

# Procedure-based Functional Decomposition for 5G Core Network Functions

3<sup>rd</sup> KuVS Fachgespräch “Network Softwarization”

**Endri Goshi**

[endri.goshi@tum.de](mailto:endri.goshi@tum.de)

**Raffael Stahl**

[raffael.stahl@tum.de](mailto:raffael.stahl@tum.de)

**Prof. Dr.-Ing Wolfgang Kellerer**

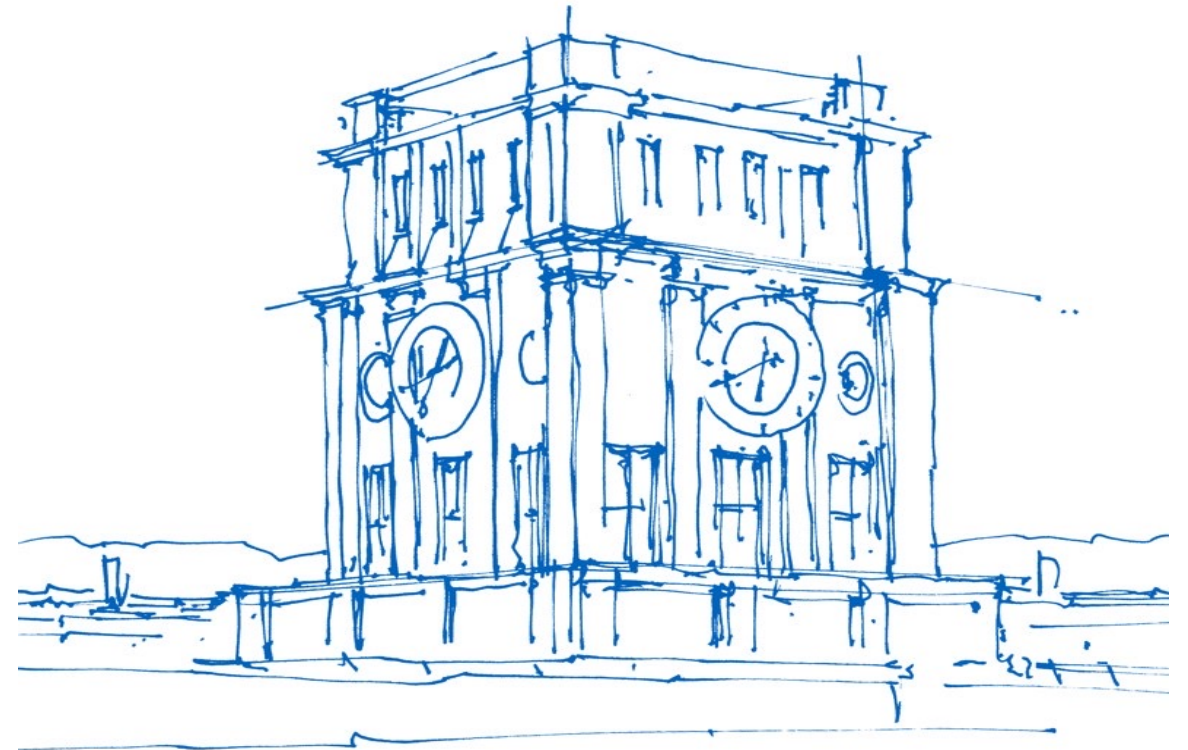
[wolfgang.kellerer@tum.de](mailto:wolfgang.kellerer@tum.de)

**Dr. Mu He**

[mu.he@nokia.com](mailto:mu.he@nokia.com)

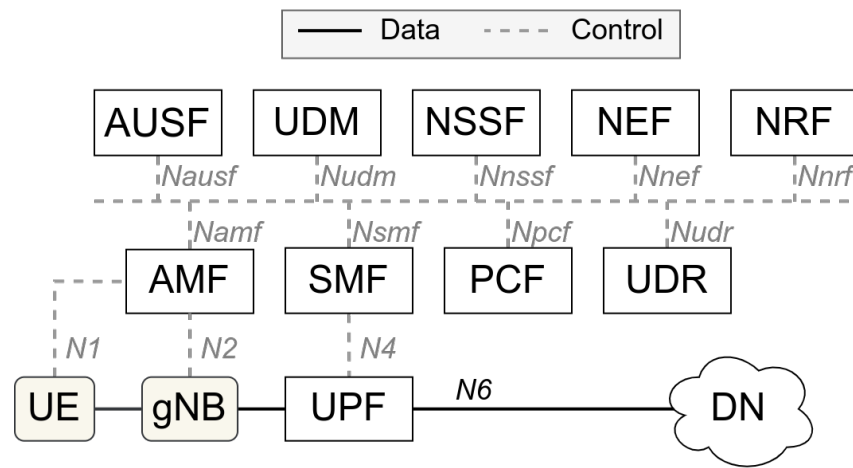
**Dr. Rastin Pries**

[rastin.pries@nokia.com](mailto:rastin.pries@nokia.com)

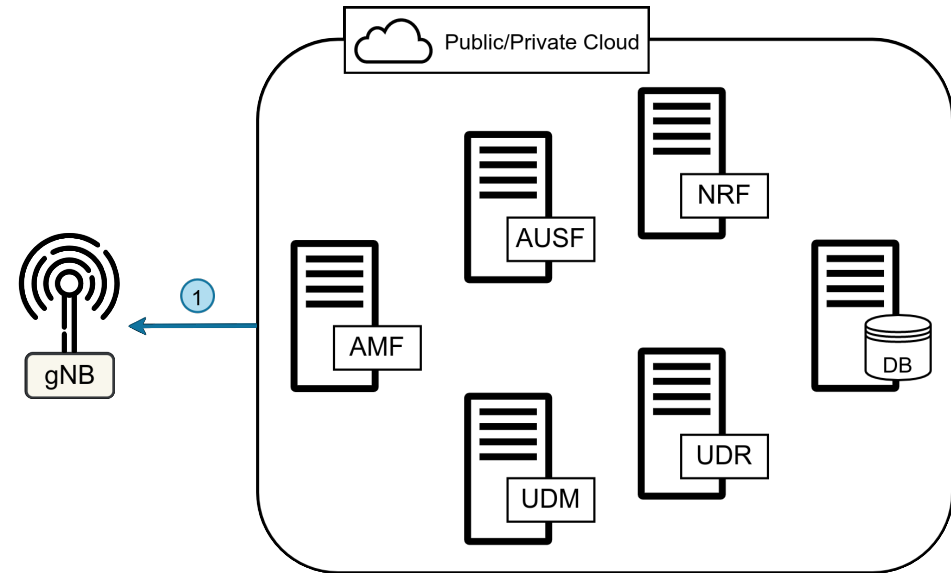


*Uhrenturm der TUM*

# Motivation



5G Core Service-Based Architecture (SBA).

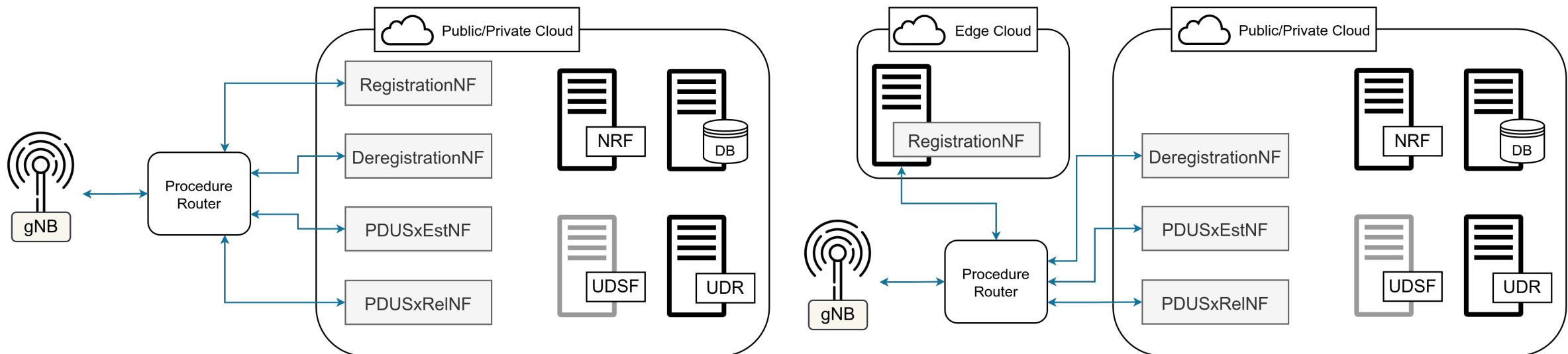


[1] – 3GPP, “3GPP TS 23.501 - System architecture for the 5G System (Rel 15)”

# Outline

- Introducing procedure-based functional (de)composition in 5G Core.
- Methodology in developing RegistrationNF.
- Evaluation and comparison with 5G SBA.
- Conclusions and future work.

- Functional (de)composition based on Control-Plane (CP) procedure processing logic:
  - Contain (most of) the processing logic in a single NF.
  - Reduce inter-NF communication (CP signaling).
  - Reduce the procedure completion times.
  - Facilitate edge offloading.

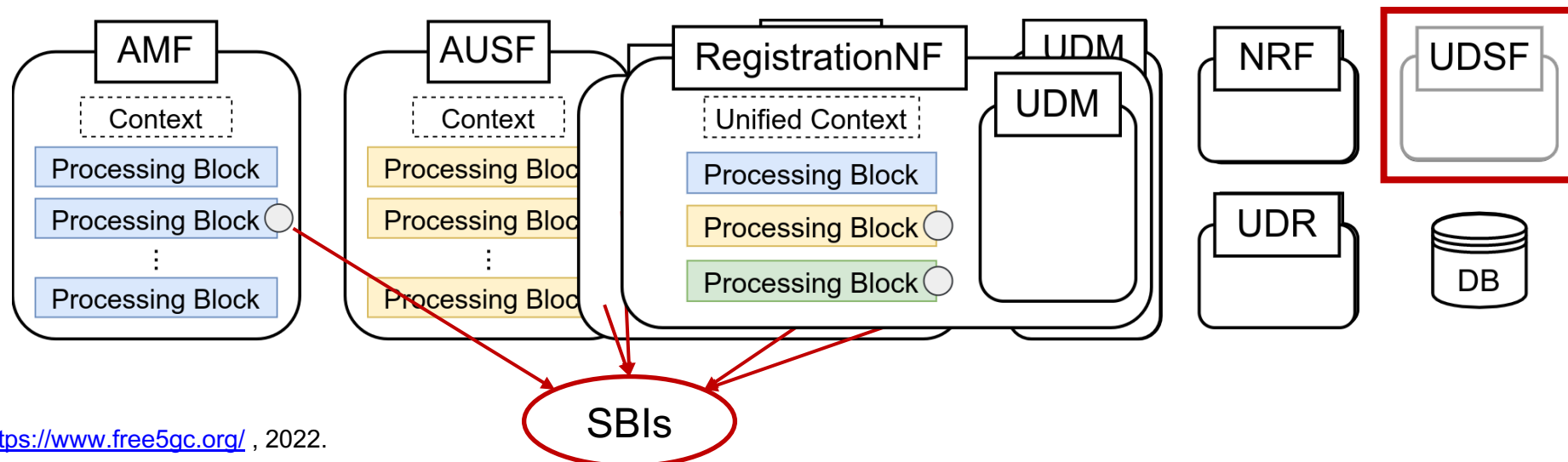


- Raza et al. [2] propose a Fat-proxy to offload the execution of some procedures in LTE.

[2] - M. T. Raza, D. Kim, K.-H. Kim, S. Lu, and M. Gerla, "Rethinking LTE network functions virtualization", ICNP, 2017

# Procedure-based RegistrationNF

- Implementation of RegistrationNF from Free5GC [3]:
  - Identify all 5GC NFs involved in UE Registration procedure.
  - AMF as base NF – identify processing blocks executed during UE Registration.
  - Leverage Service-Based Interfaces callbacks to identify processing logic in other NFs (**AUSF**, **PCF**).
  - Build a “Unified Context”.
  - Implement state serialization to enable *statelessness*.
  - Next step: integrate UDM.

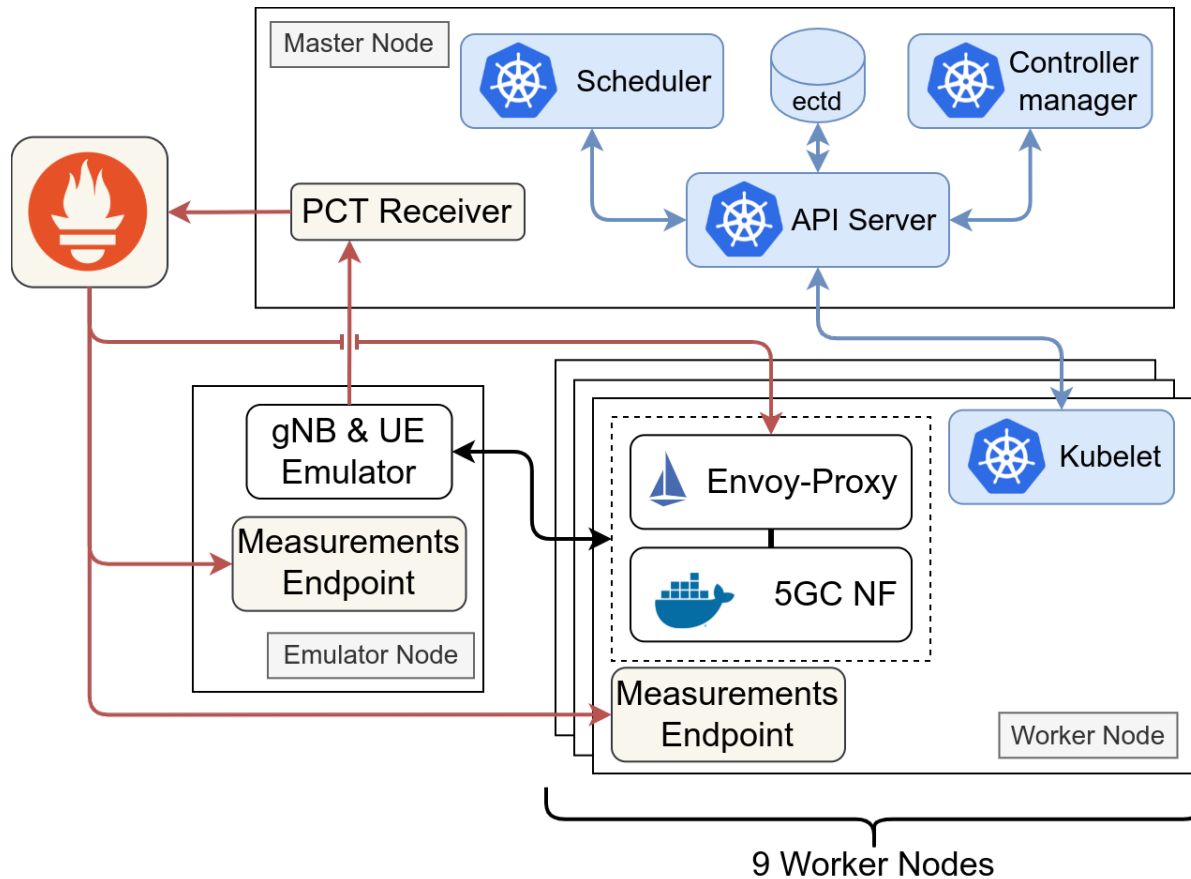


[3] - “Free5GC”, <https://www.free5gc.org/>, 2022.

# What is “statelessness” and why do we need it in procedure-based 5GC?

- Decouple state from the processing logic.
  - More reliability and flexibility in deployment.
  - Facilitates horizontal scaling of NFs.
- Two approaches: procedural and transactional.
- Unstructured Data Storage Function (UDSF).
- Why is it necessary in procedure-based 5GC?

# Evaluation Setup Overview



- On-site *Kubernetes* [4] cluster:
  - 1x master node.
  - 9x worker nodes.
- Service-mesh deployment with *Istio* [5].
- Input traffic: gNB & UE Emulator.
- Measurement collection with *Prometheus* [6]:
  - Custom endpoints for CPU utilization.
  - Envoy-Proxy for HTTP traffic data.
  - Procedure latency obtained from the Emulator.

[4] - "Kubernetes", <https://kubernetes.io/>, 2022.

[5] - "Istio", <https://istio.io/>, 2022.

[6] - "Prometheus", <https://prometheus.io/>, 2022.

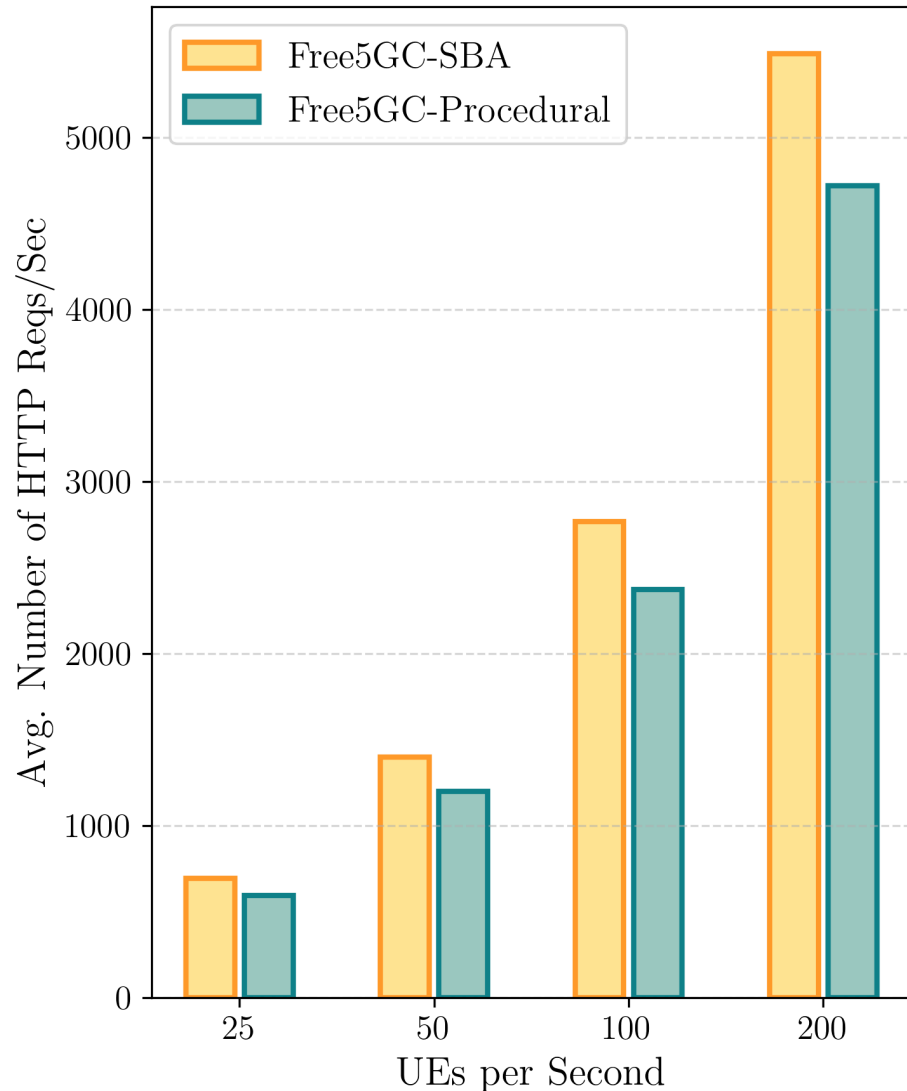
# Key Performance Indicators and Input Parameters

- Key Performance Indicators (KPIs):
  - Avg. number of HTTP requests/second.
  - Procedure Completion Times (PCTs).
- Summary of input parameters:

<b>CP Procedure</b>	Registration
<b>NF placement</b>	1 NF/node
<b>Instances/NF</b>	1
<b>Number of UEs/sec</b>	25, 50, 100, 200
<b>Measurement duration</b>	100 seconds

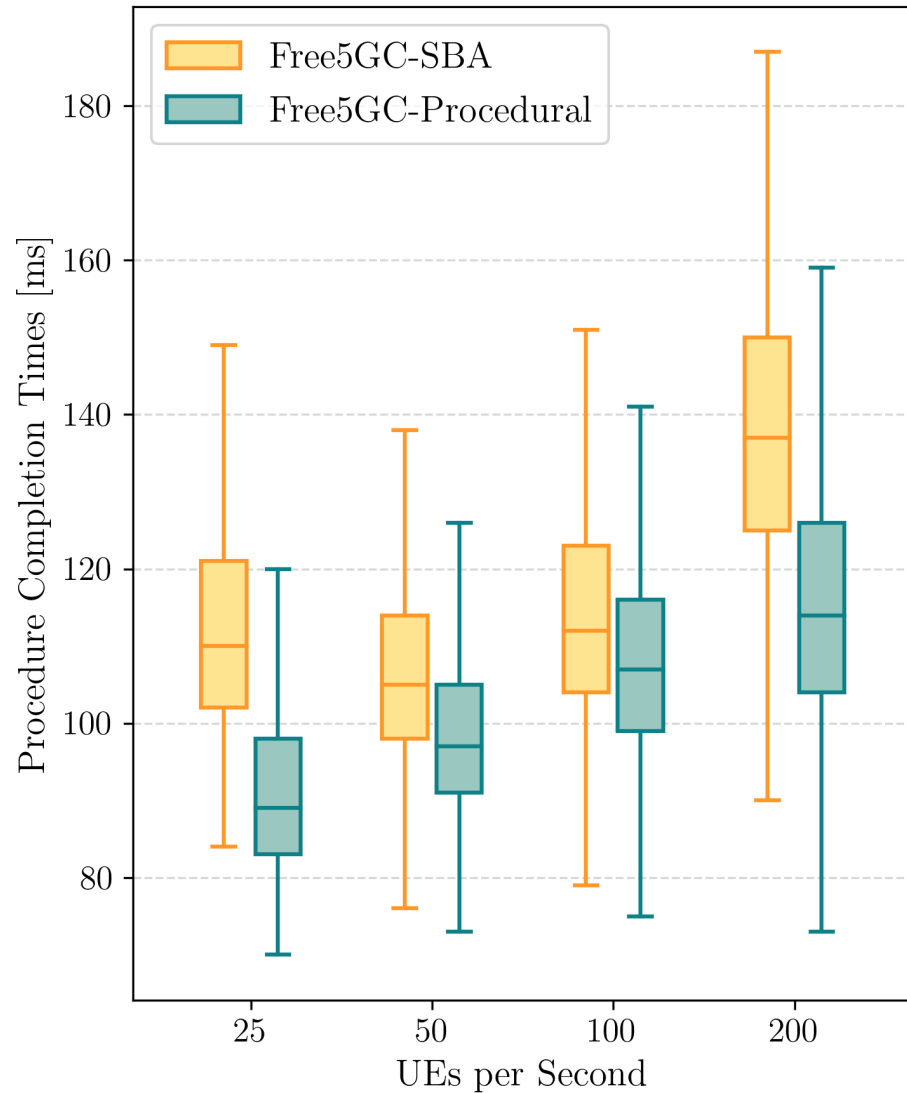


# Reduction in terms of control-plane signaling overhead



- **17,5%** reduction of signaling overhead for UE Registration.
- Considerable improvements expected with the integration of UDM:
  - In SBA it amounts for **28,5%** of total CP communication.

# Improvements in Procedure Completion Time



- Up to **17%** reduction of mean Procedure Completion Time.

## Conclusions and Future Work

- Propose a re-architecture of 5G Core with a procedure-based approach.
- Implement stateless RegistrationNF.
- Validation and evaluation in our private Kubernetes cluster.
- Achieved a 17,5% reduction in CP signaling up to 17% in PCTs.
- Future work:
  - Integrate UDM processing blocks.
  - System-wide evaluation by considering the other CP procedures.



# References

- [1] - 3GPP, “3GPP TS 23.501 - System architecture for the 5G System (Rel 15)”
- [2] - M. T. Raza, D. Kim, K.-H. Kim, S. Lu, and M. Gerla, “*Rethinking LTE network functions virtualization*”, in 2017 IEEE 25th International Conference on Network Protocols (ICNP), 2017, pp. 1–10.
- [3] - “Free5GC”, <https://www.free5gc.org/> , 2022.
- [4] - “Kubernetes”, <https://kubernetes.io/> , 2022.
- [5] - “Istio”, <https://istio.io/> , 2022.
- [6] - “Prometheus”, <https://prometheus.io/> , 2022.