

P4-Based In-Band Telemetry for OSM-Orchestrated 4G/5G Testbeds

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Motivation

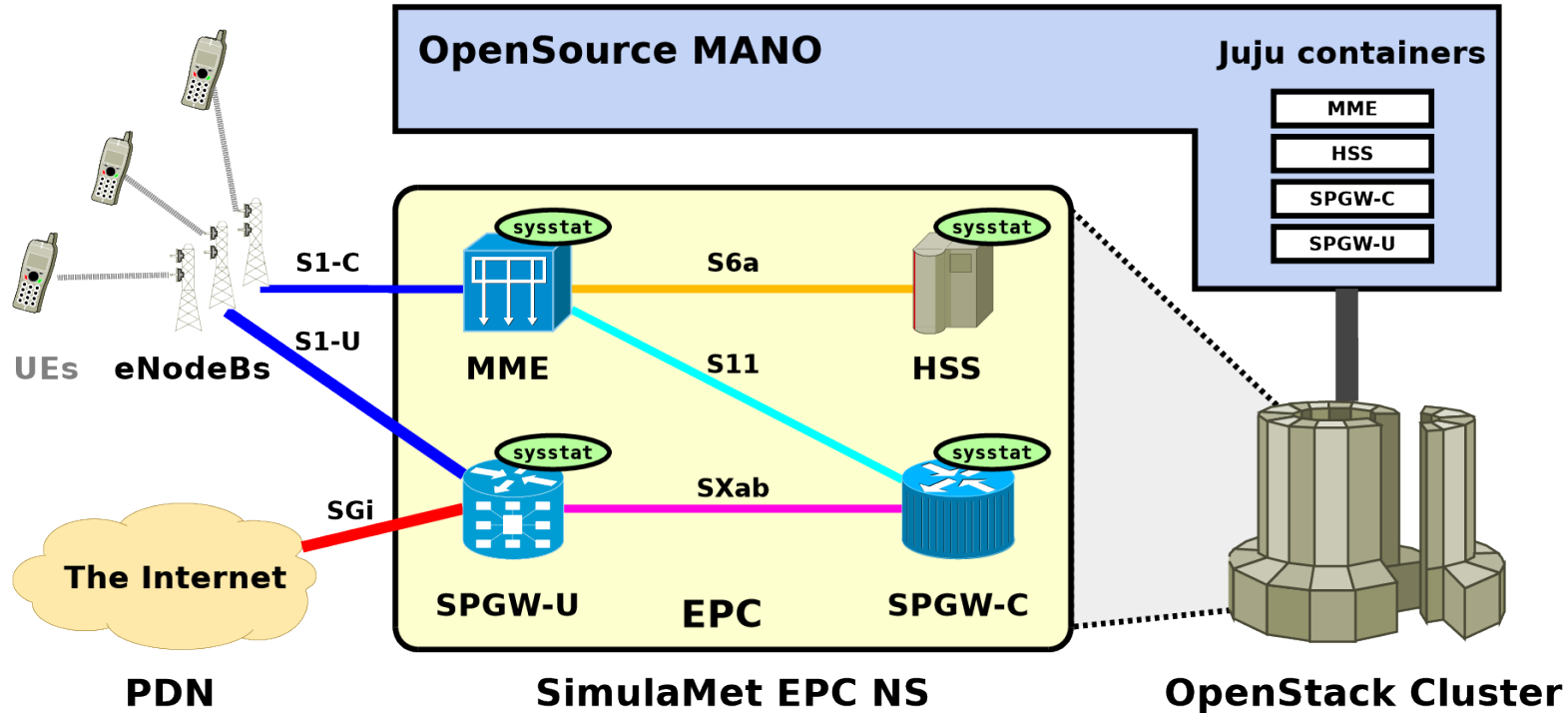
- 4G/5G networks need monitoring:
Detect problems, evaluate performance, etc.
- Basic performance: metrics in OSM, via Juju and NFVI
Useful, but not very fine-granular
- In-Band Telemetry:
 - Fine-granular monitoring at packet level
 - Possibility to add custom information into packets (additional headers, 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)

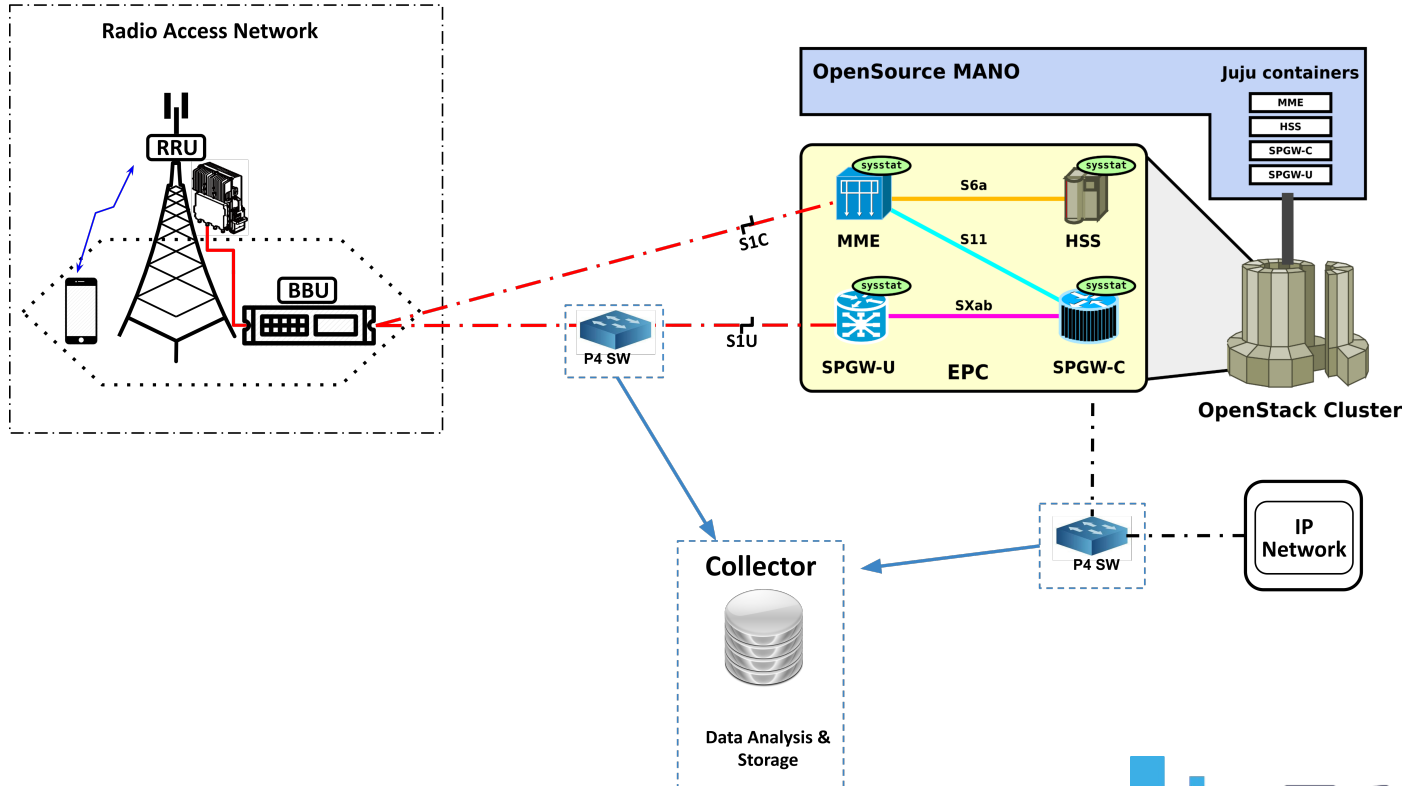
- OpenAirInterface (OAI):
 - Open Source software for EPC and eNodeB (i.e. packet core and base stations)
 - Details: <https://www.openairinterface.org>
 - 4G LTE available, 5G under development
 - Ongoing work, with many different Git branches
- Idea:
 - Manage OAI setups in OSM (at least, the EPC part)
 - 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>



Basic Testbed Setup



Telemetry Testbed



P4 Program at Switch at S1U Interface

CLONE PACKET AT THE EGRESS, AND
STORE THE NEEDED METADATA INFORMATION, TO BE USED FOR THE CLONE PACKET, IN REGISTERS

```
if(standard_metadata.instance_type==0){  
    reg_packet_length.write(0, standard_metadata.packet_length);  
    reg_deq_qdepth.write(0,standard_metadata.deq_qdepth);  
    reg_deq_timedelta.write(0,standard_metadata.deq_timedelta);  
    clone(CloneType.E2E, 100);  
}
```

DERIVE TELEMETRY DATA AT EGRESS

```
// RUN MIN COUNT SKETCH, TO COUNT PACKETS OF THE FLOW  
compute_flowid();  
compute_index();  
increment_count();  
compute_mincount(meta.count1, meta.count2, meta.count3);  
  
//CHECK IF PACKET IS PART OF BURST  
meta.marker=0;  
is_heavy_hitter();
```

P4 Program at Switch at S1U Interface

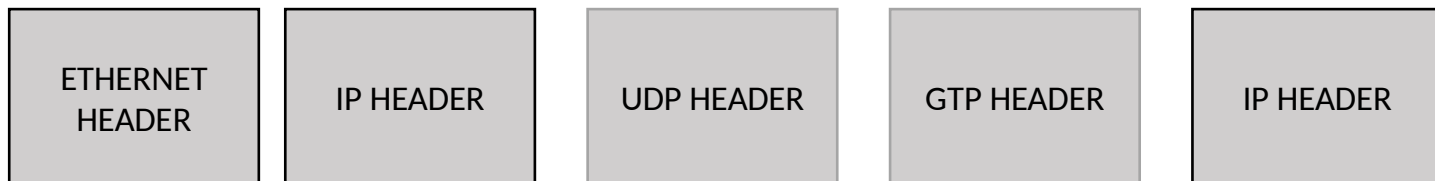
ADD INT TELEMETRY USING IP OPTION HEADER, TO THE CLONE PACKET

```
// SET IP OPTIONS VALID
hdr.ipv4_option.setValid();
hdr.gre.setValid();

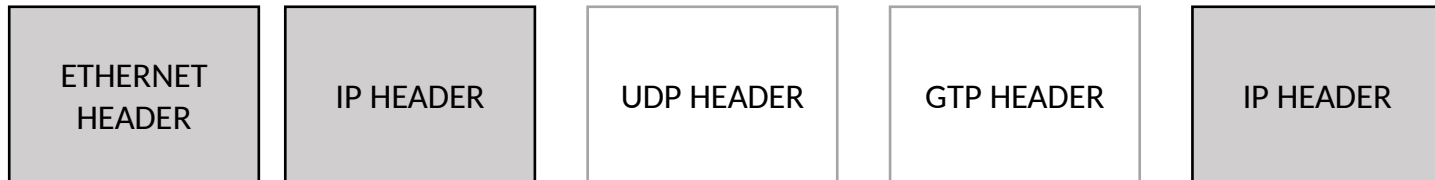
//Set UDP, GTP INVALID
hdr.gtp.setInvalid();
hdr.udp_outer.setInvalid();

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.flow_packet_count = (bit<16>) meta.min_count;//2 bytes
hdr.ipv4_option.packets_in_queue = (bit<10>) var_deq_qdepth;
hdr.ipv4_option.hitter = meta.marker; //1 bit
hdr.ipv4_option.queue_timedelta = var_deq_timedelta;
hdr.ipv4_option.packet_length= (bit<18>)var_packet_length;
hdr.ipv4_option.optionLength = 12; //total number of byte
```

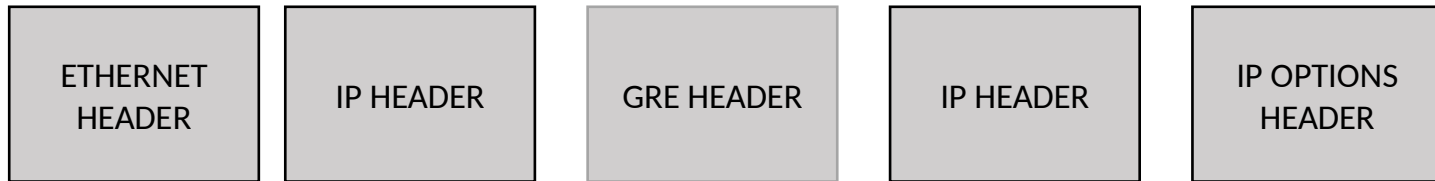

P4 Program at Switch at S1U Interface



1. PARSE THESE HEADERS



2. REMOVE THE UDP AND GTP HEADERS FOR CLONED PACKET



3. ADD GRE TUNNEL, AND IP OPTION HEADER FOR CLONED PACKET

Collector collects the data for further analysis

```
###[ Ethernet ]###
```

```
dst      = fa:16:3e:47:c4:89
src      = fa:16:3e:a8:17:95
type     = IPv4
```

```
###[ IP ]###
```

```
version  = 4
ihl      = 5
tos      = 0x0
len      = 1406
id       = 19522
flags    = DF
frag     = 0
ttl      = 30
proto    = gre
chksum   = 0xf489
src      = 10.208.0.214
dst      = 10.208.0.16
```

```
\options \
```

```
###[ GRE ]###
```

```
chksum_present= 0
routing_present= 0
key_present= 0
seqnum_present= 0
strict_route_source= 0
recursion_control= 0
flags        = 0
version      = 0
proto        = IPv4
```

```
###[ IP ]###
```

```
version  = 4
ihl      = 8
tos      = 0x0
len      = 1382
id       = 19522
flags    = DF
frag     = 0
ttl      = 64
proto    = udp
chksum   = 0xcde1
src      = 12.1.1.2
dst      = 10.1.1.96
```

```
\options \
```

```
###[ TELEMETRY ]###
```

```
| copy_flag = 1
| optclass  = control
| option    = 31
| length    = 12
| swid      = 1
| flow_packet_count= 6762
| packets_in_queue= 0
| queue_timedelta= 49
| hitter    = 0
| packet_length= 1420
```

Live Demo!

The image displays a live demo of the Open Source MANO (Multi-Access Network Open Source MANagement) interface. Two men are standing on either side of the central interface, which is shown in three overlapping windows. The man on the left is wearing a grey t-shirt and khaki pants, and the man on the right is wearing a blue t-shirt with the 'Open Source MANO' logo and jeans. The central interface shows the 'Instances' page, which lists various instances and their details. The 'NS Instances' page shows a table of network slices. The bottom window shows a terminal output with a table of application and unit status.

Model	Controller	Cloud/Region	Version	SLA	Timestamp
a089970d-d3b4-44d6-a1c3-28e1d9375e29	juju status	localhost/localhost	2.7.0	unsupported	frigg.simula.nor.net: Wed Mar 11 16:55:03 2020

App	Version	Status	Scale	Charm	Store	Rev	OS	Notes
app-vnf-5b875fa21aea-vdu-hss-cnt-z0		active	1	hsscharm	local	0	ubuntu	
app-vnf-5b875fa21aea-vdu-mme-cnt-z0		active	1	mmecharm	local	0	ubuntu	
app-vnf-5b875fa21aea-vdu-spgw-cnt-c		active	1	spgoccharm	local	0	ubuntu	
app-vnf-5b875fa21aea-vdu-spgw-cnt-u		active	1	spgwucharm	local	0	ubuntu	

Unit	Workload	Agent	Machine	Public address	Ports	Message
app-vnf-5b875fa21aea-vdu-hss-cnt-z0/0	active	executing	2	10.166.166.103		(configure-cassandra) configure_cassandra: configuring Cassandra ...
app-vnf-5b875fa21aea-vdu-mme-cnt-z0/0	active	executing	3	10.166.166.225		(configure-mme) configure_mme: configuring MME ...
app-vnf-5b875fa21aea-vdu-spgw-cnt-c/0	active	executing	0	10.166.166.50		(configure-spgw) configure_spgw: configuring SPGW-C ...
app-vnf-5b875fa21aea-vdu-spgw-cnt-u/0	active	executing	1	10.166.166.92		(configure-spgw) configure_spgw: configuring SPGW-U ...

Machine	State	DNS	Inst id	Series	AZ	Message
0	started	10.166.166.50	juju-97ae85-0	xenial	Running	
1	started	10.166.166.92	juju-97ae85-1	xenial	Running	
2	started	10.166.166.103	juju-97ae85-2	xenial	Running	
3	started	10.166.166.225	juju-97ae85-3	xenial	Running	

Any Questions?

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