MOSAIC-5G.io
A community led consortium

Leveraging an Ecosystem of 5G services

What is FlexRAN?

A Flexible and Programmable Platform for Software-Defined Radio Access Networks

FlexRAN objectives

- Centralized and distributed RAN control

- Real-time and flexible coordination

- Abstraction and programmability of reusable network functions via extendable APIs

- Support of RAN, Content and Device/Provider optimization use cases

FlexRAN features

- **RAN Control and Data plane Separation**
  - ☐ Allow operators to open RAN to authorized third-parties
  - ☐ Deploy innovative applications for mobile subscribers, enterprises and vertical segments
- **Centralized & Real-time Control**
  - ☐ Ease BS coordination and simplify sophisticated control mechanisms
  - ☐ Support real-time control applications with stringent time constraints (e.g., MAC scheduler)
- **Abstraction and Virtualized Control Functions**
  - ☐ Modular structure and well-defined interfaces
  - ☐ *"On-the-fly"* upgrade of any control function without affecting the rest of the system
- **Control Delegation & Policy Reconfiguration**
  - ☐ Delegate control functions from FlexRAN controller to BSs at runtime
  - ☐ *"On-the-fly"* reconfiguration of the functions parameters

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FlexRAN schema
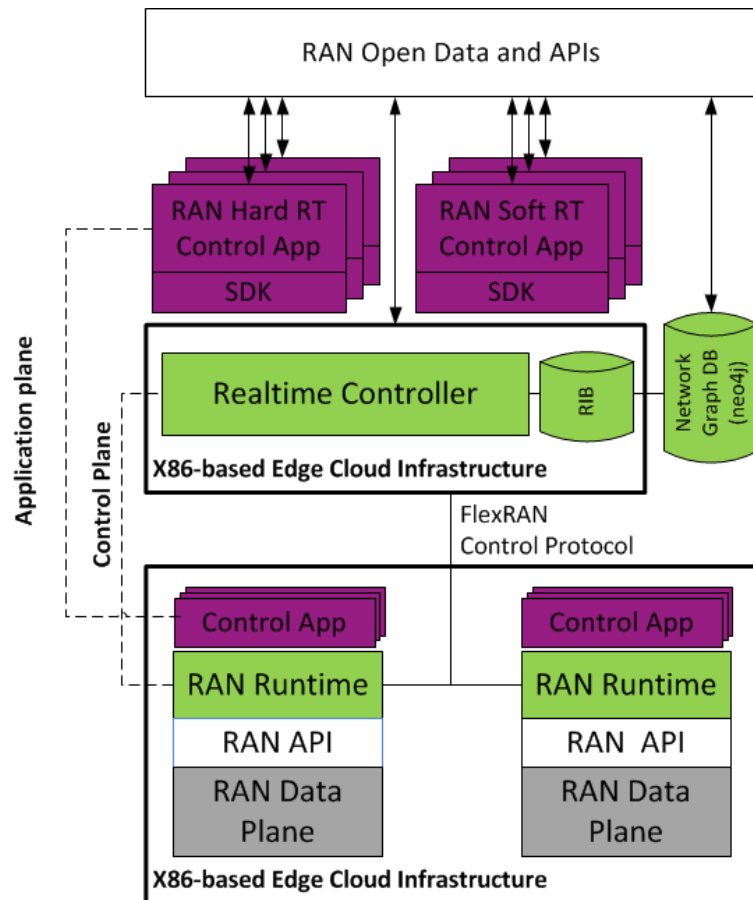
- ❑ **Plug & Play control apps**
  - ✓ SDK for App-to-App and App-to-RAN
- ❑ **FlexRAN Master Controller**
  - ✓ Top level controller/orchestrator
  - ✓ eNB/UE state and resources
- ❑ **FlexRAN Runtime**
  - ✓ Abstraction and programmability of network functions
  - ✓ Extendable RAN APIs
  - ✓ Virtualized resources and states
  - ✓ Local controller
- ❑ **FlexRAN Protocol**
  - ✓ Statistics
  - ✓ Configurations
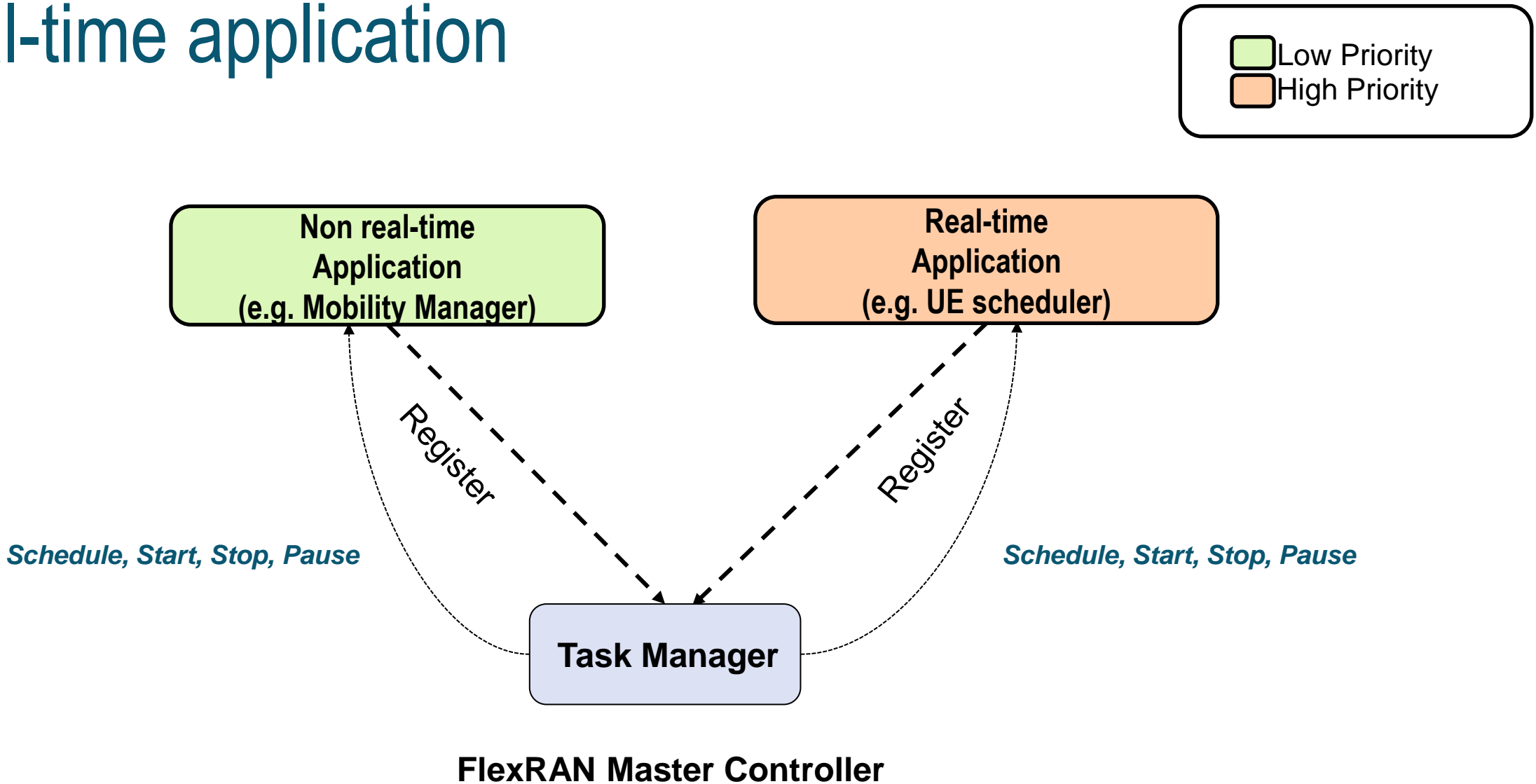 - ✓ Commands
  - ✓ Event Trigger
  - ✓ Control delegation

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FlexRAN implementation

- FlexRAN Realtime Controller (aks as RTC)

  ☐ From scratch in C++ (a test version in Python)

  ☐ x64 Linux support

  ☐ Support hard real-time and soft real-time mode of operation

  ☐ Software release under Apache V2.0 license

- FlexRAN Runtime (aka Agent)

  ☐ Developed in C

  ☐ Build on the top of OpenAirInterface (OAI) LTE software platform

  ☐ Local RAN control

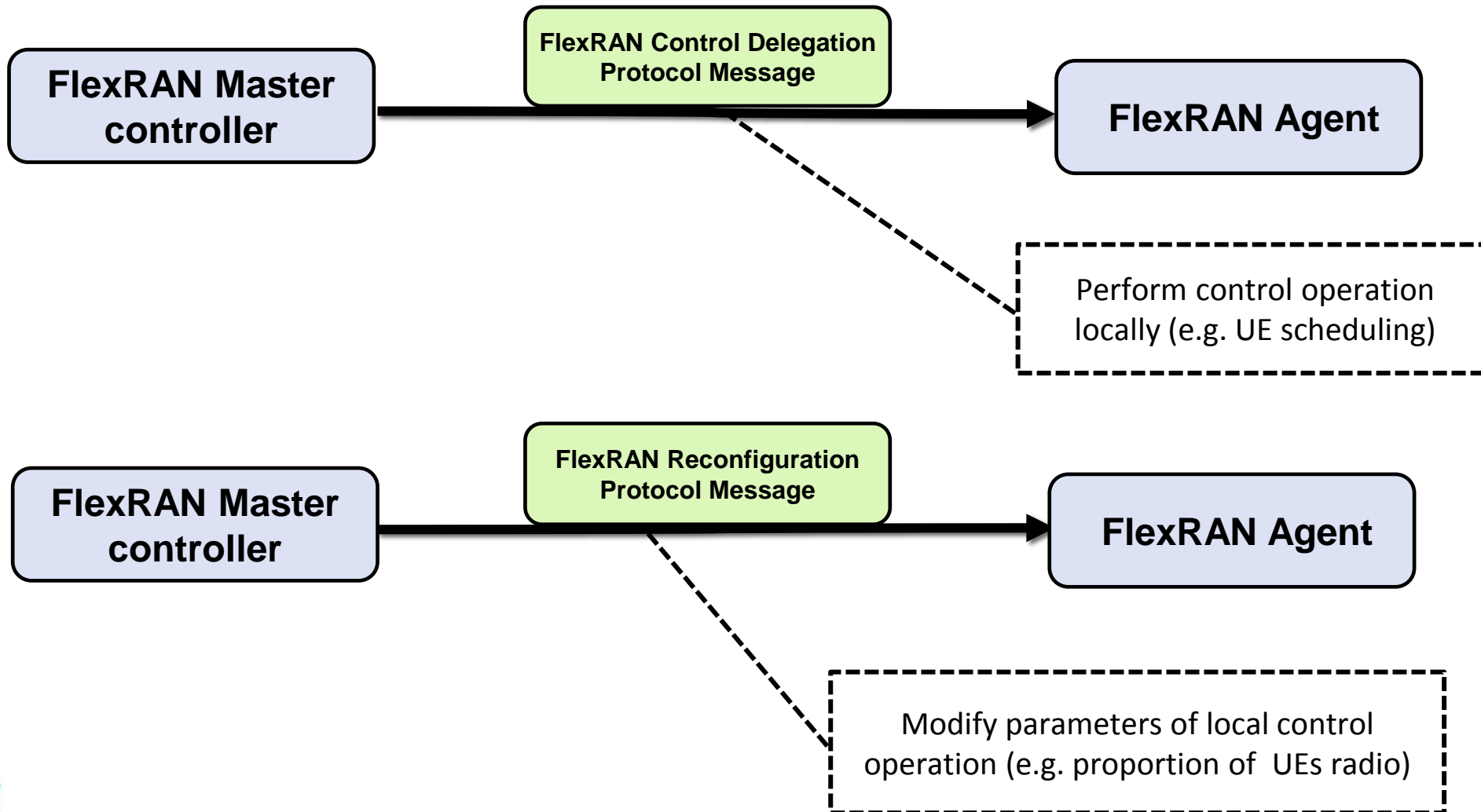 ☐ Software release under OAI Public License V1.1

- FlexRAN Protocol: Protobuf

FlexRAN API

API	Target	Direction	Example	Applications
Configuration (Synchronous)	eNB, UE, Slice	Controller → RAN	• UL/DL cell bandwidth, Reconfigure DRB, • RSRP/RSRQ/TA	• Monitoring • Reconfiguration • SON → cognition
Stats, Measurements (Asynchronous)	eNB, UE, Slice	RAN → Controller	• CQI measurements • SINR measurements • UL/DL performance	• Monitoring, • Optimization, • SON → cognition
Commands (Synchronous)	Agent	Controller → RAN	• Scheduling decisions • Admission control • Handover initiation	• Hard real-time control • Soft real-time control • SON → cognition
Event Trigger	Master	RAN → Controller	• Per TTI • UE attachment • Scheduling request • Slice created/destroyed	• Monitoring, • Control actions
Control delegation	Agent	Controller → RAN	• Update DL/UL scheduling • Update HO algorithm	• Programmability, • Multi-service

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Real-time application

| Low Priority |
| High Priority |

Non real-time Application (e.g. Mobility Manager)

Real-time Application (e.g. UE scheduler)

Register

Register

Schedule, Start, Stop, Pause

Schedule, Start, Stop, Pause

Task Manager

FlexRAN Master Controller

Control Delegation and Reconfiguration

FlexRAN Master controller → FlexRAN Control Delegation Protocol Message → FlexRAN Agent

Perform control operation locally (e.g. UE scheduling)

FlexRAN Master controller → FlexRAN Reconfiguration Protocol Message → FlexRAN Agent

Modify parameters of local control operation (e.g. proportion of UEs radio)

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FlexRAN apps

- RAN programmability and re-configurability

- RAN Sharing & Virtualization

- Mobility Management

- Network Slicing

- Spectrum Management

- RAN Data Mining and Analysis

- RAN-aware video optimization

- Dynamic function split and changes in service definition

- Centralized Coordinated Scheduling and Interference management

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FlexRAN scalability (1/2)
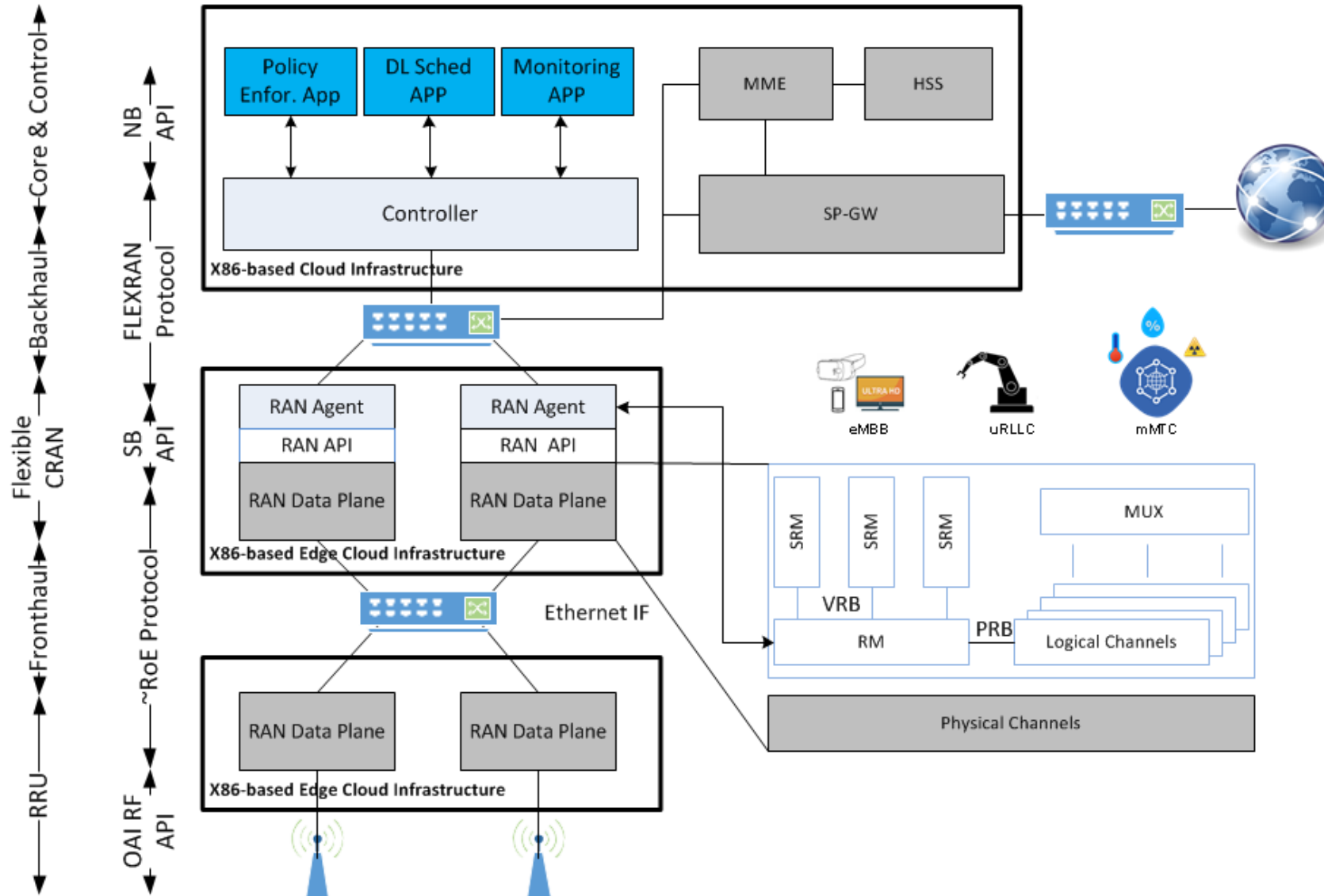

Agent-to-controller overhead
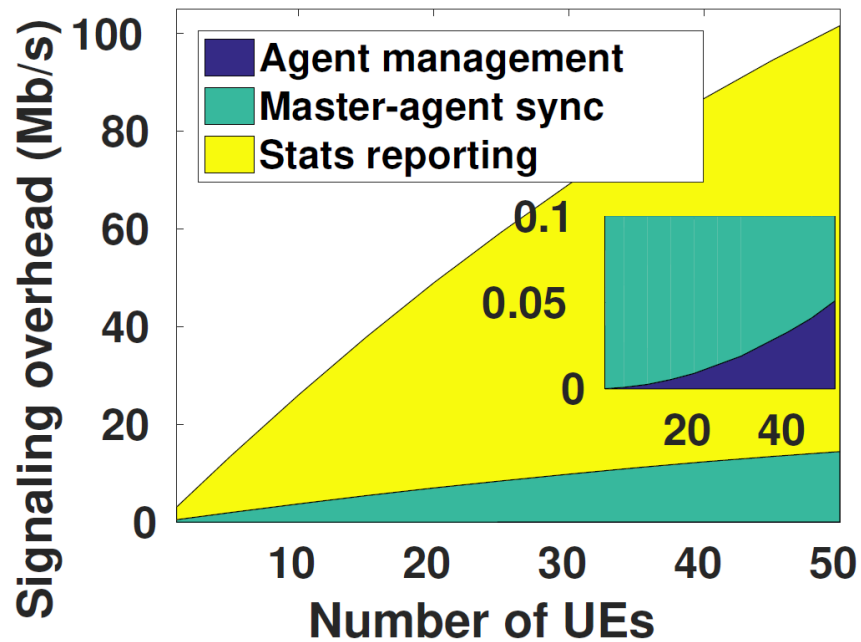
Controller-to-agent overhead
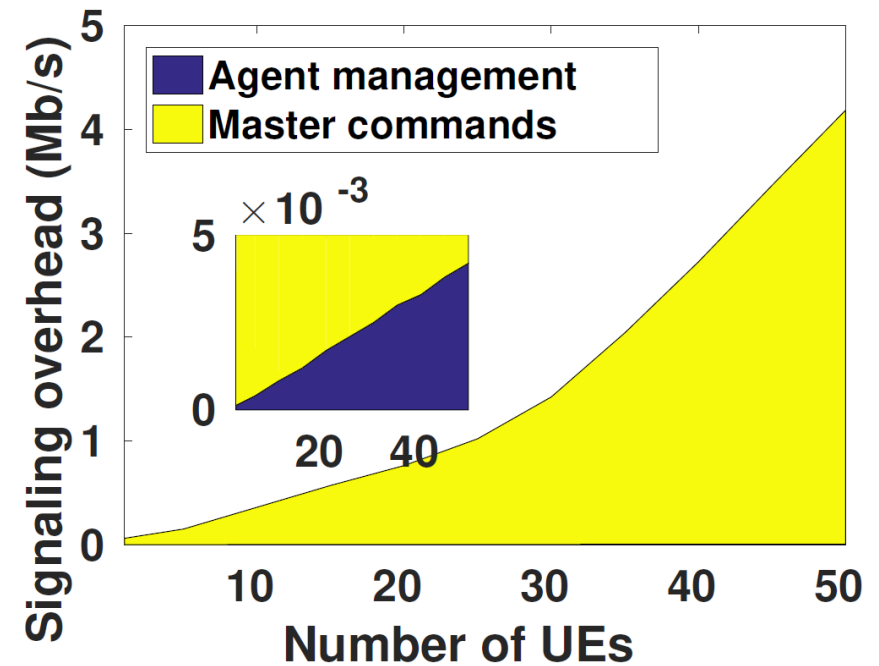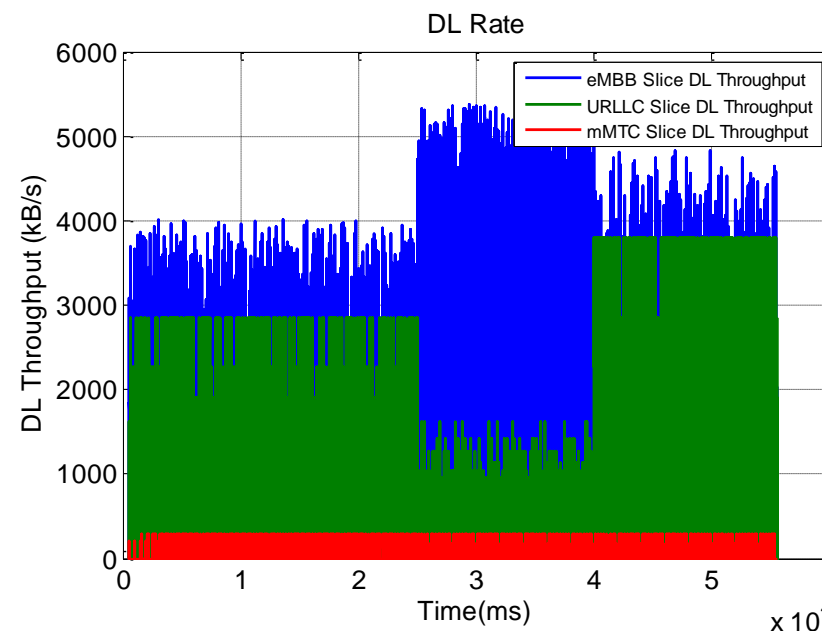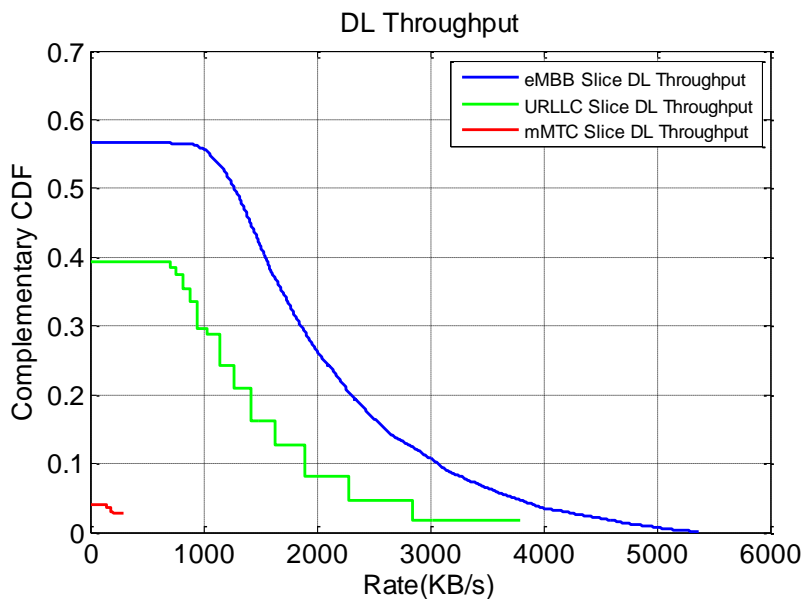
FlexRAN scalability (2/2)
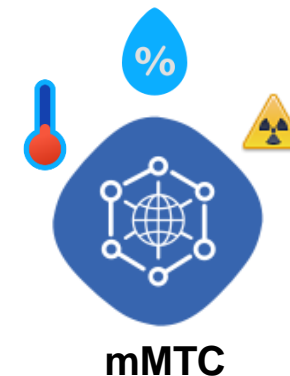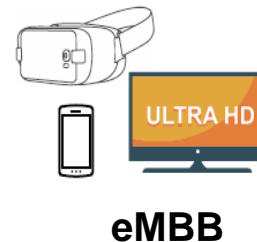
CPU Utilization
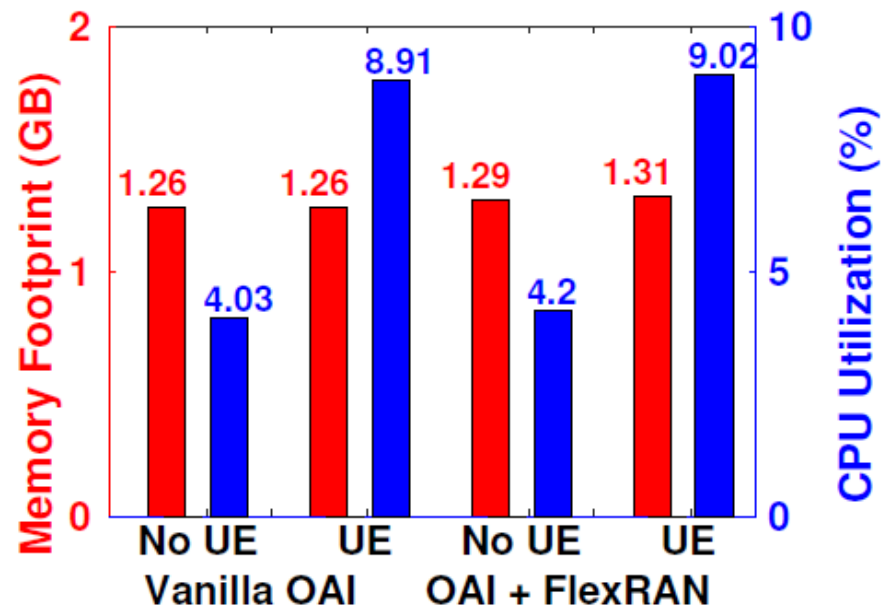
Memory footprint
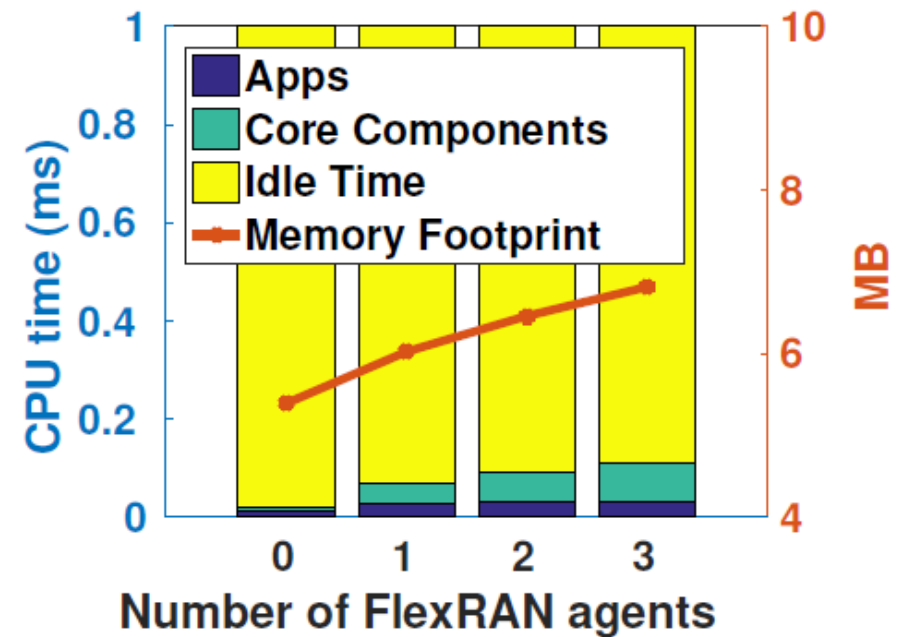
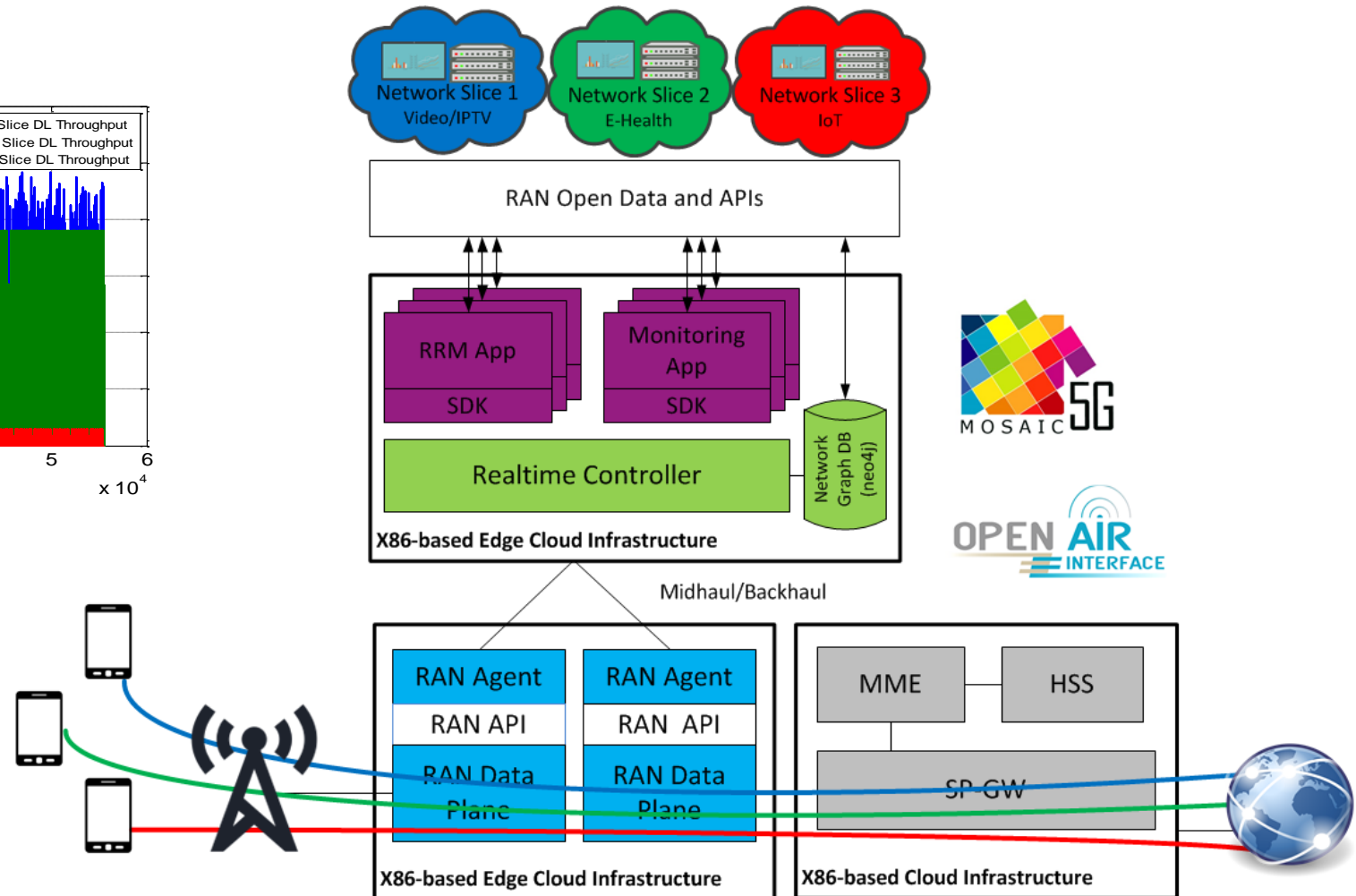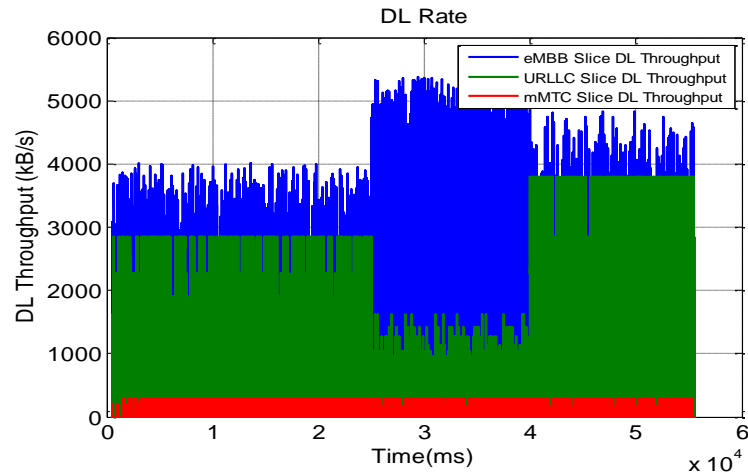# PoC Setup: RAN Slicing demonstrated at ITU workshop

RAN Slicing sample results

- ✓ 3 slices
- ✓ Slice-specific scheduling
- ✓ Dynamic slice resource management
- ✓ Enforce different policies over time

eMBB

uRLLC

mMTC

DL Throughput

Complementary CDF vs Rate(KB/s)
- eMBB Slice DL Throughput
- URLLC Slice DL Throughput
- mMTC Slice DL Throughput

DL Rate

DL Throughput (kB/s) vs Time(ms) $\times 10^4$
- eMBB Slice DL Throughput
- URLLC Slice DL Throughput
- mMTC Slice DL Throughput

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PoC Setup: RAN and Spectrum Sharing Demo

FlexRAN evaluation results

- Minimal memory and CPU overhead at BS with FlexRAN runtime support

- Lightweight and scalable operation of FlexRAN Master Controller

- No service disruption due to control delegation

- Adaptable centralized scheduling in the presence of Master-Agent communication latency

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Useful links

- RAVEN

- Slicing Cloud RAN

- FlexRAN platform

- How to build a RAN slicing platform?

Mosaic5G-Contact

E-mail: flexran_user@lists.eurecom.fr

Website: mosaic-5g.io/flexran

Twitter: @mosaic5g