Characterization and troubleshooting of cloud gaming applications on mobile networks

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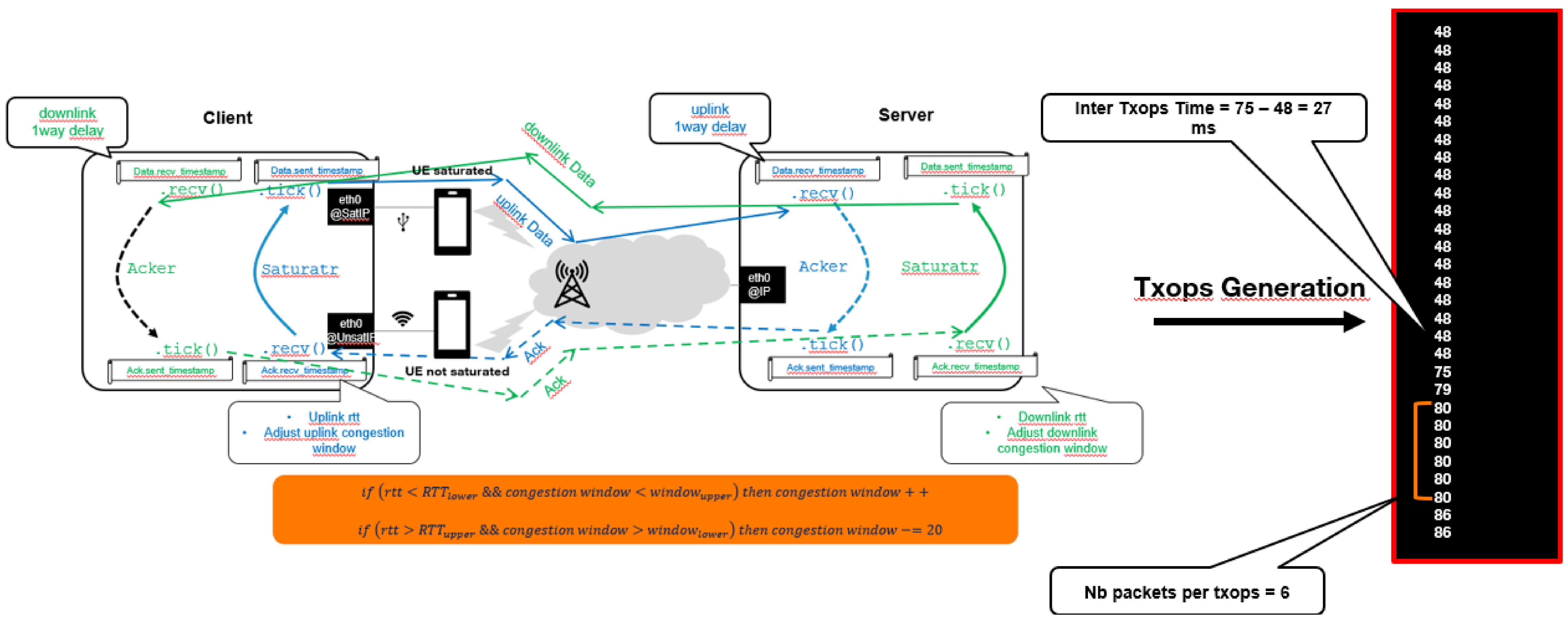
Motivation

Low-latency applications (cloud-gaming, cloud-robotics, metaverse...) have soared with the rapid evolution of Internet.
Current network capacities (especially **time-varying capacity networks** like 4G/5G networks) struggle to ensure user QoE (Quality of Experience).
There is therefore a need to **collect, identify and analyze** metrics specific to low-latency applications in network equipment (switches, base stations, UEs...) for **efficient troubleshooting** of user QoE degradation purposes.

Transmission Opportunities of 4G network

To conduct controlled experiments on time-varying capacity network, we use **Saturatr tool** [1].This experiment allows, by saturating the network link, to capture different behaviors of 4G base stations for one UE. From those captures, the tool generates **transmission opportunities (txops)** files, one for uplink and one for downlink, which we can use to emulate time-varying network conditions.

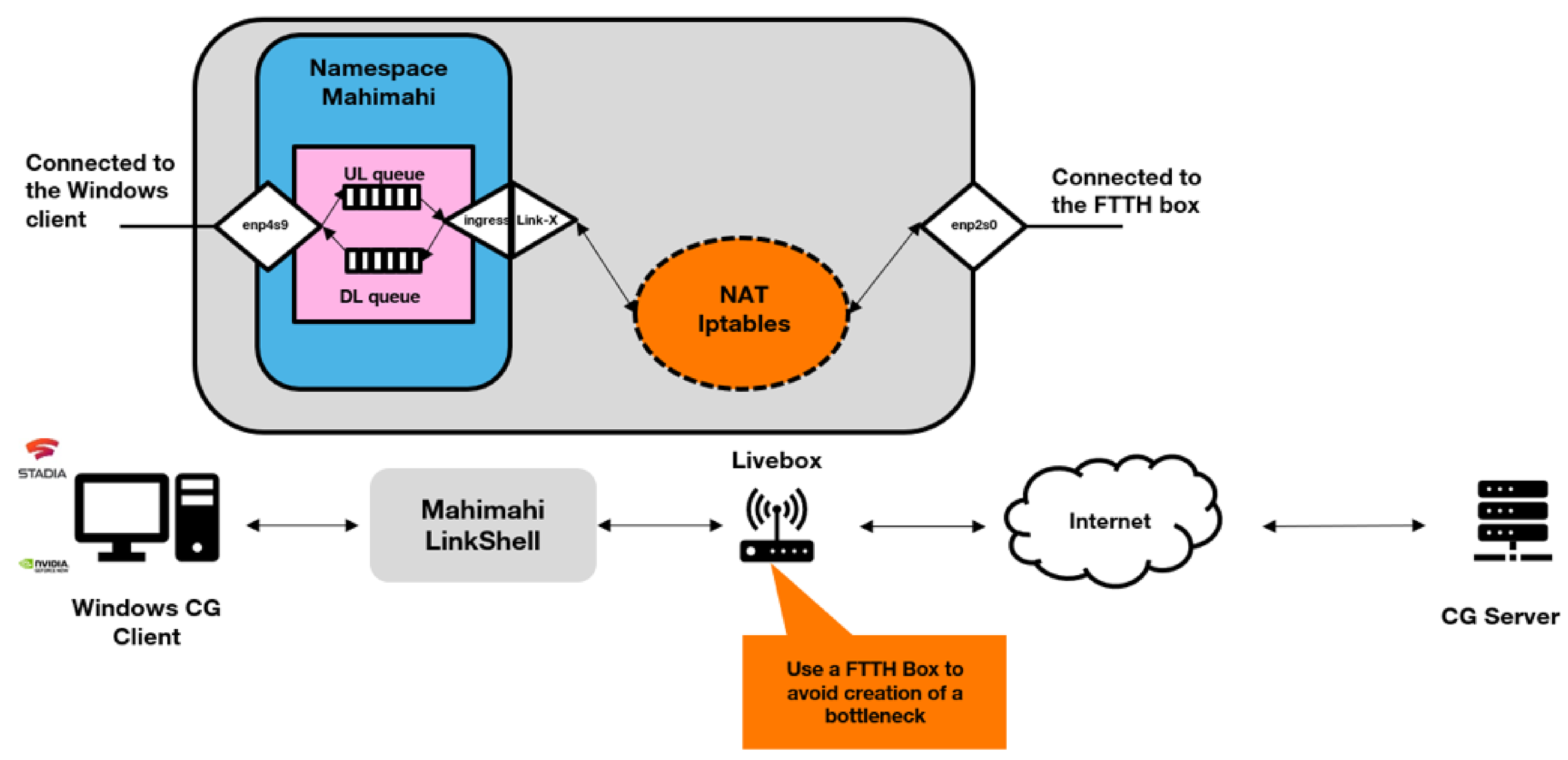
In a given txops file, one line represents a time (in ms) when the base station can send a **MTU-sized packet**.



Usage of txops for cloud gaming

We use the txops files to conduct experiments on cloud gaming applications like Google Stadia, NVIDIA GeForceNow under different emulated 4G network conditions. For this purpose, we use the **LinkShell tool** from the framework **Mahimahi** [2].

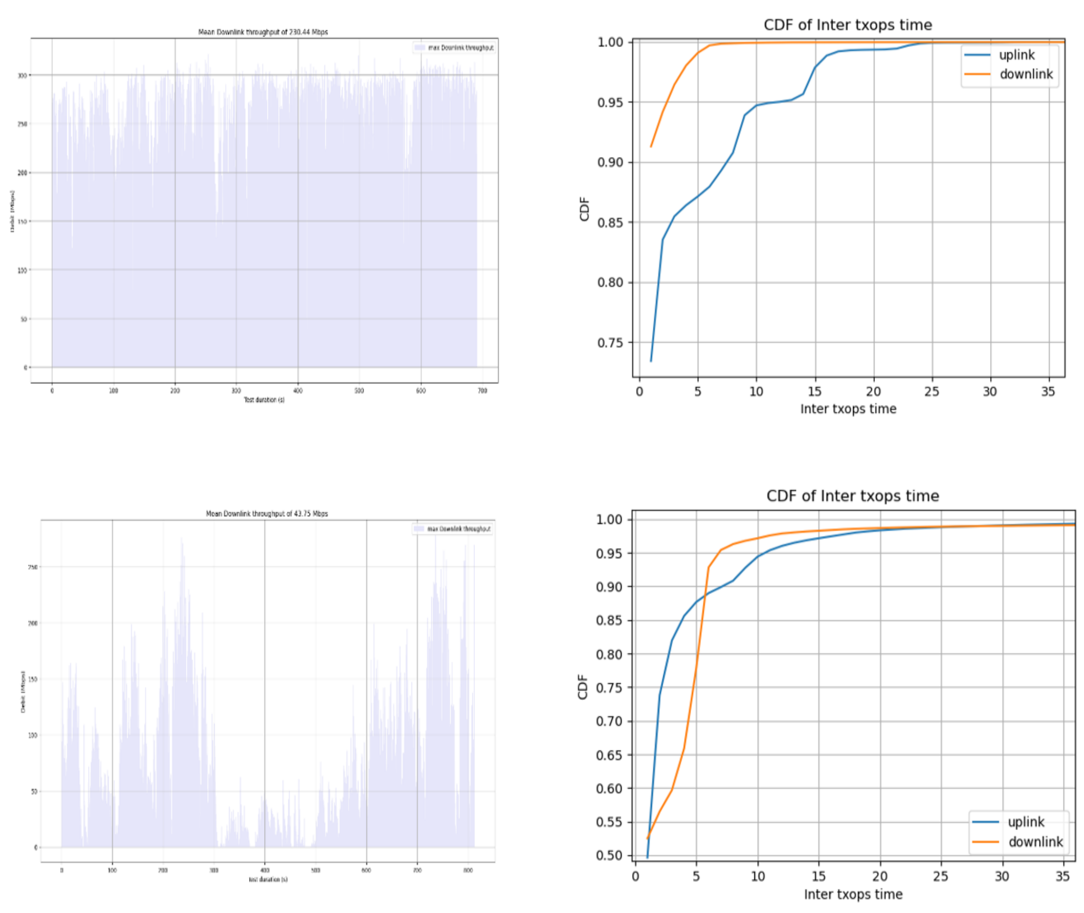
We collect metrics from Google WebRTC API (client delay, network RTT, frame rate, bit-rate...) and traffic traces from Wireshark to analyze the cloud gaming applications behaviors under time-varying capacity networks.



Txops Generation

We captured 06 different configurations, 05 static conditions and one on a highway at the steady speed of 110km/h, on Orange 4G network in France. These configurations lead to txops files that differ by the average throughput, the frequency and the importance of the txops.

Conditions	Throughput (Mbps)	Location
File 1	220	Orange
File 2	160	Orange
File 3	120	Brélévenez
File 4	80	Brélévenez
File 5	40	Plemeur-Bodou
File 6 (Highway)	45	Guingamp - Lannion



The txops files data are available in **OpenData** at the following link: `https://cloud-gaming-traces.lhs.loria.fr/cellular.html`

References

[1] Keith Winstein. Saturatr tool. `https://github.com/keithw/multisend`.

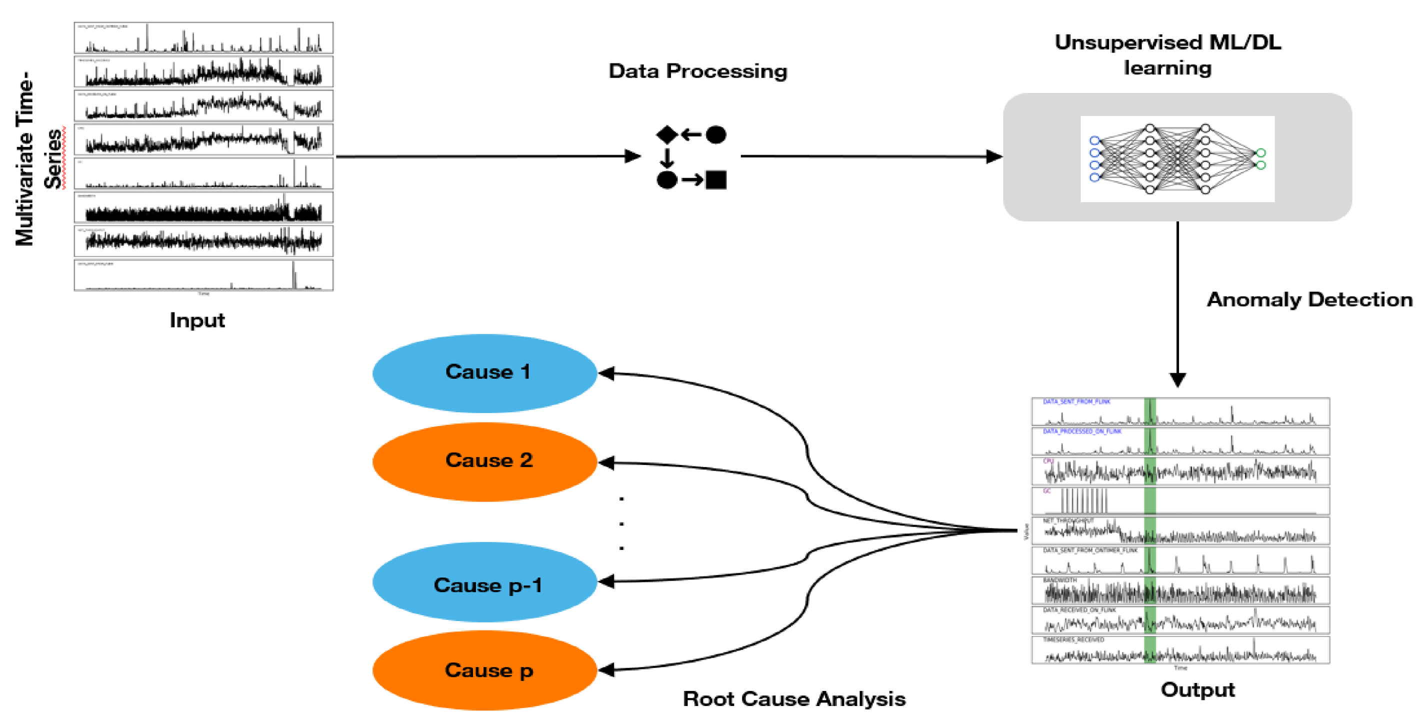
[2] Ravi Netravali. Mahimahi. `https://github.com/ravinet/mahimahi`.

Troubleshooting of cloud gaming applications

Machine learning and/or deep learning **unsupervised learning approaches** for anomaly detection are applied on the data collected, which are **multivariate time-series** KPIs.

Those approaches learn to reconstruct the time-series from *normal* inputs. Then, they are applied on samples and those with high reconstruction errors are identified as **anomalous**.

Once anomalous samples are detected, their causes must be identified based on the input features in order to consider remedial measures.



Acknowledgements

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