

Detecting Issues with In-Band Telemetry in OSM-Orchestrated Core Networks

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Motivation

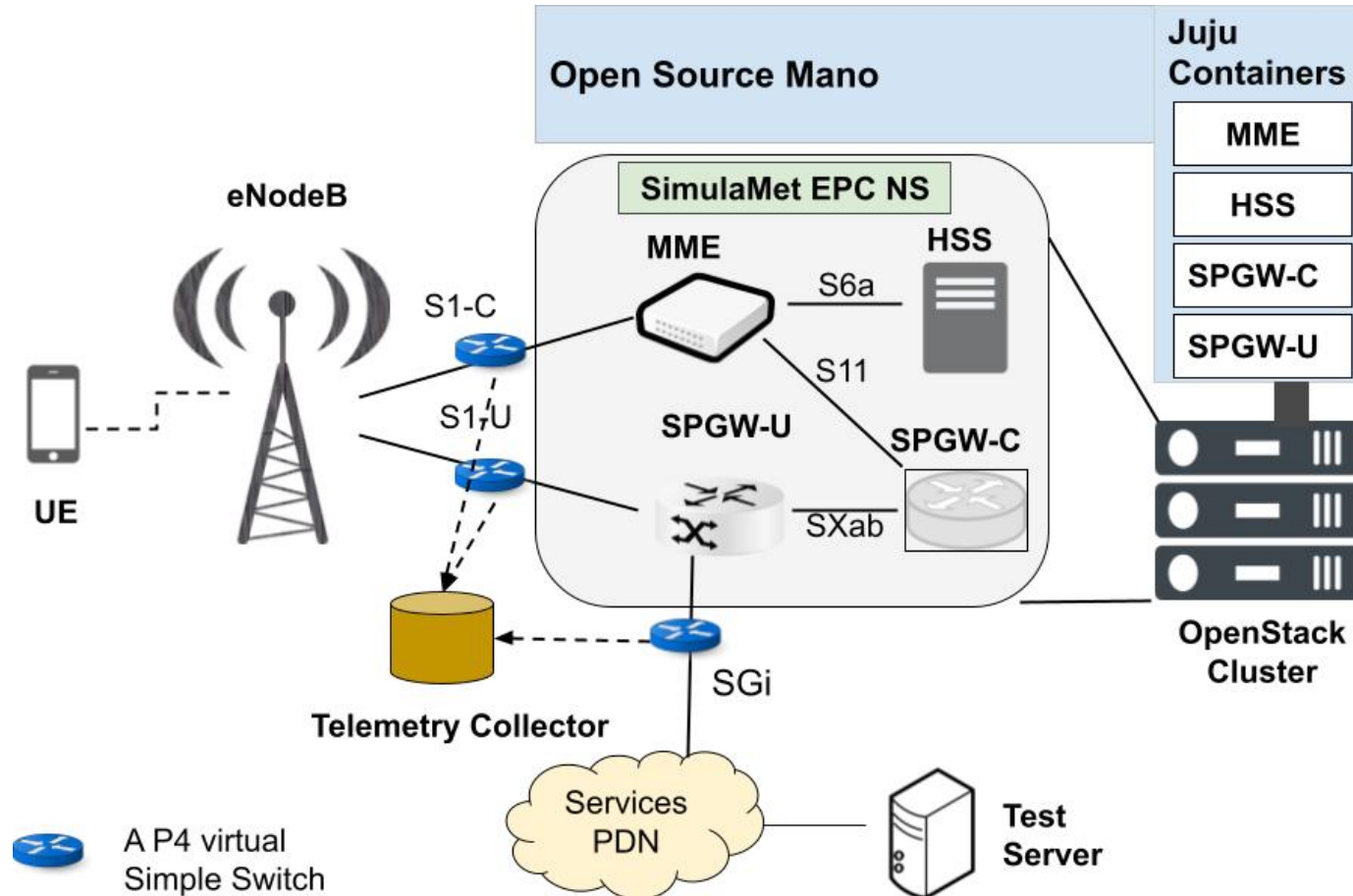
- 4G/5G networks need monitoring:
Detect problems, evaluate performance, etc.
- Basic performance: metrics in OSM, via Juju and NFVI
Useful, but not very fine-granular
- In-Band Telemetry:
 - Fine-granular monitoring at packet level
 - Possibility to add custom information into packets (additional headers, etc.) and process them elsewhere
- Our approach:
 - Usage of Programming Protocol-independent Packet Processors (P4)
 - Custom P4 software switches as VDUs in our testbed

OpenAirInterface (OAI)

- OpenAirInterface (OAI):
 - Open Source software for EPC and eNodeB (i.e. packet core and base stations)
 - Details: <https://www.openairinterface.org>
 - 4G LTE available, 5G under development
 - Ongoing work, with many different Git branches
- Idea:
 - Manage OAI setups in OSM (at least, the EPC part)
 - Automatic setup and deployment
 - Easy to add additional features (e.g. Mobile Edge Computing components)
 - Open Source, of course! → <https://github.com/simula/5gvinni-oai-ns>



Our Testbed Setup



Telemetry at S1-U Switch: Added IPv4 Option Header

```
//Inband Telemetry with IP OPTIONS.....  
hdr.ipv4_option.copyFlag = 1;  
hdr.ipv4_option.optClass = 0;  
hdr.ipv4_option.option= 31;//1 byte  
hdr.ipv4_option.swid = 1; //3 bits  
hdr.ipv4_option.flowid = meta.flowid;  
hdr.ipv4_option.flow_packet_count = (bit<16>) meta.min_count;//2 bytes  
hdr.ipv4_option.packets_in_queue = (bit<8>) var_deq_qdepth;  
hdr.ipv4_option.hitter = meta.marker; //1 bit  
hdr.ipv4_option.queue_timedelta = (bit<26>) var_deq_timedelta;  
hdr.ipv4_option.packet_length= (bit<18>)var_packet_length;  
hdr.ipv4_option.optionLength = 24; //total number of byte
```

Telemetry at S1-U Switch: P4 Program Example

```
control MyDeparser(packet_out packet, in headers hdr) {  
    apply {  
        packet.emit(hdr.ethernet);  
        packet.emit(hdr.ipv4_outer); //modify in the mirrored packet  
        packet.emit(hdr.gre); // add this in mirrored packet  
        packet.emit(hdr.udp_outer); //skip this in mirrored packet  
        packet.emit(hdr.gtp); //skip this in mirrored packet  
        packet.emit(hdr.ipv4_inner); //modify in the mirrored packet  
        packet.emit(hdr.ipv4_option); //add this in the mirrored packet  
        packet.emit(hdr.udp_inner);  
        packet.emit(hdr.tcp_inner);  
    }  
}
```

Logging of Telemetry by the Telemetry Collector

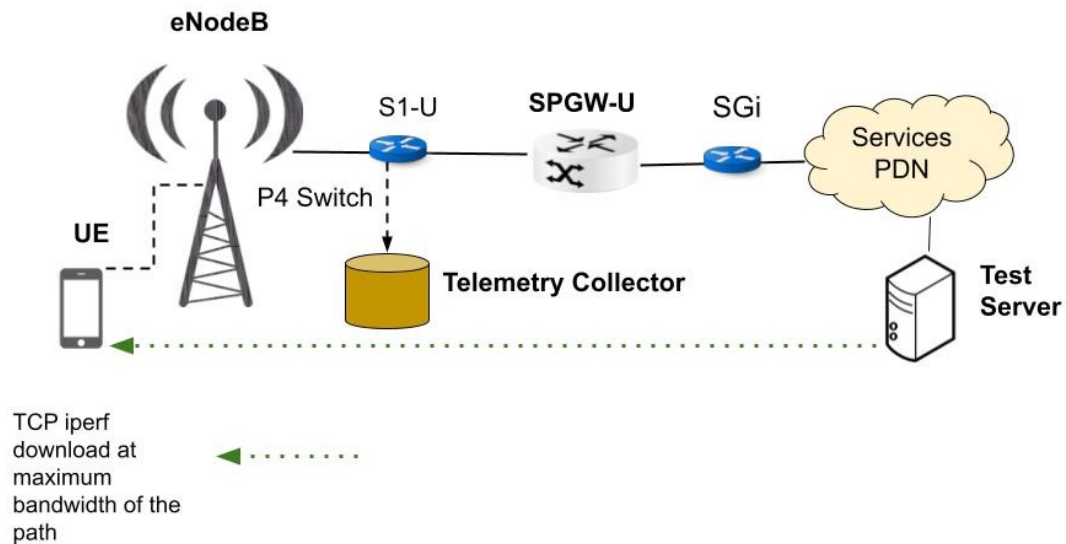
```
timestamp;flowid;swid;flow_packet_count;packets_in_queue;queue_timedelta;hitter;packet_length
1648111655;15419781162709721707195771453792L;1;4;0;105;0;98
1648111656;2401682570707420864648904962L;1;5;0;98;0;98
1648111656;2401682570707420864631931349L;2;5;25;34379;1;1342
1648111658;2401682570707420864648904962L;1;7;0;225;0;98
1648111658;2401682570707420864631931349L;2;7;0;170;0;62
1648111658;15419781162709648806083041493344L;2;7;0;25;0;62
1648111662;15419781162709721707195771453792L;1;9;0;2941;0;98
1648111674;2401682570707420864648904962L;1;24;0;132;0;98
1648111678;2401682570707420864631931349L;2;29;0;129;1;62
```

Shown in real time on the collector

Has P4-switch a potential to detect anomaly in end-to-end communication?

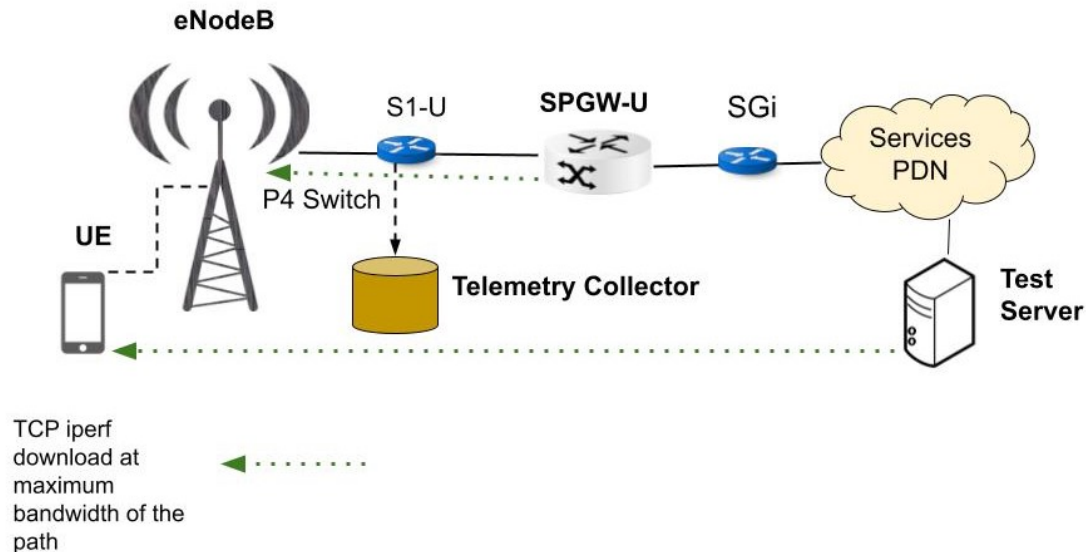
Scenario: End-to-End Performance Degradation

Scenario	Description	UE (Performance Tracking Metric)	P4 Switch (S1-U) Telemetry metric
Baseline	TCP downlink data from the test server to UE (using Iperf)	RTT to the test server Jitter to the test Server Transfer (MB) Bitrate (Mbps) Packet loss	dequeue time delta Packets in queue Hitter Packet loss

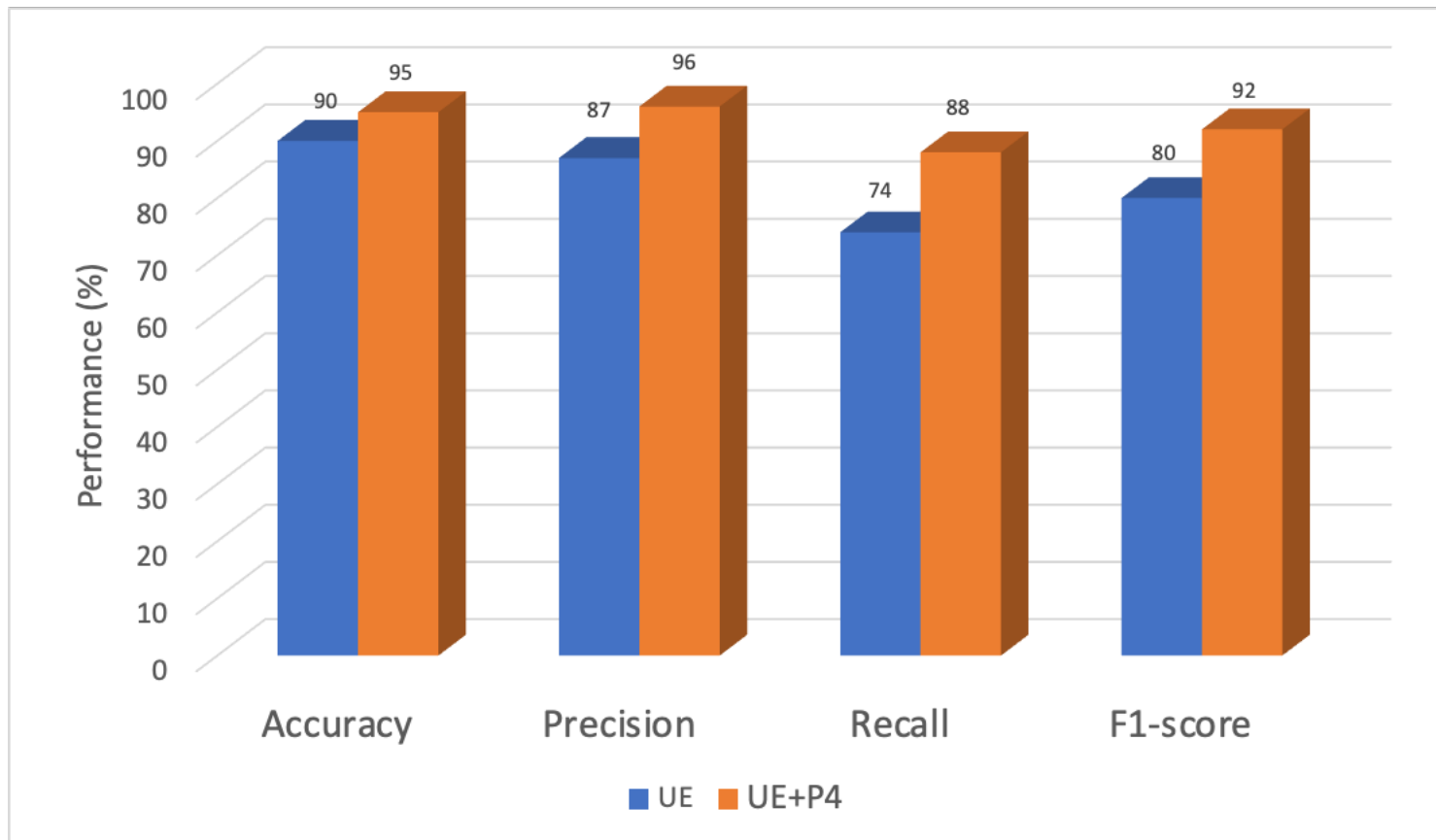


Scenario: End-to-End Performance Degradation

Scenario	Description	UE (Performance Tracking Metric)	P4 Switch (S1-U) Telemetry metric
E2E Anomaly: Bottleneck at S1-U	TCP downlink data from the test server to UE (using Iperf) + TCP downlink data from the SPGW-U to eNodeB (using Iperf)	RTT to the test server Jitter to the test Server Transfer (MB) Bitrate (Mbps) Packet loss	dequeue time delta Packets in queue Hitter Packet loss



Potential of In-band Telemetry



Live Demo!

The image shows a live demo of the Open Source MANO (Multi-managed Network Orchestrator) interface. Two men are standing in a server room, with a large overlay of the web browser displaying the MANO interface. The man on the left is holding a smartphone, and the man on the right is pointing at the screen.

The web browser displays the Open Source MANO interface, showing a list of NS Instances. The interface includes a sidebar with navigation options like Home, Overview, Packages, VNF Packages, and NetSlice Templates. The main content area shows a table of NS Instances with columns for Name, Identifier, Nsd name, Operational Status, Config Status, Detailed Status, and Actions.

Name	Identifier	Nsd name	Operational Status	Config Status	Detailed Status	Actions
SimulaMet-OAI-EPC	a89970d-d3b4-44d6-a1c3-28e1d9375e29	SimulaMet-OAI-EPC_md	Not	Not	Deploying ns at VM	Info, Refresh, Delete, Actions

Below the table, there is a section for 'Showing 1 to 1 of 1 entries' with 'Previous' and 'Next' buttons.

The bottom part of the image shows a terminal window displaying the output of the 'juju status' command. The output shows the status of various components, including the Controller, Cloud/Region, Version, SLA, and Timestamp. It also lists the status of various applications and units, including 'app-vnf-5b875fa21aea-vdu-hss-cnt-z0', 'app-vnf-5b875fa21aea-vdu-mme-cnt-z0', 'app-vnf-5b875fa21aea-vdu-spgw-cnt-c', and 'app-vnf-5b875fa21aea-vdu-spgw-cnt-u'.

Any Questions?

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