Application of broker-based mechanisms for end-node attachment in mobile networks
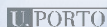
Masters Defense

Ana Patrícia Gomes da Cruz

Supervisor: Prof. Dr. Daniel Corujo

Co-supervisor: Prof. Dr. António Nogueira

July 2020

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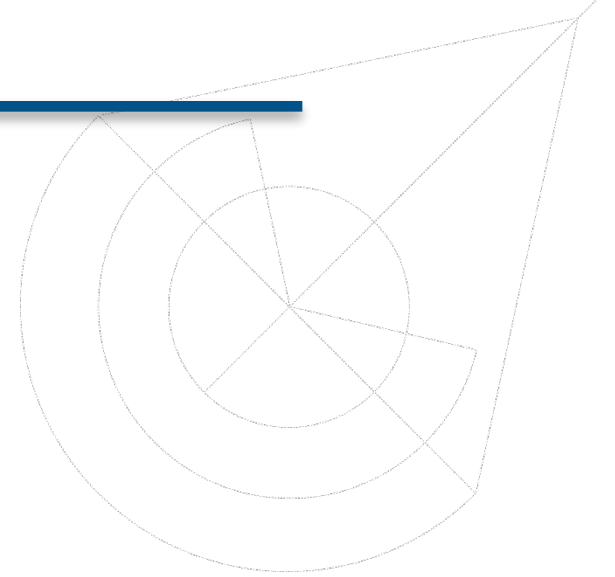
Topics covered

1 Introduction

2 Requirements and Architecture

3 Results

4 Final Remarks

Insights on current networks trends

- In 2017 mobile data traffic increased by 71% and it is predictable that the traffic keeps growing [1];

- Network operators are continuously upgrading and extending their network infrastructure to attend the user demand [2];

- 5G network developed to attend user demand with high data rates and reduce the costs [3];

[1] Cisco, "Cisco visual networking index: Global mobile data traffic forecast update, 2017-2022", Feb. 2009, Cisco, White Paper.

[2] F. Z. Yousaf, M. Bredel, S. Schaller, and F. Schneider, "Nfv and sdn—key technology enablers for 5g networks", IEEE Journal on Selected Areas in Communications, vol. 35, no. 11, pp. 2468–2478, 2017.

[3] C. Zhang, X. Wen, L. Wang, Z. Lu, and L. Ma, "Performance evaluation of candidate protocol stack for service-based interfaces in 5g core network", in 2018 IEEE International Conference on Communications Workshops (ICC Workshops), 2018, pp. 1–6.

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4G network

- Follow 3GPP standards;

- IP network architecture:

  - "Flat architecture"

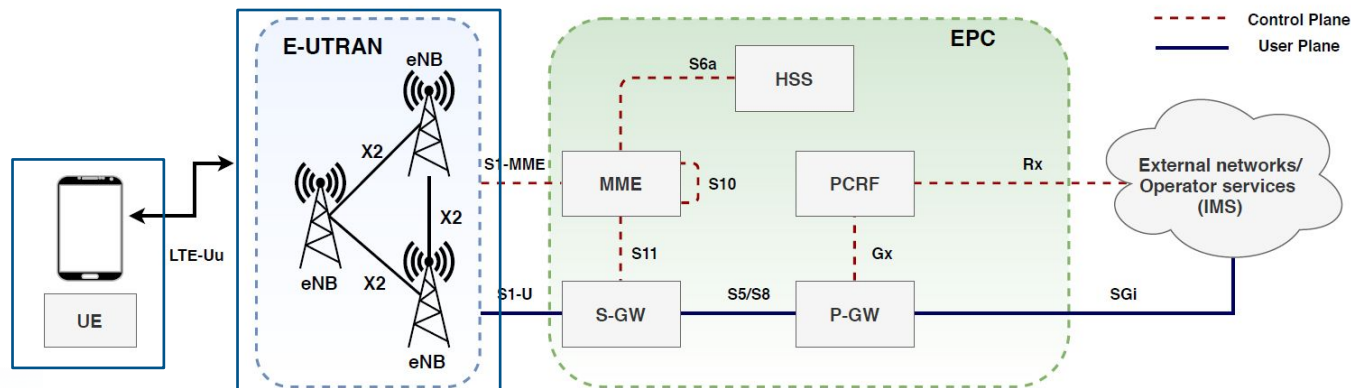 - Separation of the control plane from the user plane
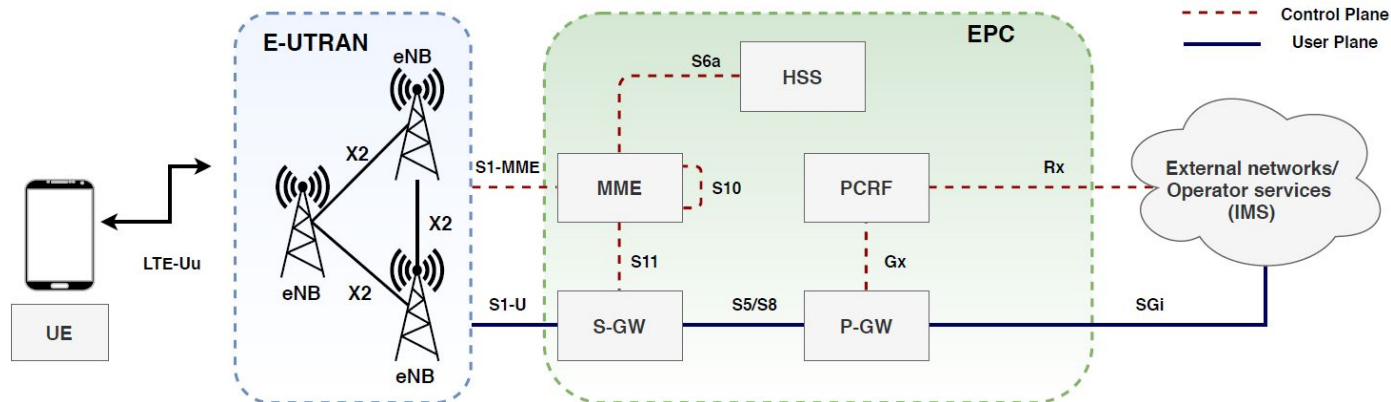
4G network

Evolved Universal Terrestrial Radio Access Network (E-UTRAN)

Evolved NodeB (eNB):
- Radio resource management
- Radio bearers

4G network

Evolved Packet Core (EPC)

MME:
- Bearer management
- Connection management
- NAS security

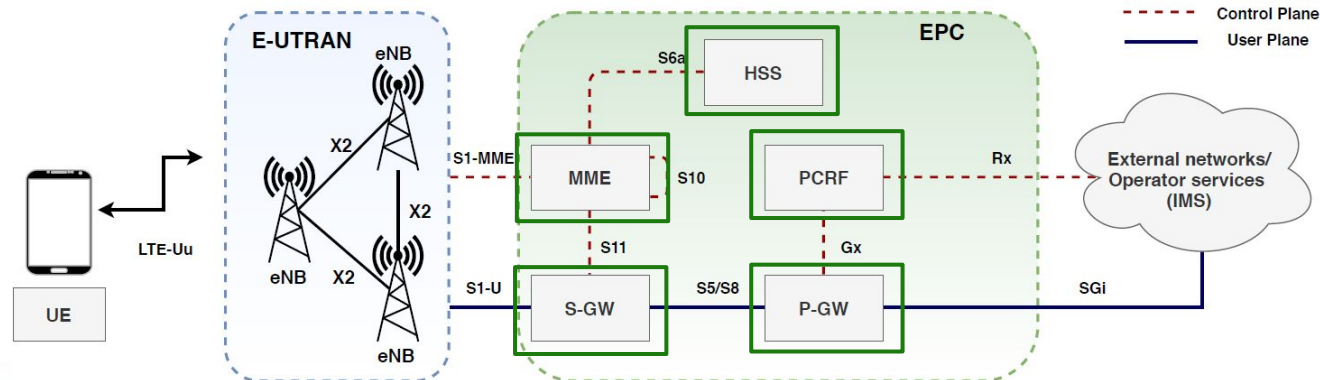**HSS:**
- Central subscriber database
- Provides authentication vector

S-GW:
- Mobility anchoring
- Terminates user plane towards E-UTRAN

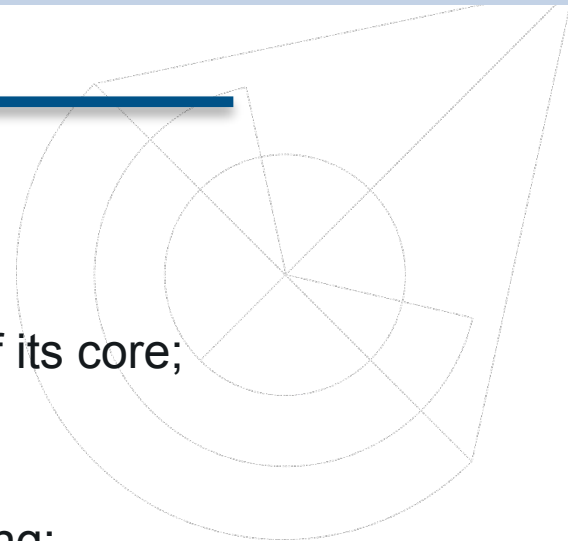**P-GW:**
- UE IP address allocation

PCRF:
- Policy control decision

5G network

- Service-Based Architecture;

- Separating the Control Plane from the User Plane;

- Service-Based Interface.
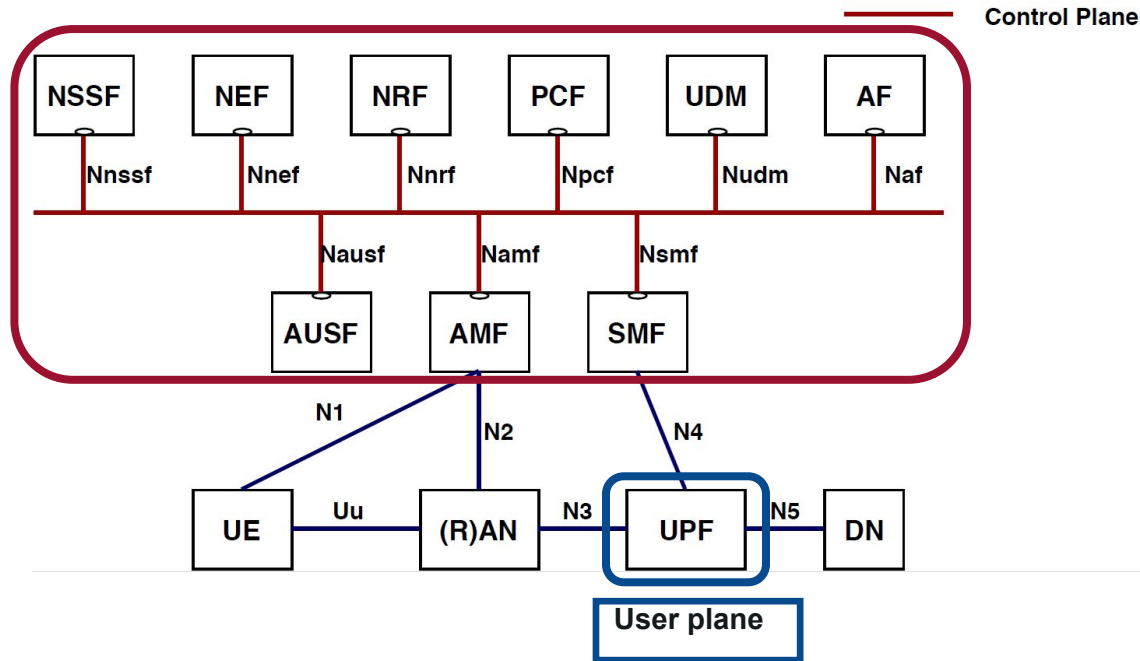
Motivation and goals

- 5G network with a reformulation of the architecture of its core;

- 5G core architecture closer to cloud-native systems;

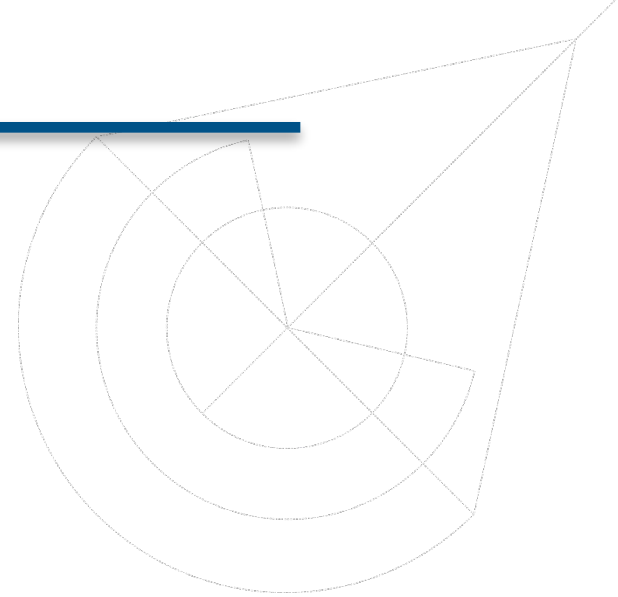- Impact of message brokers for control signaling routing;

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What to evaluate?

- Signaling routing between core entities

- Integration of messages brokers
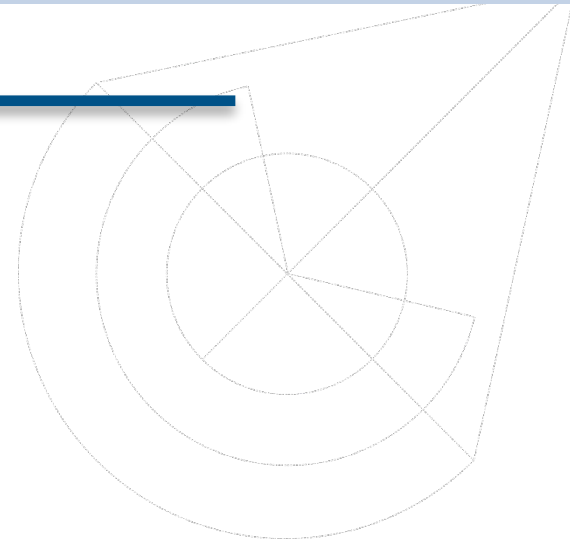
Software platform selection

- Three requirements were established:

  ▪ Has to provide full implementation of the LTE network;

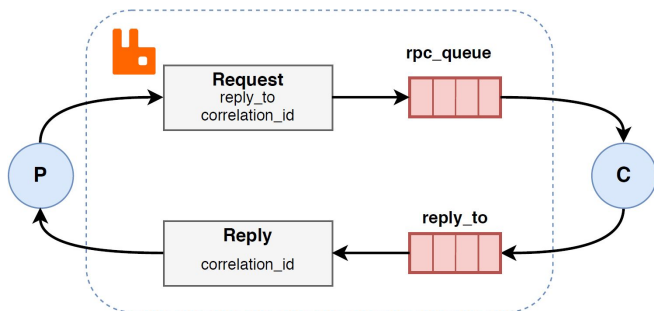 ▪ Has to have UE emulator tool;

  ▪ Has to be free.

Gr-LTE   **OSLD**

OpenAirInterface (OAI)

- Managed by the OAI

  Software Alliance;

- Emulator tool:

  - OAISIM program allow

    emulate multiple users;

  - Emulator not stable.
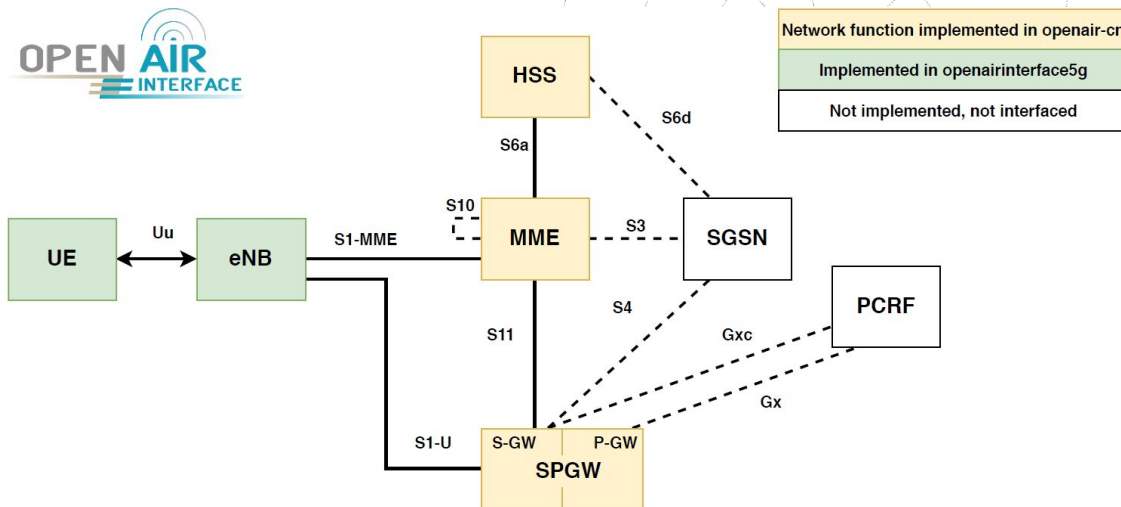
Message Brokers

- Integration on OAI platform;

- Messages brokers that provide libraries in C code.
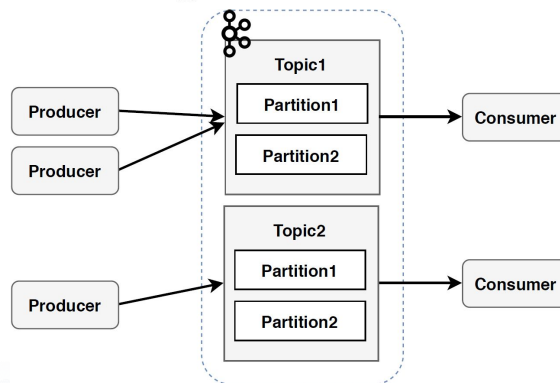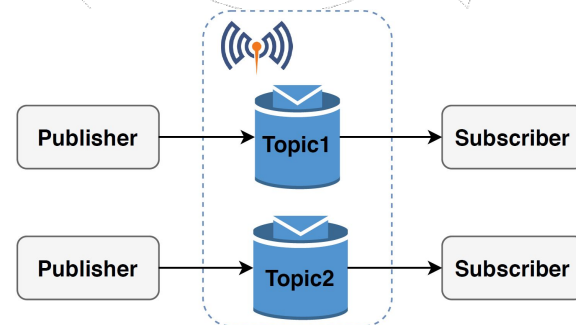
Proposed solution

- Service-based interface between 4G core network
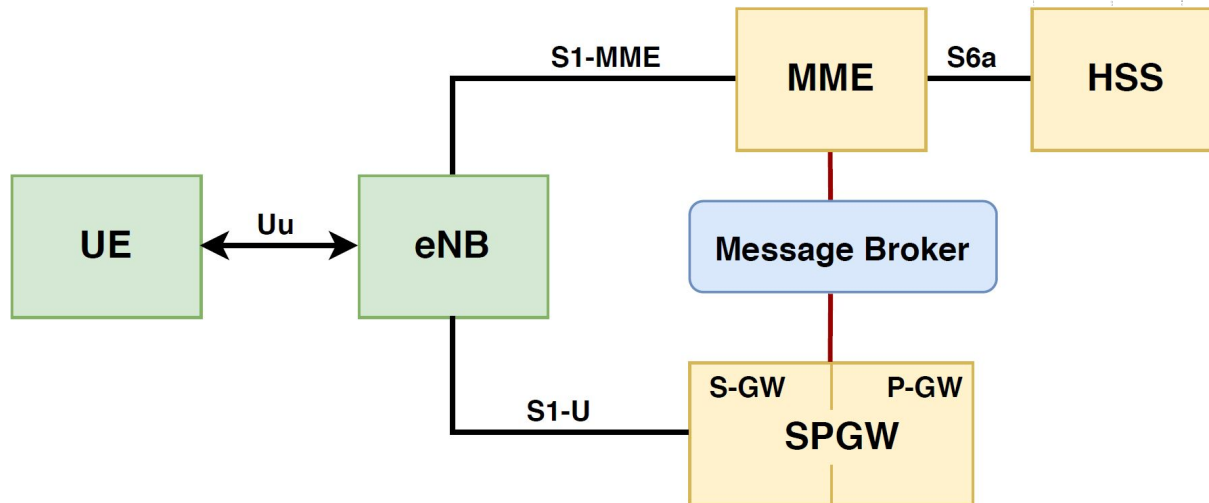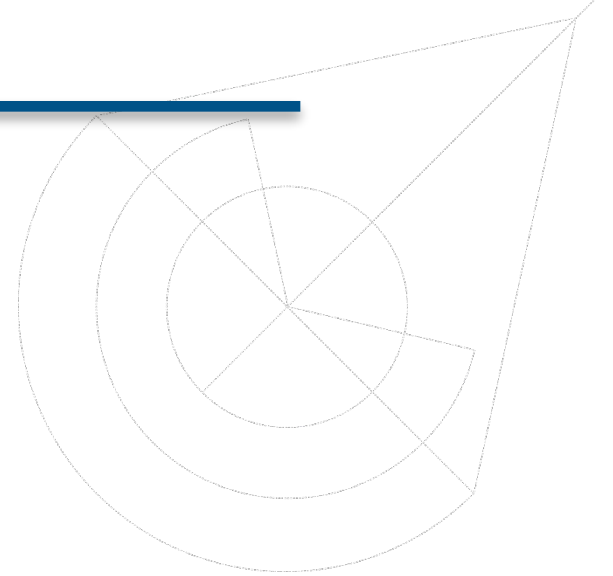
Topics covered

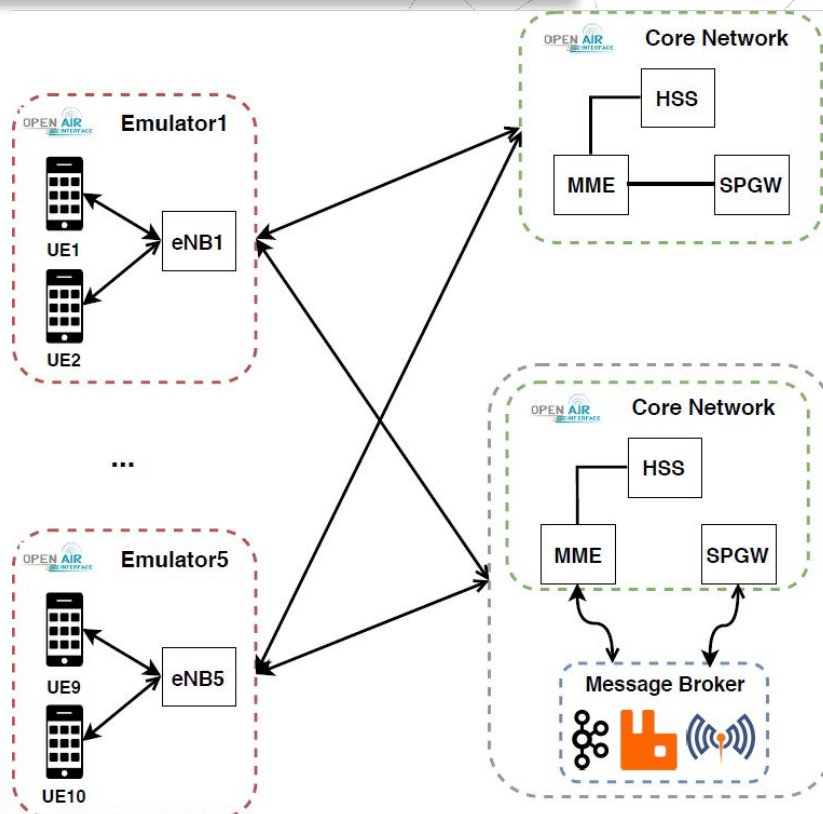**1** Introduction

2 Requirements and Architecture

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Scenario

- Connect different amounts of users (maximum 10 users);
- Testing different message brokers;
- Ran 100 times;
- Flask server implemented in all VMs.

Throughput

#User	Throughput (kbps)					
	Original EPC			Message Brokers		
	S1-MME	S6a	S11	Kafka	Mosquitto	RabbitMQ
1UE	15.7(±0.64)	55.66(±4.27)	0.663(±0.057)	4.66(±0.092)	7.52(±0.429)	8.06(±0.493)
2UE	12.94(±0.91)	44.03(±7.66)	0.86(±0.105)	5.95(±0.791)	9.74(±2.769)	11.24(±4.314)
3UE	13.27(±0.86)	44.37(±4.85)	0.864(±0.104)	6.03(±0.927)	9.86(±2.332)	10.61(±1.832)
4UE	13.14(±0.93)	51.43(±5.14)	0.977(±0.395)	5.96(±0.491)	9.43(±0.809)	11.37(±3.054)
5UE	13.67(±0.53)	57.56(±3.2)	0.977(±0.189)	6.26(±1.165)	9.68(±1.799)	12.08(±4.182)
6UE	13.12(±0.24)	58.41(±3.05)	1.037(±0.275)	6.48(±1.407)	10.22(±1.885)	11.28(±1.743)
7UE	14.23(±0.18)	59.47(±1.30)	1.003(±0.114)	6.54(±1.113)	10.26(±2.697)	12.38(±4.291)
8UE	13.15(±0.14)	55.74(±2.18)	1.029(±0.181)	6.49(±1.018)	9.89(±1.3)	12.45(±6.265)
9UE	13.19(±0.11)	54.99(±1.73)	1.066(±0.582	6.27(±1.189)	10.41(±0.946)	11.83(±1.556)
10UE	13.17(±0.11)	52.14(±2.65)	1.022(±0.181)	6.61(±0.961)	11.29(±2.634)	12.07(±1.935)

# Exchanged messages through entities

Original EPC
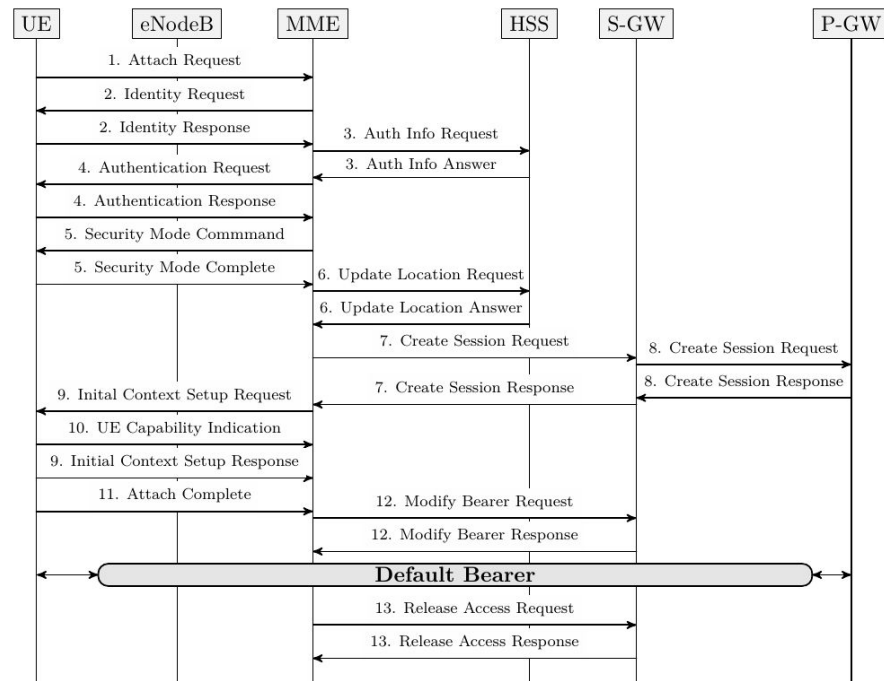
Exchanged messages through entities
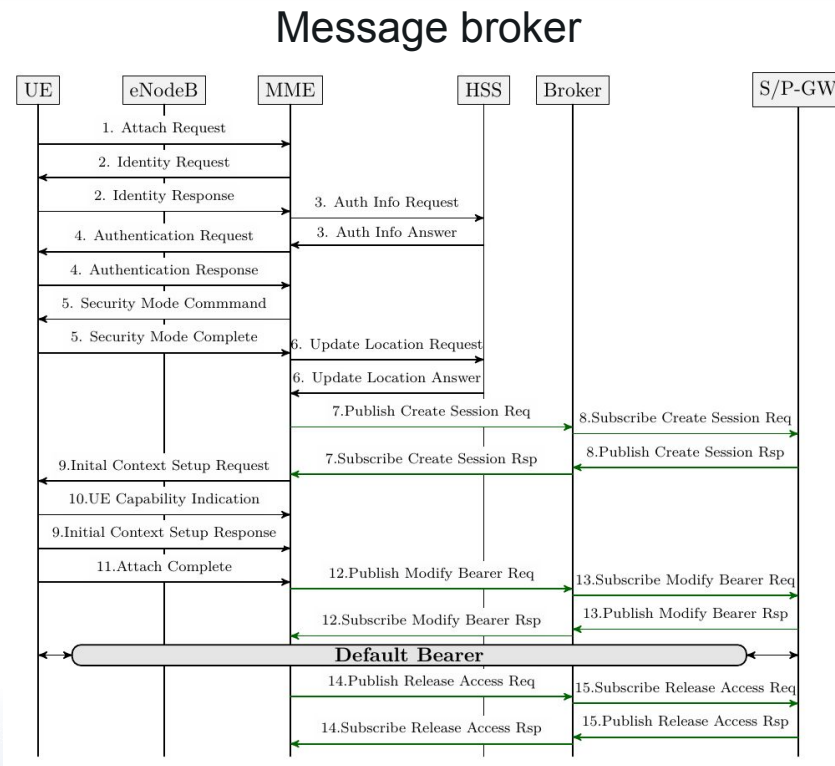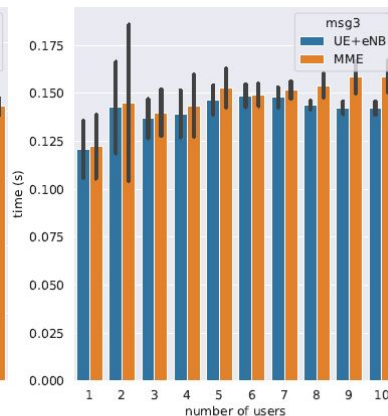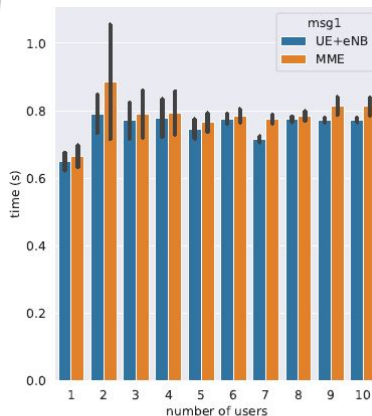

Message broker
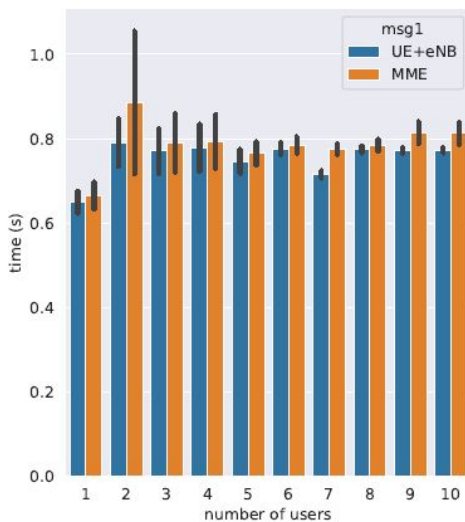
Delay on the control plane: UE+eNB and MME

- **Messages exchanged between UE + eNB and MME entities (Original EPC):**
  - Attach Request/Complete (msg1)
  - Authentication Request/Response (msg3)
  - Security Mode Command/Complete (msg4)
  - Initial Context Request/Response (msg7)
  - Initial Context Request/UE Capability (msg8)
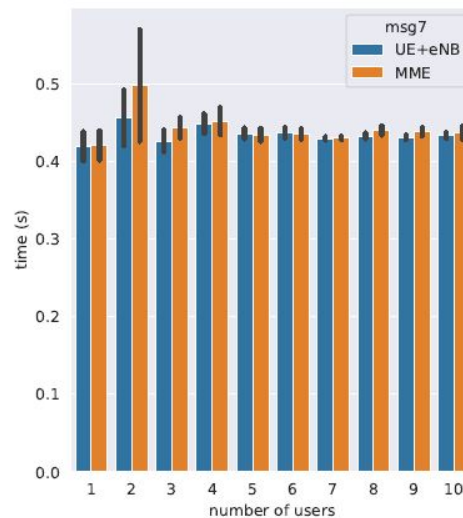 - UE Capability/Initial Context Response (msg9)
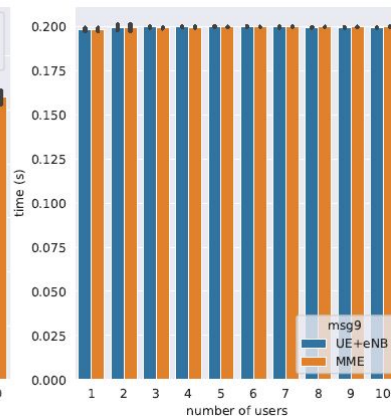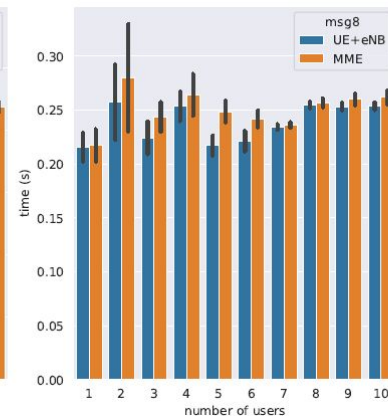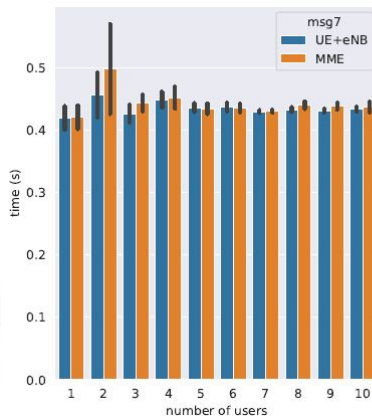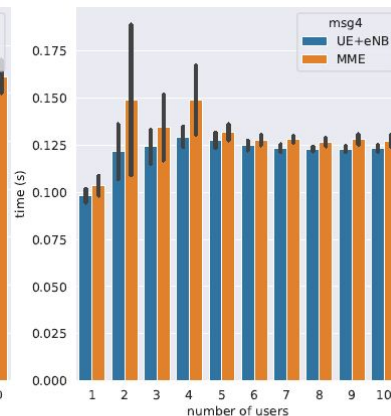
Delay on the control plane: UE+eNB and MME

Attach Request/Complete (msg1)

Initial Context Request/Response (msg7)
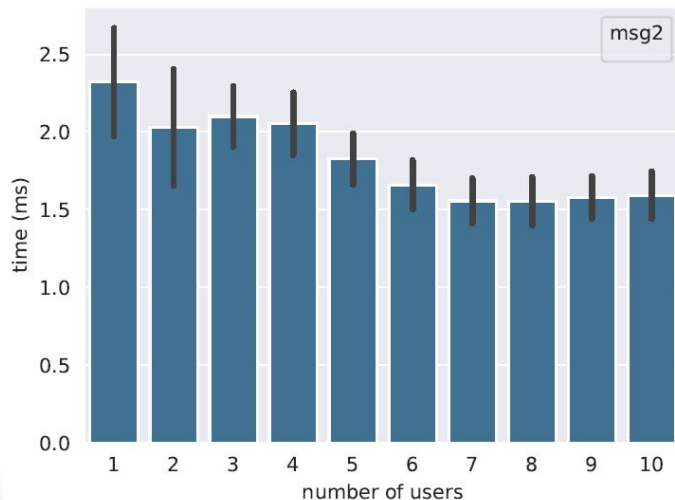
Delay on the control plane: UE+eNB and MME

- **Messages exchanged between UE + eNB and MME entities**

- Emulator present different behavior with 2 users configured.
- Peak value between 1 and 2 users.
- Peak value between 2 and 3 users:

```
        2VMs
        /    \
  2 users    1 user
```

Attach Request/Complete

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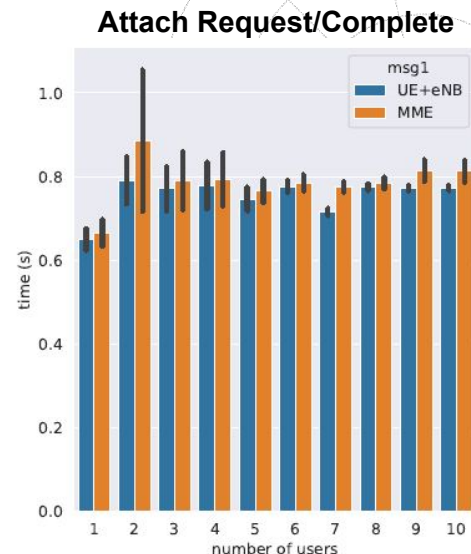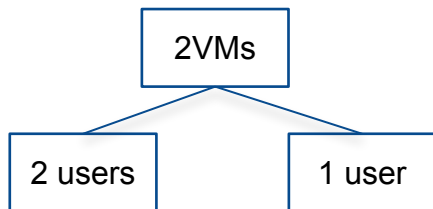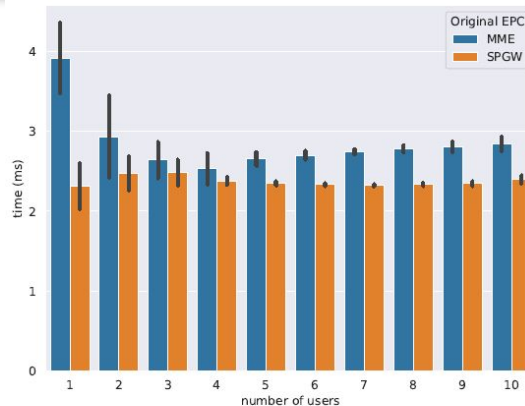
Delay on the control plane: MME and HSS

- **Message exchanged between MME and HSS:**
  - Authentication Information Request/Answer (msg2)
  - Update Location Request/Answer (msg5)
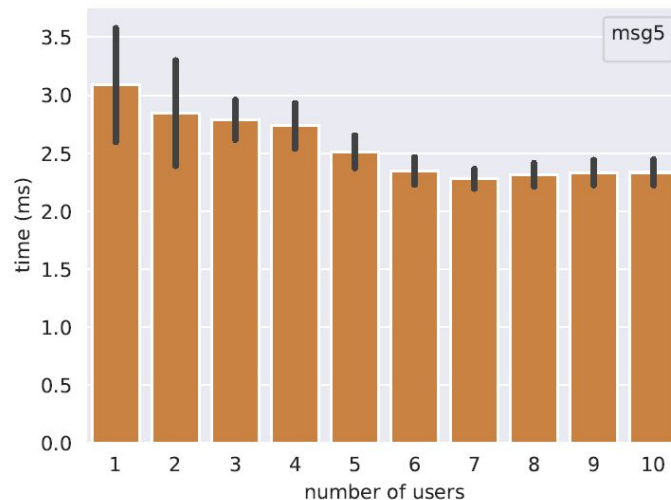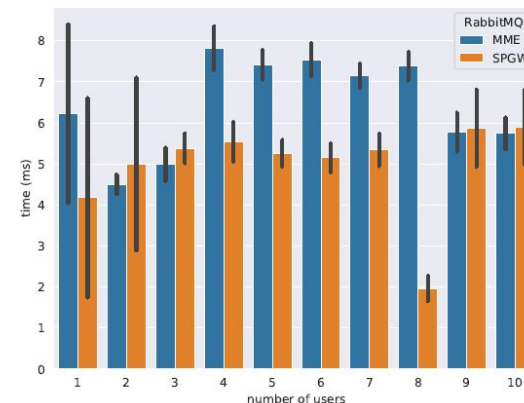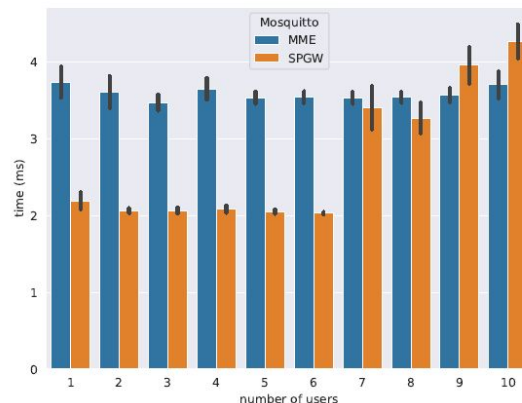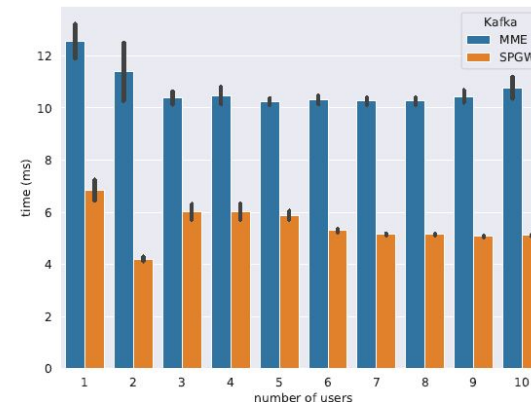
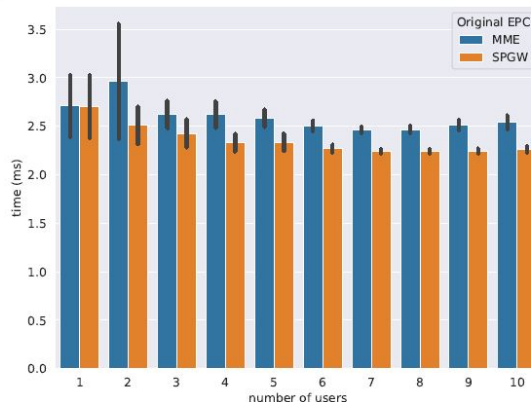# Delay on the control plane: MME and SPGW (1)

- **Messages exchanged between MME and SPGW entities:**
  - Create Session Request/Response message
  - Original EPC and different implementations
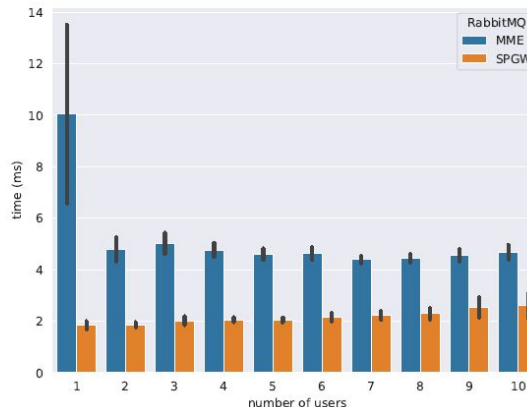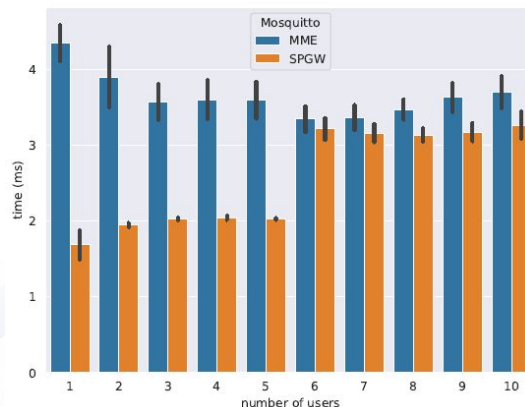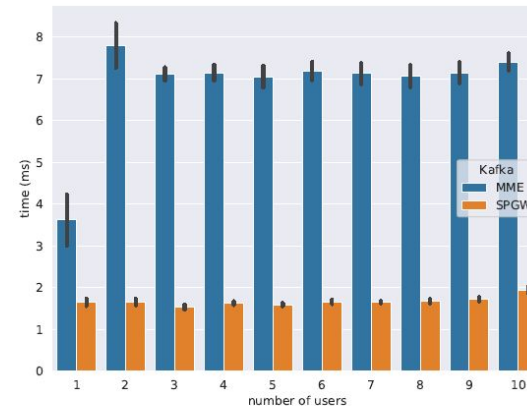
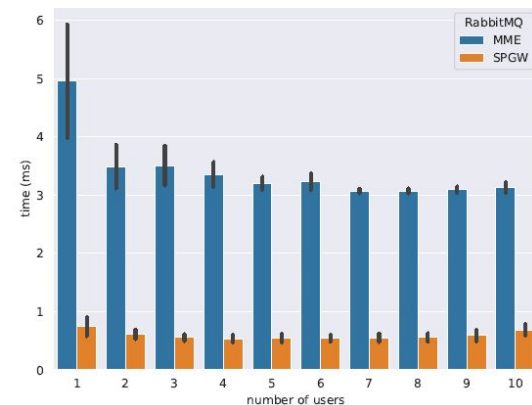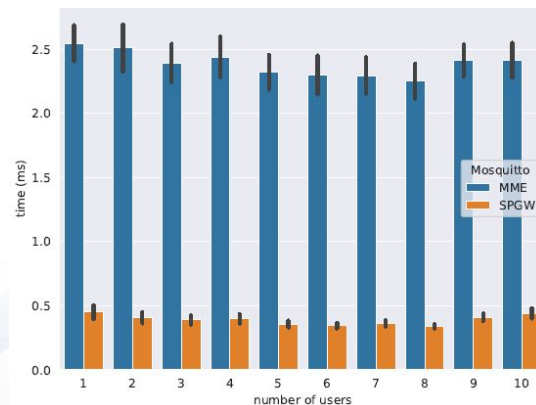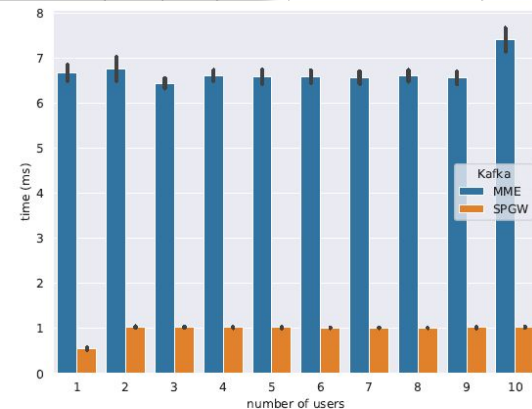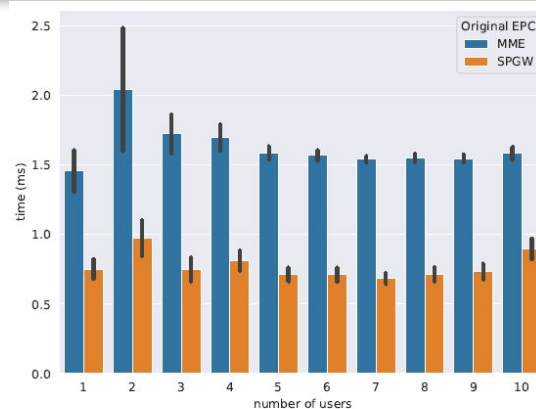# Delay on the control plane: MME and SPGW (2)

- **Messages exchanged between MME and SPGW entities:**
  - Modify Bearer Request/Response message
  - Original EPC and different implementations

# Delay on the control plane: MME and SPGW (3)

- **Messages exchanged between MME and SPGW entities:**
  - Release Access Request/Response message
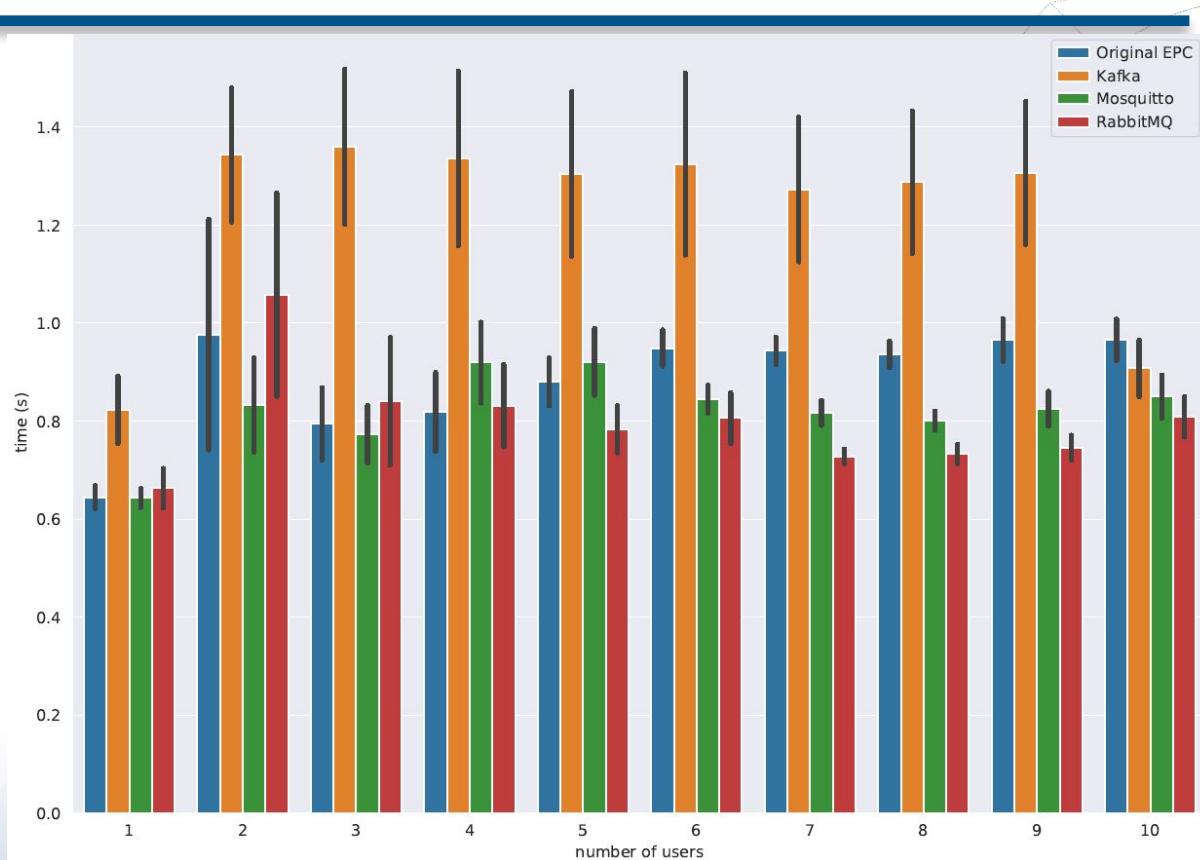 - Original EPC and different implementations

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Delay on the control plane: Broker

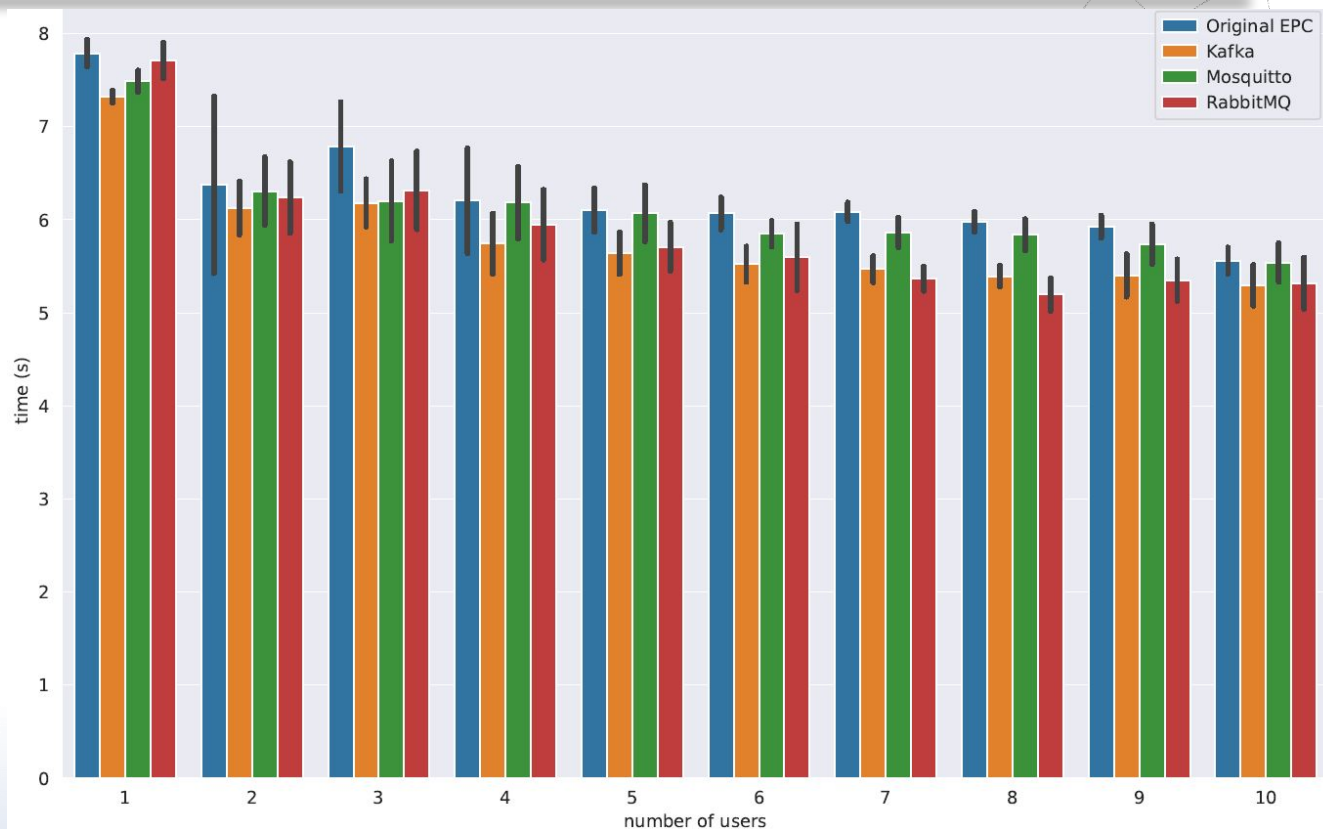- **Processing time in broker:**
  - Request message: Request MME -> Broker and Broker ->SPGW (msg12)
  - Response message: Response SPGW -> Broker and Broker -> MME (msg13)
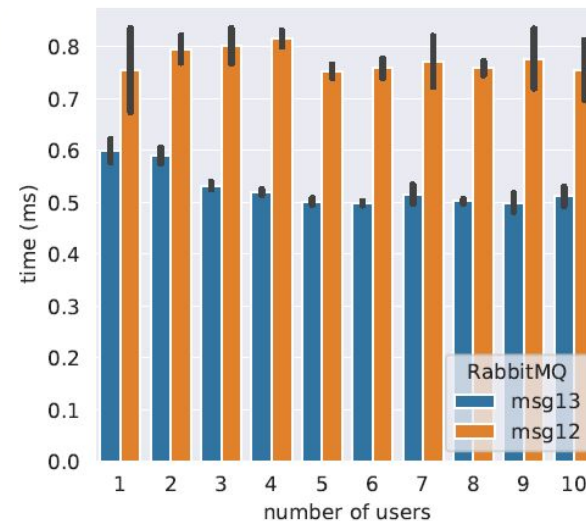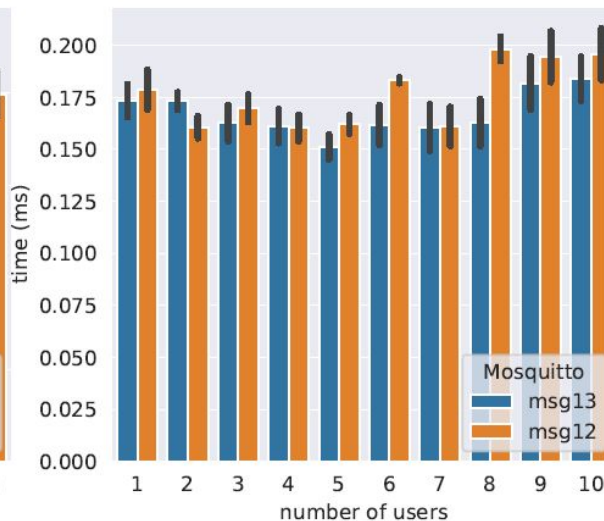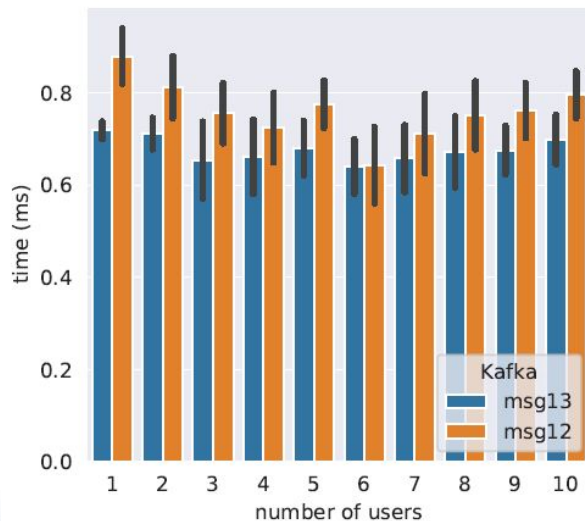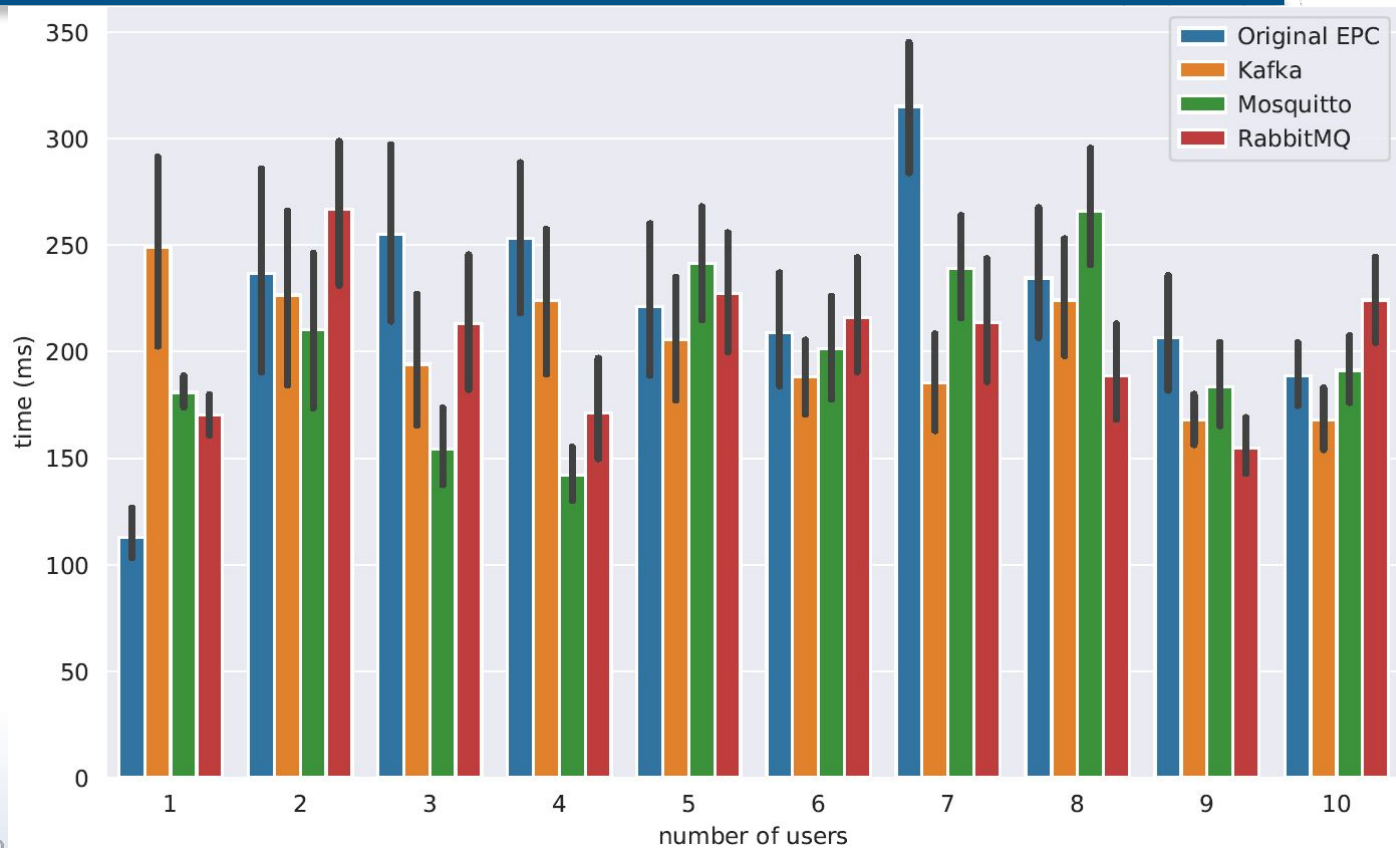
Attachment time

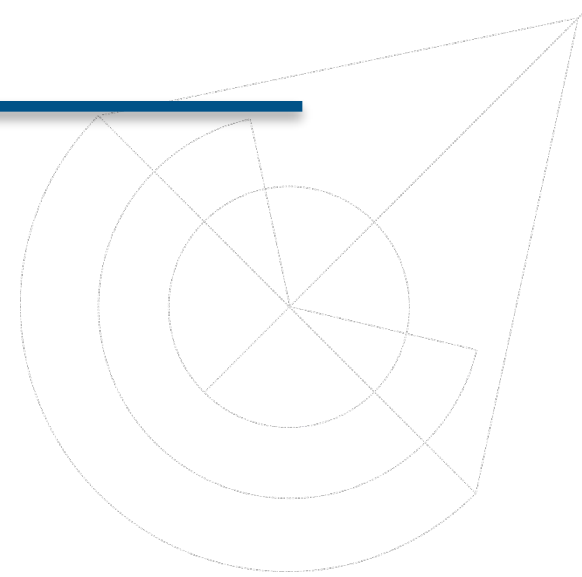# Execution time

Latency

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Conclusions

- Solution aimed to evolve intercommunication mechanisms between mobile networks using brokers;

- Although some results are marginally worse than Original EPC, they represent a small percentage of the entire execution;

- Message broker is a viable option because it enables communication with generic interfaces.

Future work

- Use physical devices;

- Integrate message brokers between the other entities of the control plane;

- Development of MME and SPGW using REST API;

- When OAI's 5G version is available, do the same tests and compare to the ones presented;