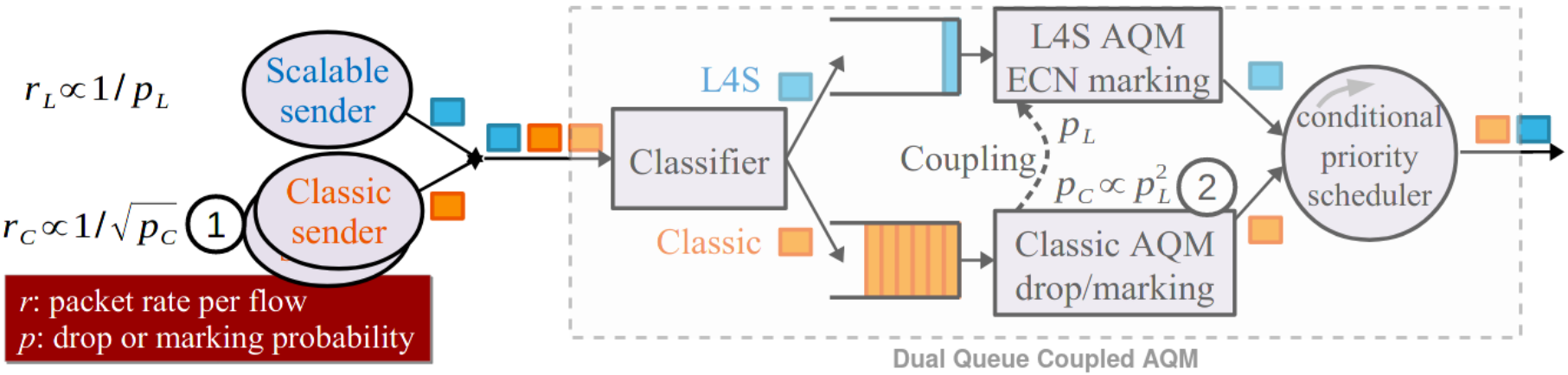
$\Longrightarrow$ Unresponsive flows and Malformed flows are usual on the today's Internet

Low latency: L4S architecture (2/2)

L4S: Low Latency, Low Loss and Scalable throughput

General principle:

- Classic flows (C) and Low Latency flows (L) must coexist
- Latency isolation between (C) flows and (L) flows

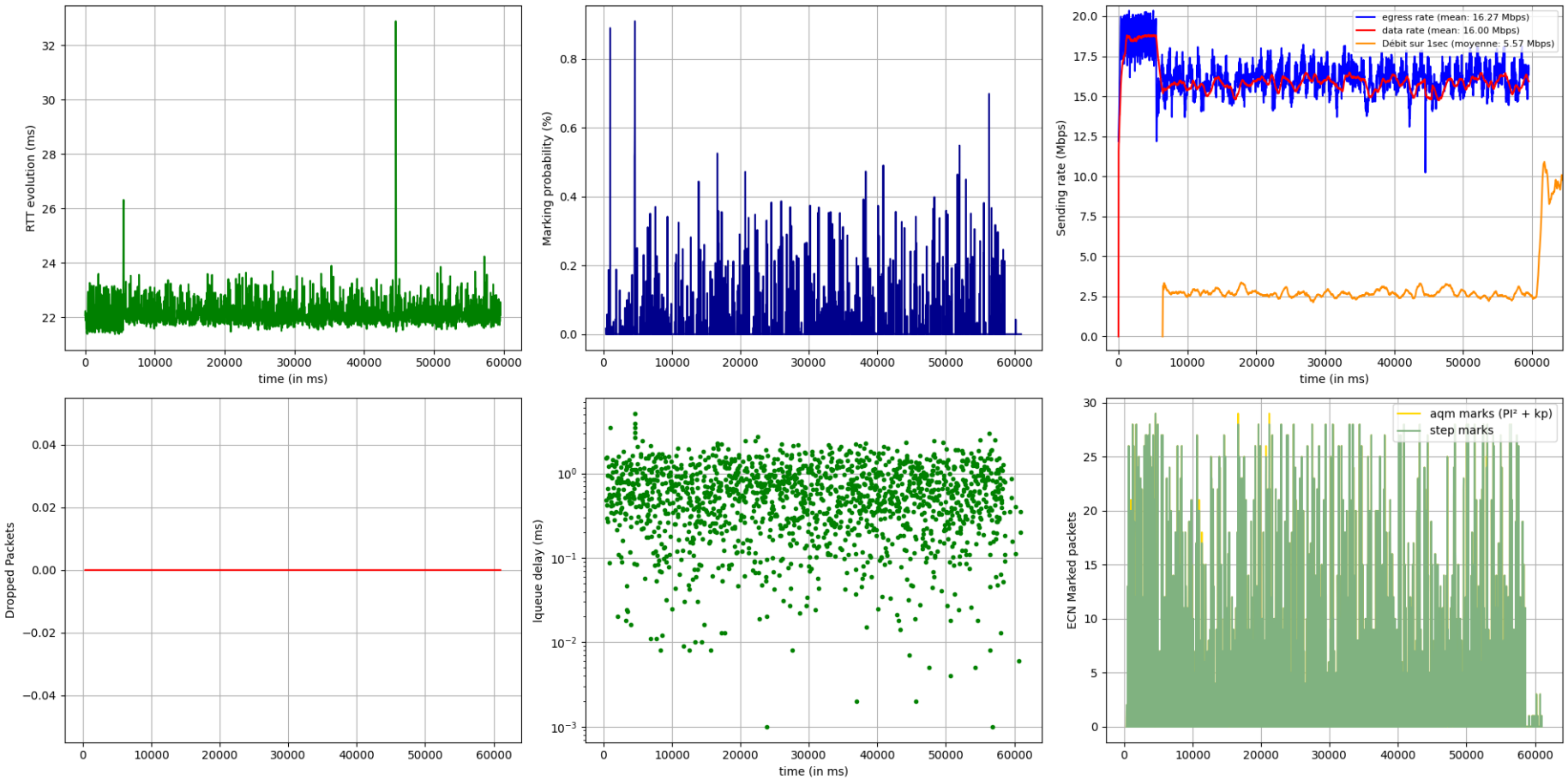


Based on *Implementing the 'Prague Requirements'for Low Latency Low Loss Scalable Throughput (L4S) Netdev 0x13, 2019*

$\Longrightarrow$ The reference implementation of the Dual Queue Coupled AQM is DualPI²

Reference situation

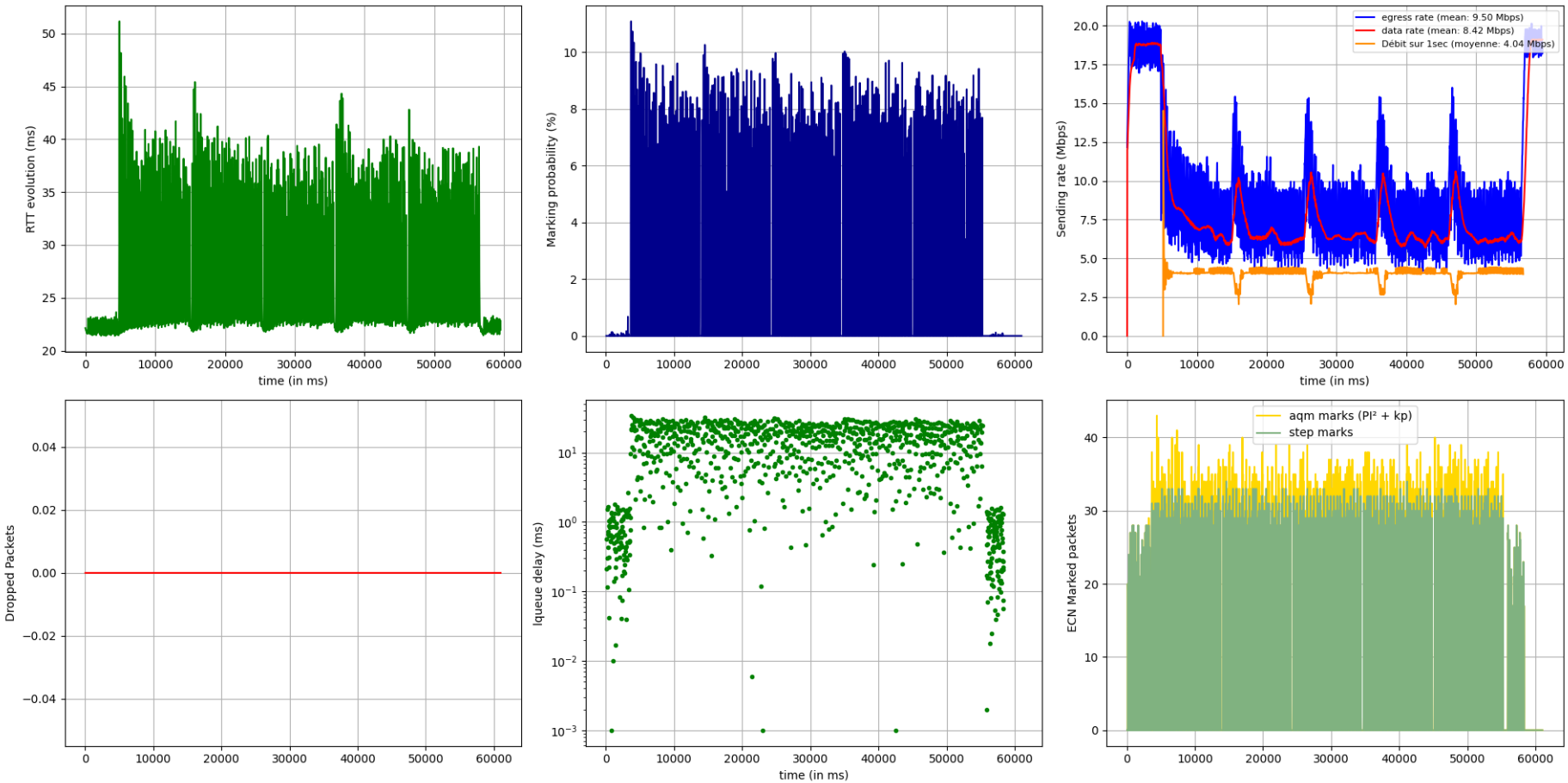
This is the reference situation used as a control sample



Standard behavior of the L4S architecture with one LL and one classic flows.
Horizontal axis is the time in ms.

Undesirable flows comparison: An example

Example of an undesirable flow: connection bursts (loop requesting a 80kO file)



Impacts of connection bursts in (L) queue (AQM Rate: 20 Mbps, Size of file requested 80ko)

Conclusion

- The L4S architecture is promising but still needs security enforcements to protect the LL requirement
- Three main categories of threats have been identified and implemented
- Impacts of each category were evaluated independently but further studies need to be conducted
- Some characteristics are remarkable and statistical analysis lead us to a better understanding of how DualPI2 behaves
- These characteristics may hopefully be reused for detection purpose ...
- ... that is the topic of our ongoing work!

Thank you !

References

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- [SHE05]: *Misbehaving TCP Receivers Can Cause Internet-Wide Congestion Collapse* - ACM Conference on Computer and Communications Security, 2005
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- [ZHI20]: *Low-Rate DoS Attacks, Detection, Defense, and Challenges: A Survey* - IEEE Access, 2020
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- [STE17]: *Destruction Testing: Ultra-Low Delay using Dual Queue Coupled Active Queue Management* - Masters Thesis Univ. Oslo, 2017