QoS Session-Aware SDN Planes for xURLLC Cellular Hybrid Backhauls

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MIT Portugal 2023 Annual Conference

The use of Ultra-Dense Networks within 5G networks is driving the adoption of millimeter-wave technology for backhaul, resulting in cost reductions and faster deployment of the current cellular generation. However, this shift also introduces new challenges and restrictions. The technology's susceptibility to signal strength and link loss degradation due to line-of-sight characteristics can be mitigated by employing software-defined networks. With a hybrid, heterogeneous backhaul network, link management becomes complex. To achieve URLLC standards, this infrastructure controller must be able to provide QoS enforcement to 5G Protocol Data Unit (PDU) session data at the flow level, to deliver contracted services at a very high reliability to the end-user, with path one-way latency at the sub-millisecond range per each hop that traverses on the network.

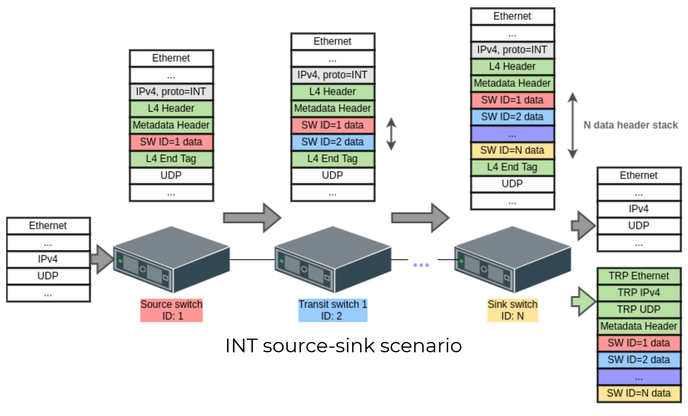
In-Band Telemetry System

The Shim header identifies the protocol and provides packet length. The Telemetry Header defines the common information fields of the end-to-end flow state: the GTP-U Tunnel Endpoint ID, the Qos Flow ID and a transient timestamp.

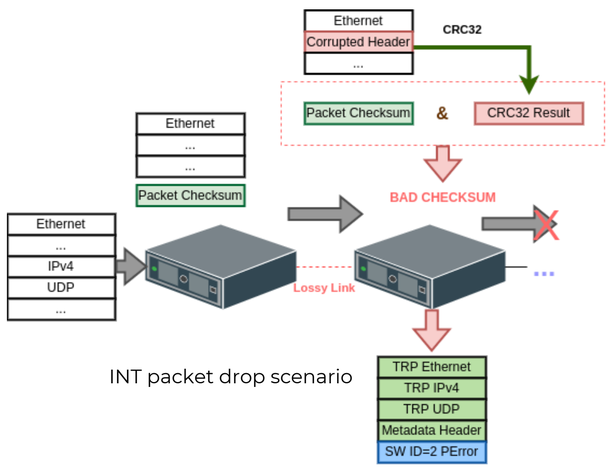
The Telemetry Metadata Stack includes the device path information, which field values are specific to each device that it traverses – the switch ID, egress port, hop delay.

A packet checksum error identified on header parsing will trigger the sending of a drop report type, sent directly to the telemetry aggregator.

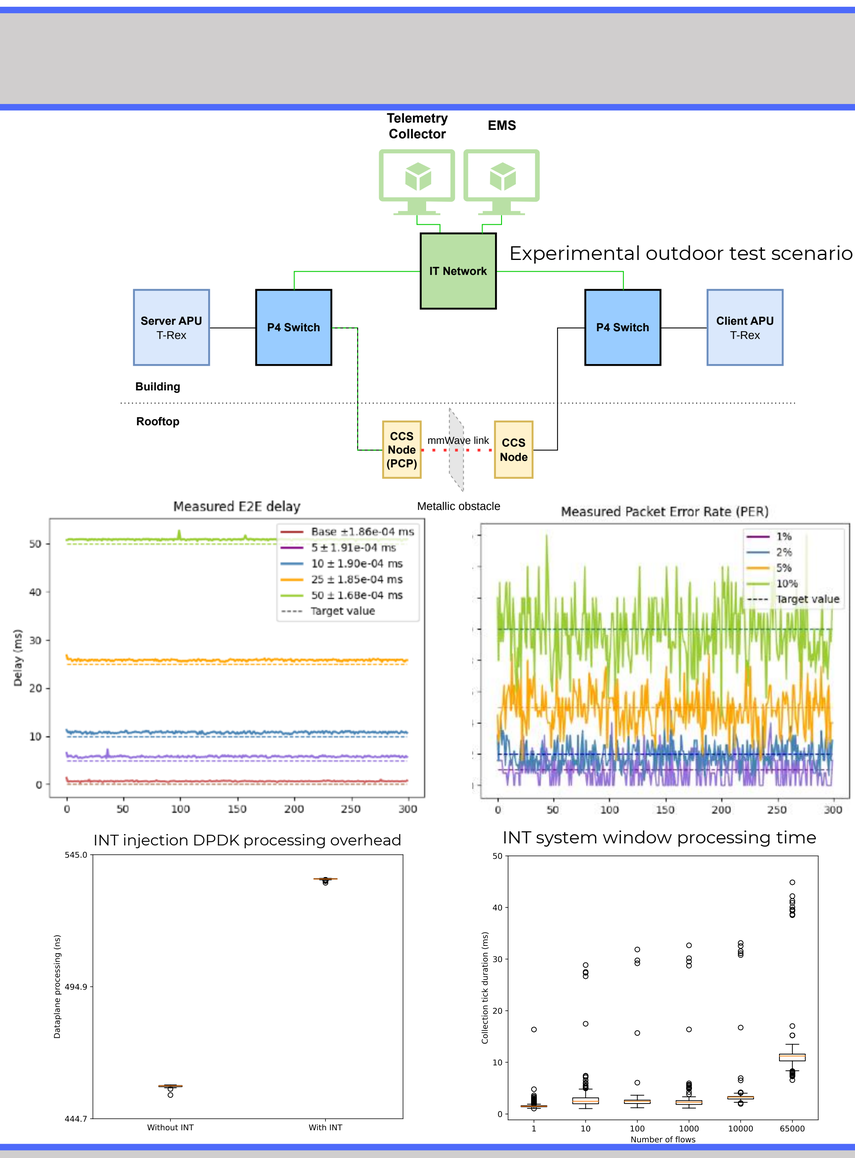
The telemetry aggregator identifies and processes the reports received, indexing per-link (switchID, outPort) and per-flow (Source TLD IP, GTP-U, TEID, QFI), and storing as aggregate of the defined averaging window.



INT source-sink scenario



INT packet drop scenario



Session-Aware Programmable Backhaul for 5G QoS Flows

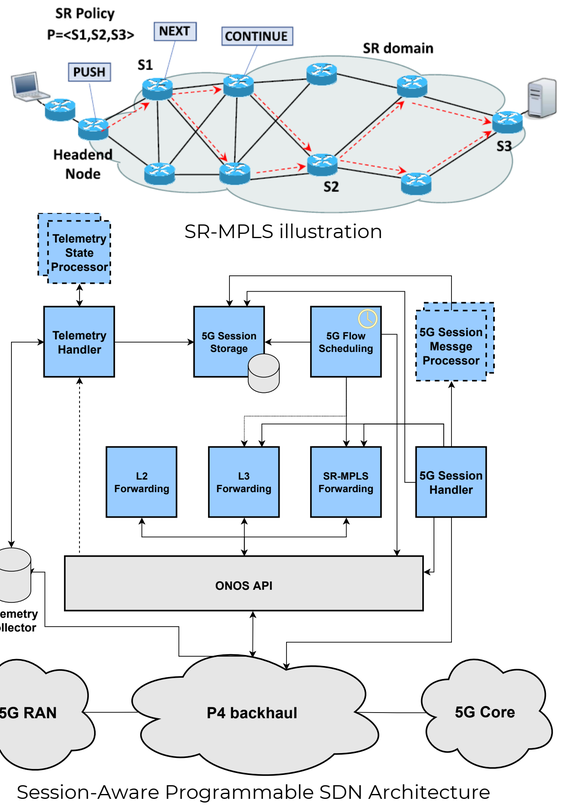
SR-MPLS Forwarding – implementation of Segment Routing (SR)-MPLS protocol. Supports the creation of data flow paths for communication over the N3 interface (between the gNodeB and the UPF), using existing GTP tunnel information that is being exchanged over the cellular architecture from the network 5G Core state N2 protocol interface (NGAP protocol), between the AMF and the gNodeB.

5G Session Handler - processes the user and flow session handling messages from the N2 interface protocol, validates and stores information obtained from PDU session resource messages on a cache map.

Telemetry Handler - middleman between the external collector and the application - it will query the INT system for windowed metrics.

5G Data Flow Scheduling Task - periodic task updating every flow state, computing new paths based on the metrics on the respective telemetry state, and performs a path scheduling algorithm for the current flows.

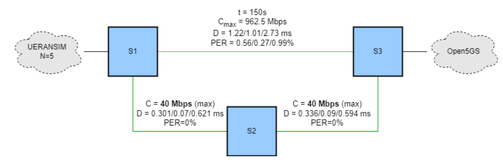
The algoirthm will take current telemetry state for a specific flow and validate QoS contstraint for every flow, over a priority buffer. It will take the best path for each flow and force lower priority flows to be reallocated if it cannot be performed due to any link capacity overflow along the path.



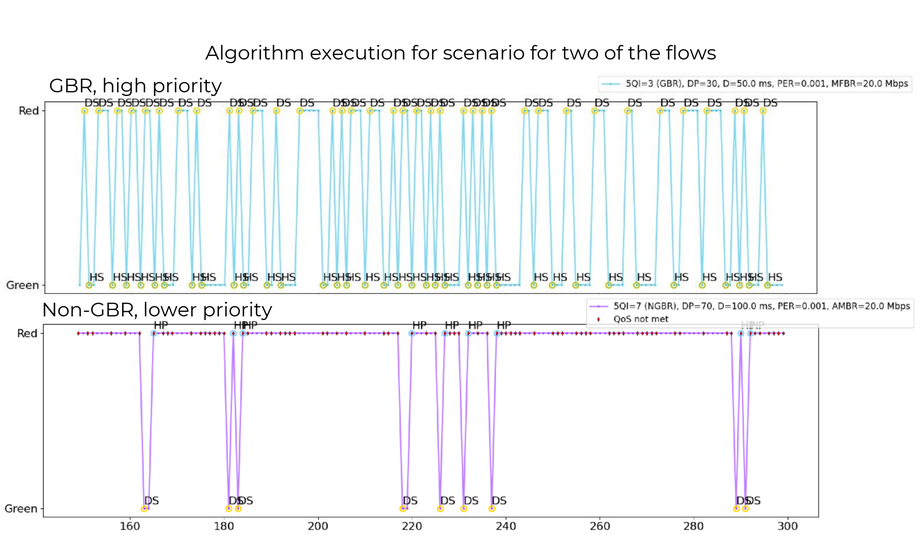
SR-MPLS illustration

Session-Aware Programmable SDN Architecture

High bottleneck testing scenario. Two paths to core network
Five user flows – two GBR. three non-GBR



Algorithm execution for scenario for two of the flows



Co-funded by: This work was financed by the Fundo Europeu de Desenvolvimento Regional (FEDER), through the Programa Operacional Regional do Centro (CENTRO 2020) of Portugal 2020 and by National Public Funds FCT I.P. (OE) [Projeto SNOB- 5G com o no 045929 (CENTRO-01-0247-FEDER-045929)], and by the FCT/MCTES through National Funds and when applicable co-funded EU funds under Project UIDB/50008/2020-UIDP/50008/2020

under the Flagship Project: SNOB5G | Sustainable Cities