LatSeq

A Low-impact Internal Latency Measurement tool for OpenAirInterface

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IEEE WCNC’21, 30th March 2021, Nanjing, China

Overview

1 Motivation

2 On Internal latency

3 Implementation

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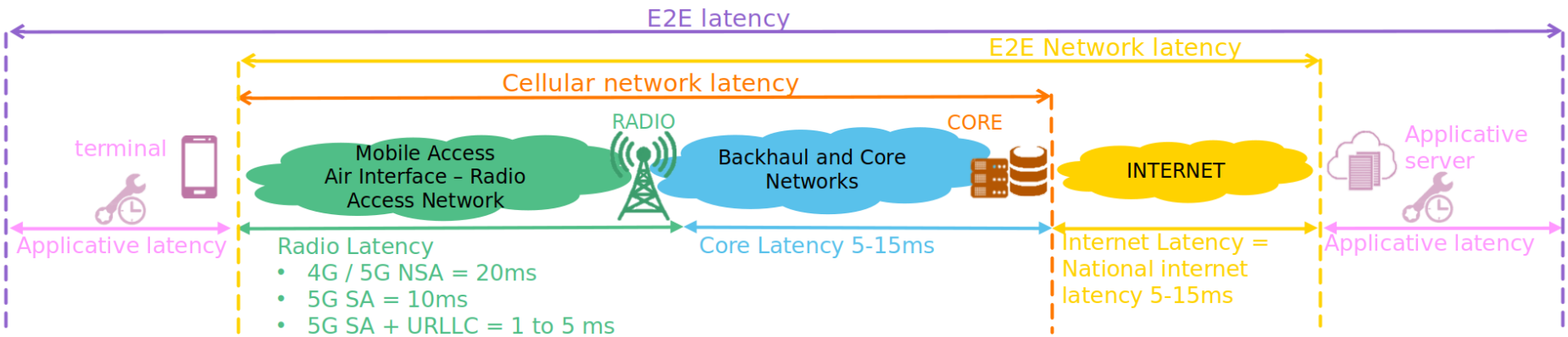
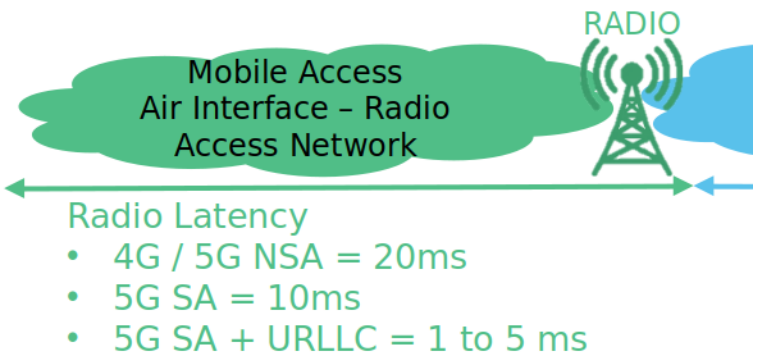
Motivation

Motivation I



End-to-End latency for a cellular internet connection

Motivation II



Radio Access Network segment

Latency and jitter on the RAN :

- radio propagation
- radio encoding and processing
- radio access
- radio scheduling and queueing
- radio retransmissions and error corrections

Motivation III

Methods to measure latency:

- Network captures
  - pro : per-packet and per-flow latency
  - con : no details on latency components
- Statistics exposed by the Base Station
  - pro : Global statistics on latency
  - con : not always available, no per-packet statistics

Motivation IV

Objective

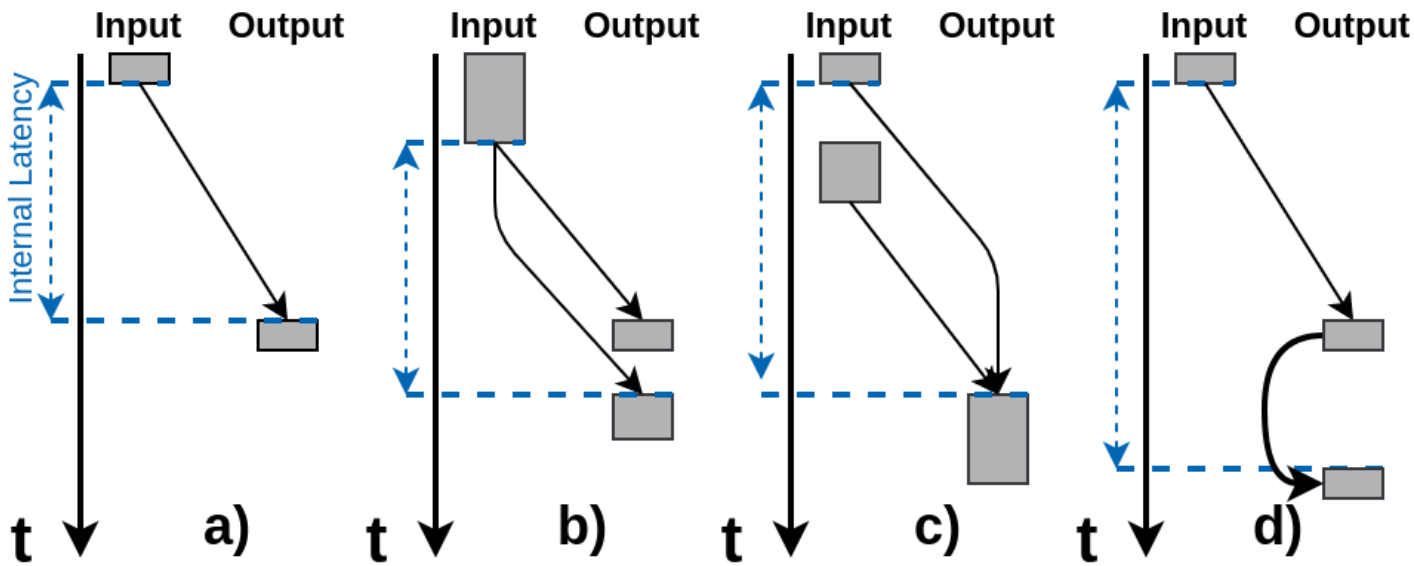
Measure detailed internal latency on the base station, **per packet** with a **low impact** on it.

On Internal latency

On Internal latency I

Internal latency

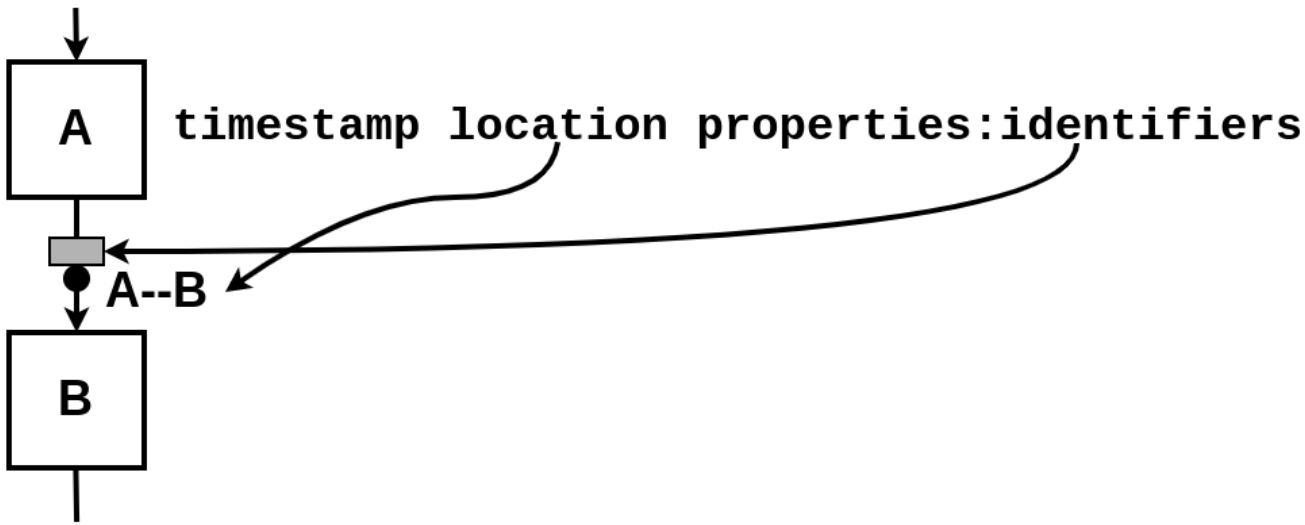
The time between the moment when the packet is fully received by the node from the input interface and the moment when all the segments making up the packet leave the software part of this node to be transmitted.



On Internal latency II

Packet fingerprint

The measurement of a packet at a measurement point.

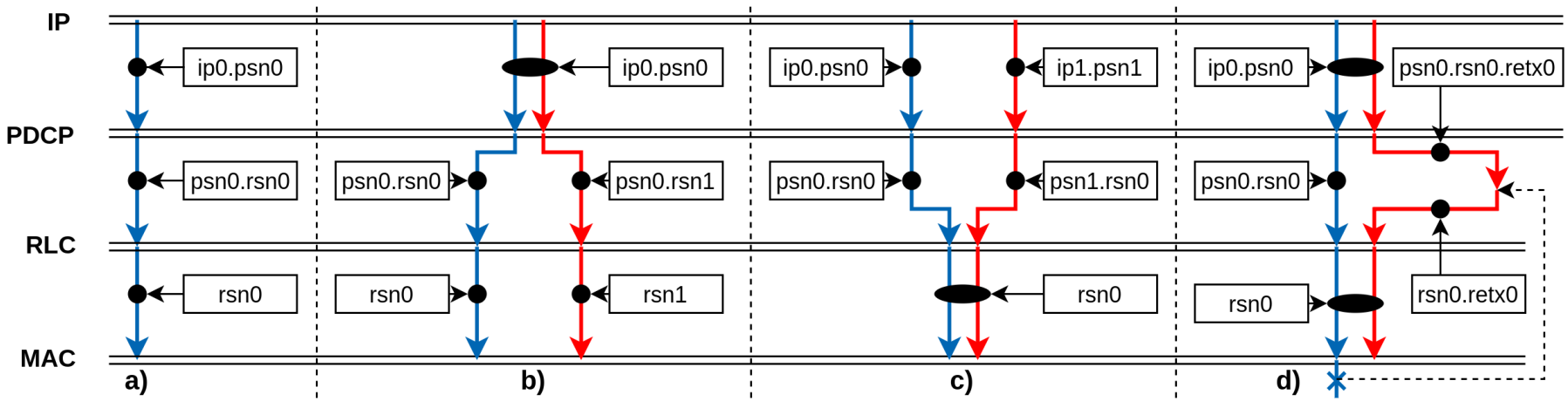


LatSeq fingerprint

On Internal latency III

Packet journey

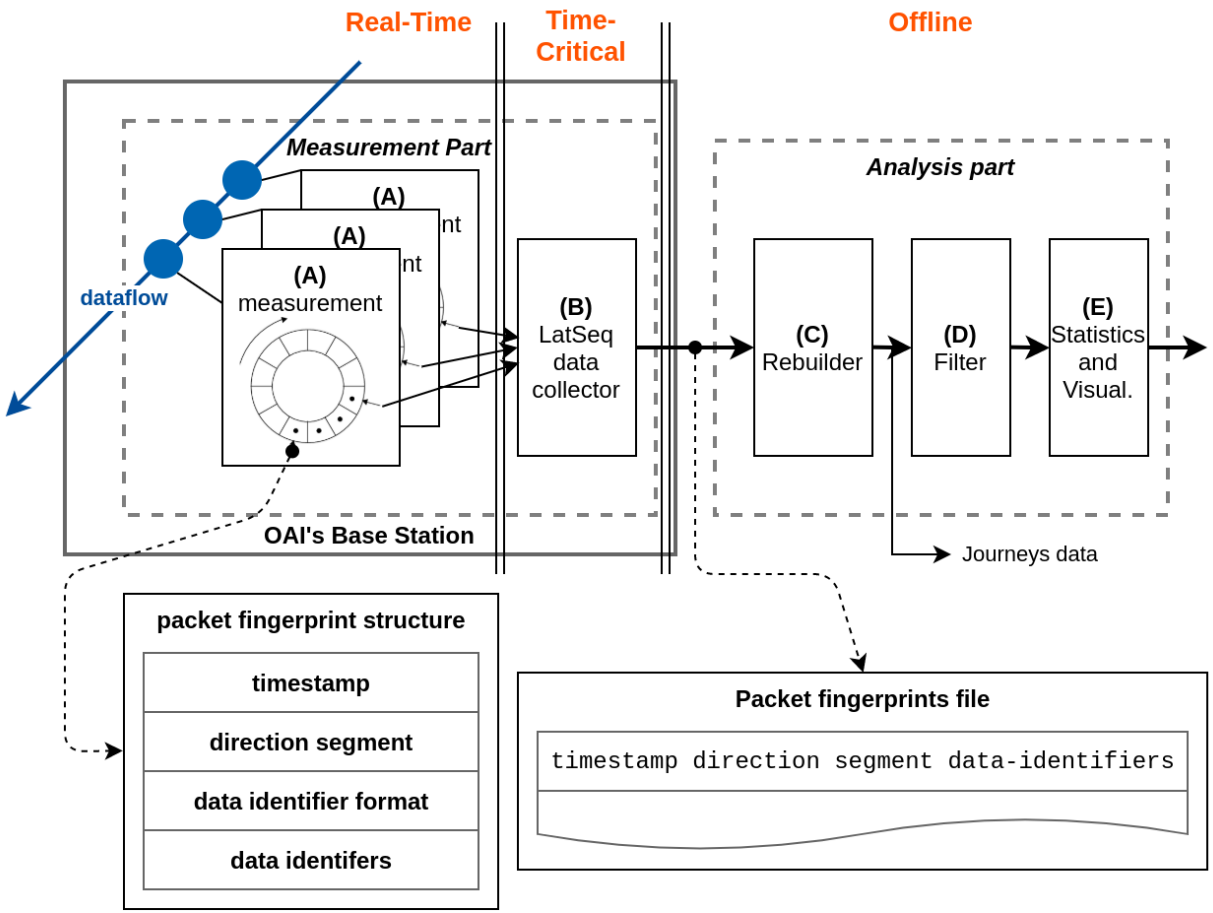
The list of successive fingerprints associated to a given packet.



Examples of packet journeys

Implementation

Implementation I



Tool architecture, low-to-no impact by design

Implementation II

- **(A)** : 16ns / measurement
- **(B)** : lockless mechanism for the single data collector
- **(C)** : rebuilding journeys from Fingerprint list
- **(D)** : filtering packets for fine-grained analysis
- **(E)** : scripts to produce visualizations and statistics

Implementation III

```
1 #ifdef LATSEQ
2     LATSEQ_P("D rlc.tx.am--rlc.seg.am",
3              "len%d:rnti%d:drb%d.sdu%d.rsn%d.rso%d",
4              sdu->size, entity->ue_rnti, entity->channel_id, sdu->sdu_num, pdu->sn, pdu->so
5              );
6 #endif
```

```
1 20201030_203524.504785 D pdcp.tx--rlc.tx.am len62:rnti53421:drb1.psn87.sdu88
2 20201030_203524.506512 D rlc.tx.am--rlc.seg.am len62:rnti53421:drb1.sdu88.rsn72.rso0
3 20201030_203524.506513 D rlc.seg.am--mac.mux len64:rnti53421:drb1.lcid3.rsn72.rso0.reqfm686
```

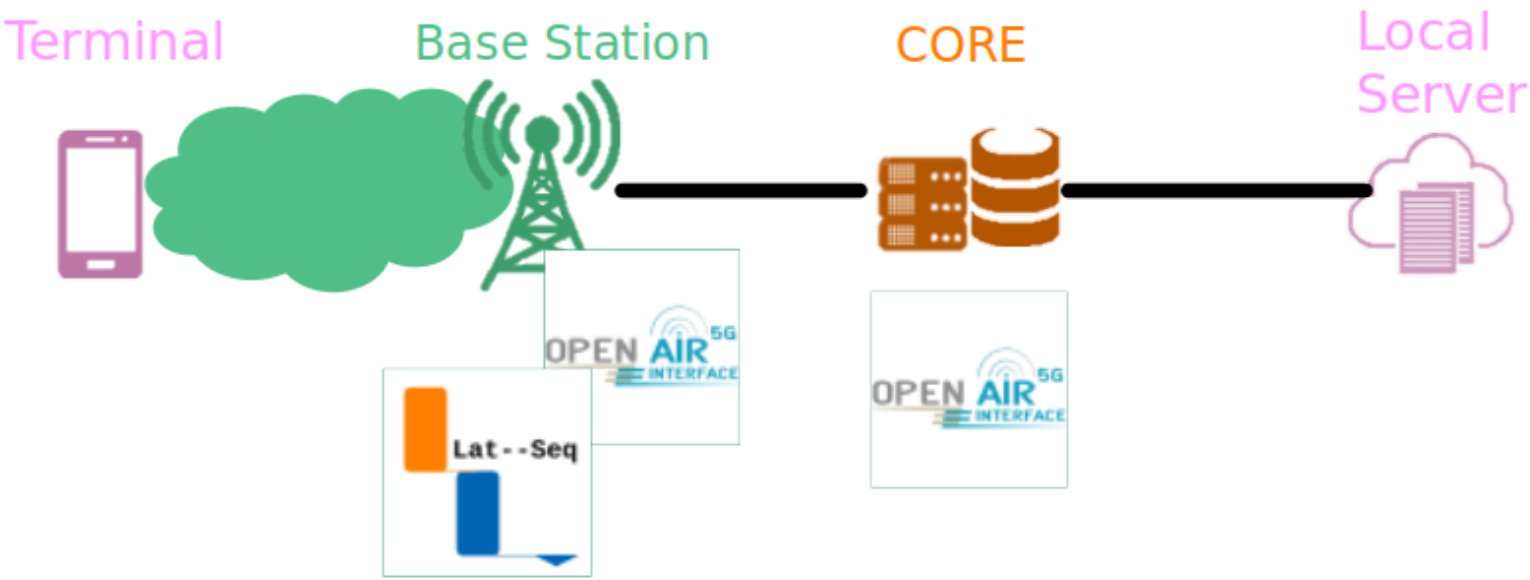
From **LatSeq point** (Instrumentation) to **packet fingerprint** (Formatted output)

Testbed

Implementation: Testbed I

- **OpenAirInterface**
- An open-source software-defined Base Station (LTE/5G)
- Project started in 2014 [1]

Implementation: Testbed II



Our simplified radio access network testbed

Implementation: Testbed III

Core	software	OAI EPC
eNodeB	software	OAI main-ocp[1]
	CPU	Intel Xeon 16cores@2.60GHz
	RAM	16GB
	Disk speed	264MBps
	Radio Interface	USRP B210
	LatSeq points	11 (DL), 8 (UL)
Terminal	model	LeEco 2 Android
RAN properties	Radio config	FDD, Band7 (2.68GHz), BW10MHz
	DRB config	RLC AM, default qci
	Scheduler	Default (1UE, 1DRB)
	Expected throughput	35 Mbps (DL), 17 Mbps (UL)
	Radio Signal Quality	Excellent

Testbed setup

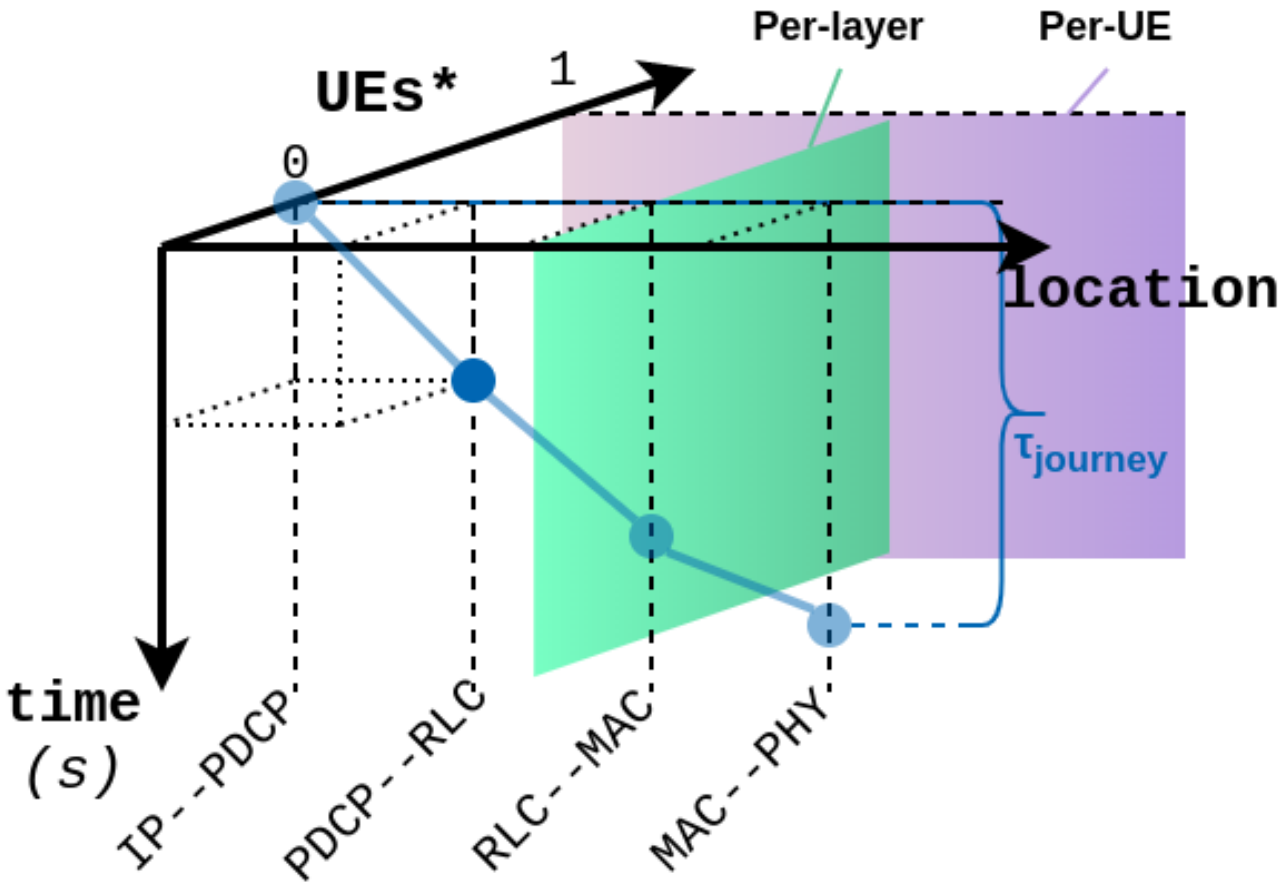
[1] https://gitlab.eurecom.fr/oai/openairinterface5g/

Results

Results: Low impact

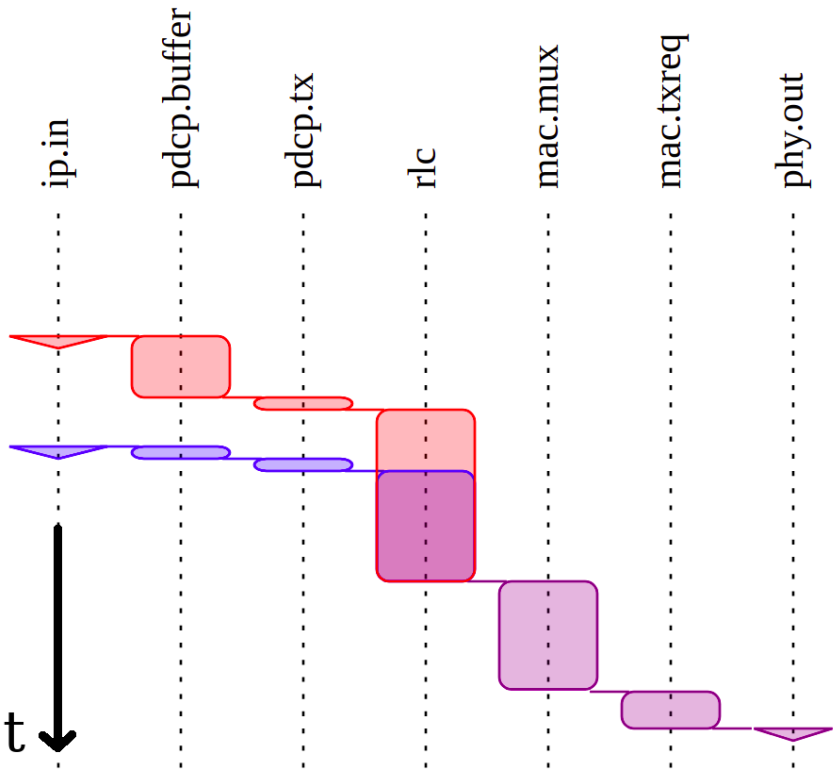
- **Theoritical analysis** : measurement point costs 35 CPU cycles
- **Unit performance evaluation** of measurement module : $[10.98, 18.56]$ ns
- **Performance evaluation** of the data collector : only limited by the disk write speed. Overall impact less than 1%.

Results: Usage – Statistical Analysis



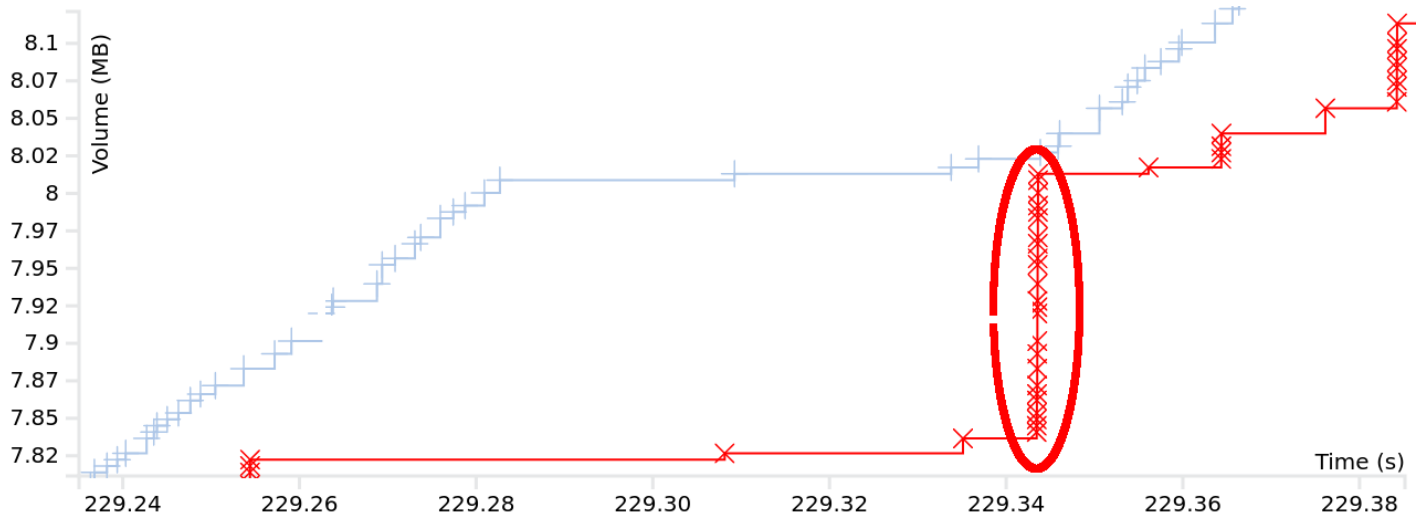
Space of internal latencies

Results: Usage – Waterfall



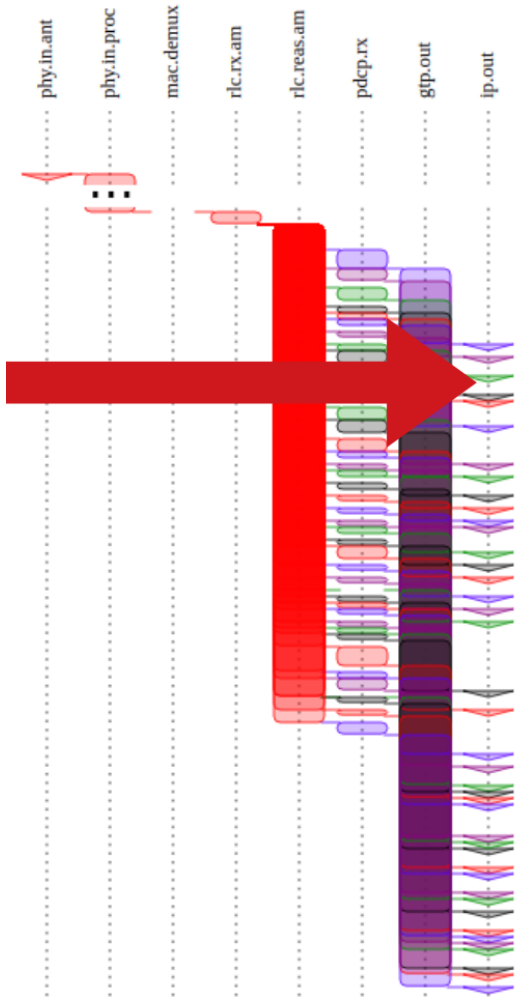
Waterfall visualization of packet journeys

Results: Usage – Case Study I



Network captures at Terminal (Blue) and Base Station output (Red)

Results: Usage – Case Study II



LatSeq waterfall for the packet burst

Future Workand Discussion

- Can be associated with other analysis approaches (*e.g. network captures*)
- Add control information (*e.g. MAC Control Element, scheduling decision*)
- Participate to OpenAirInterface open-source community[2]
- Ready to be adapted to other projects (*e.g. srsLTE*)

[2] https://github.com/Orange-OpenSource/LatSeq

Conclusion

- A novel method to analyse internal latency of Base Station
- A tested proof of concept to analyse latency dynamics

References I

[1] N. Nikaein, R. Knopp, F. Kaltenberger, L. Gauthier, C. Bonnet, D. Nussbaum, and R. Ghaddab.
Demo: Openairinterface: An open lte network in a pc.
In *Proceedings of the 20th Annual International Conference on Mobile Computing and Networking*, MobiCom '14, page 305–308, New York, NY, USA, 2014. Association for Computing Machinery. 10.1145/2639108.2641745.