# Resource Allocation in vRANs

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## Research context and motivation

- Requirements of beyond 5G and 6G wireless communications demand to support
  - ➔ service heterogeneity,
  - ➔ coordination of multi-connectivity technologies,
  - ➔ on-demand service deployment.
- **Virtualised Radio Access Networks RAN (vRAN)**- key technology enabling such a transformation using the concepts of *virtualization*, *flexibility*, and *intelligence*.
- **Network slicing** enables diversified services to be accommodated by isolated slices in vRANs.
- Virtualized baseband functions can instead, be run on commodity server hardware, usually at the *edge*.

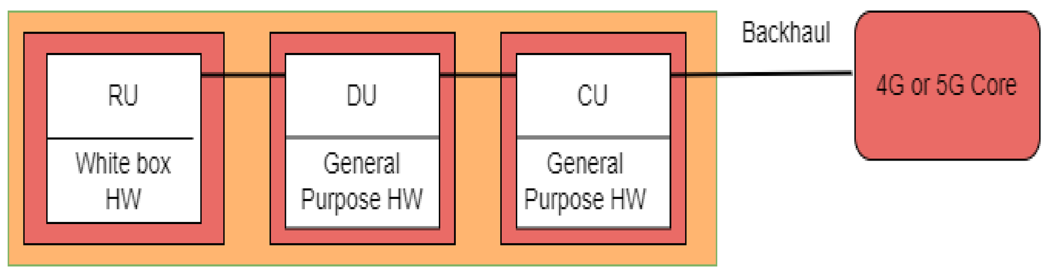



**Fig. 1. Disaggregation Functional Split RAN**
**RU: Radio Unit, DU: Distributed Unit, CU: Centralized Unit**

- Advantages:
  - ➔ Cost-effectively *scales up or down* computing resources with demand
  - ➔ Infuses RAN with capacity for *application intelligence* to significantly improve *service quality* and *reliability*.
- Challenges:
  - ➔ limited resource availability at the edge
  - ➔ competition for resources between user and network services
  - ➔ complex dependencies between data processed by each service
  - ➔ heterogeneous, stringent KPIs.
  - ➔ maintain satisfactory user experience, high profit for service providers in a dynamic environment

## Addressed research questions/problems

- Substantial cost savings- Dynamically adapting allocation of resources to the temporal variations of demand across vRANs.
- When to scale, how much to scale?
  - ➔ Hands-on understanding of the behavior of vRANs and the relation between radio and computing/memory resources
- Design of automated and efficient resource orchestration framework at the edge.
  - ➔ VERA (Virtualized Edge for Radio and user Applications), a novel RL framework for joint allocation of computing and radio resources across user applications and vRAN
  - ➔ Pareto analysis for fair and efficient decision making.
  - ➔ Proof-of-concept through a containerised edge and an srsRAN-based testbed.

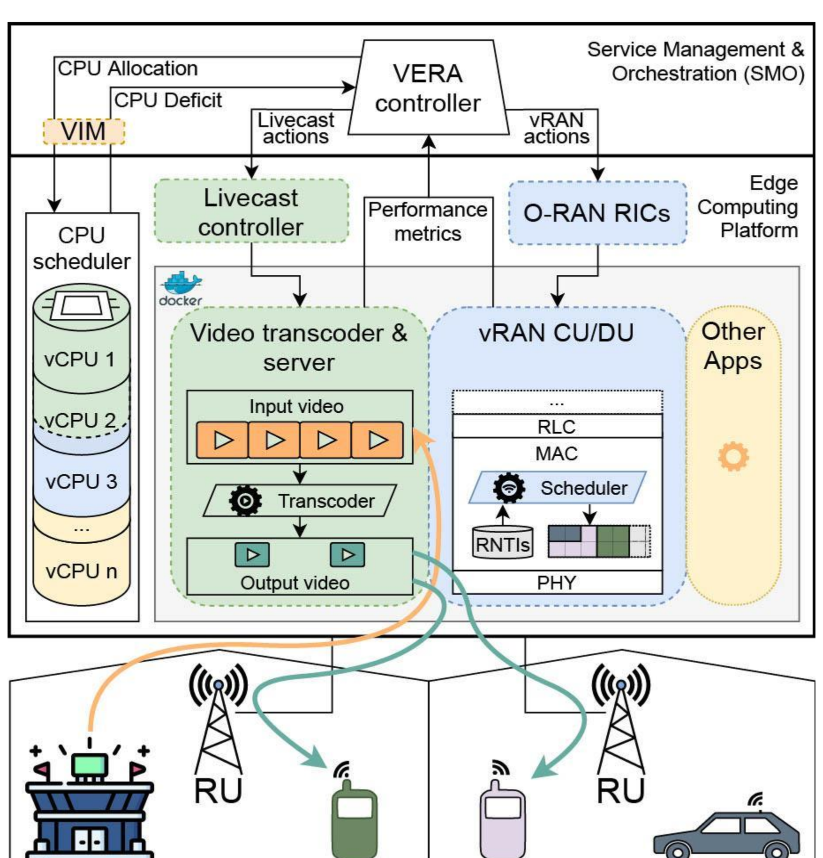



**Fig. 2. Virtualized livecast and vRAN at the edge**

- Design of optimal RAN slicing control strategy, which tends to maximise the expected long-term slice profit when resources are scarce while guaranteeing the QoS objectives for the slices, as well as slice isolation.
  - ➔ Relationship between resource efficiency and profit maximization
  - ➔ Maximization of net social welfare and slice providers profit are two consistent objectives when resources are scarce.

## Submitted and published works


- Characterizing the Computational and Memory Requirements of Virtual RANs, Somreeta Pramanik, Adlen Ksentini, Carla Fabiana Chiasserini, 17th Wireless On-demand Network systems and Services Conference (WONS) 2022
- VERA: Resource Orchestration for Virtualized Services at the Edge, Sharda Tripathi, Corrado Puligheddu, Somreeta Pramanik, Andres Garcia-Saavedra, Carla Fabiana Chiasserini, International Conference on Communications (ICC) 2022.
- Fair and Scalable Orchestration of Network and Compute Resources for Virtual Edge Services, Sharda Tripathi, Corrado Puligheddu, Somreeta Pramanik, Andres Garcia-Saavedra, Carla Fabiana Chiasserini, submitted to IEEE Transactions on Mobile Computing (TMC), 2022


## Novel contributions

- Regression model- predicts CPU utilization of virtual eNB with number of served users.
- Every additional UE is expected to entail about 4.1% of increase in CPU usage at the eNB.

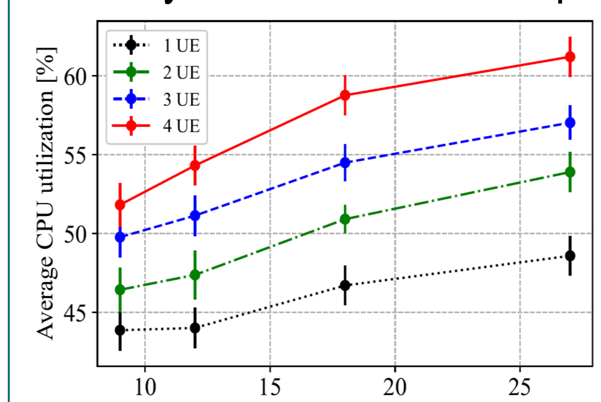



**Fig. 3(a)**

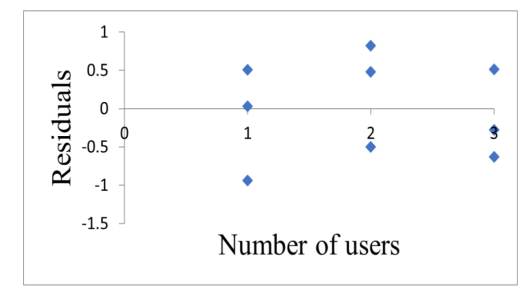



**Fig. 3(b) Residual plot for different MCS & 36 occupied RBs**

| MCS index | Actual CPU [%] | Predicted CPU [%] |
|---|---|---|
| 12 | 54.31 | 55.55 |
| 18 | 58.76 | 57.71 |
| 27 | 61 | 61.19 |

**TABLE I: Actual vs predicted CPU usage with 4 UEs**

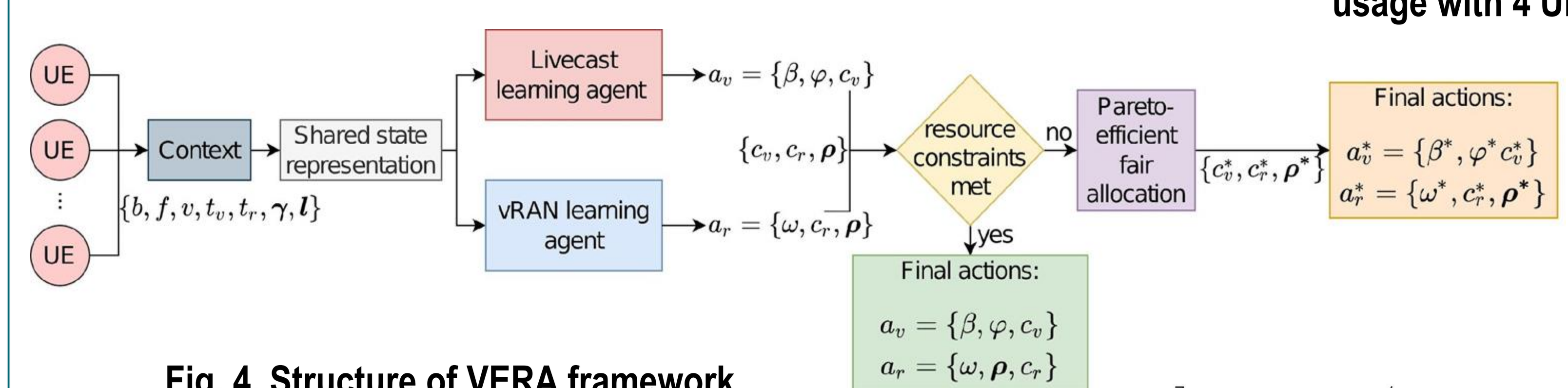
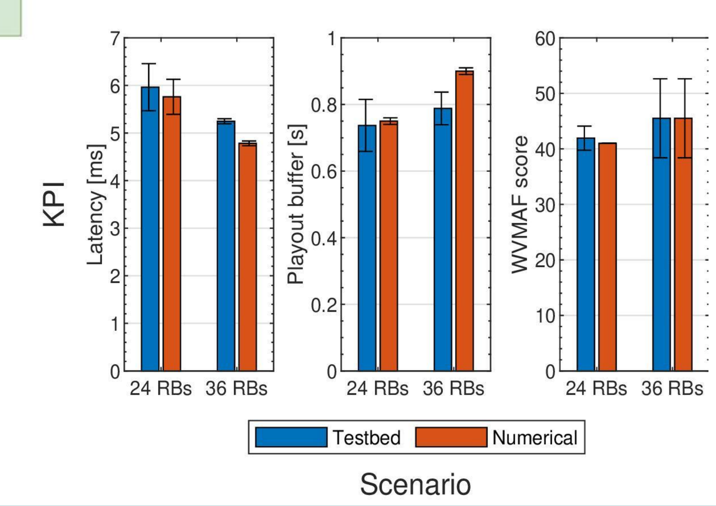



**Fig. 4. Structure of VERA framework**

- Pre-trained model of VERA RL agents in the test-bed for different available RBs and CPU
- Similarity between test-bed and numerical results validates VERA performance in real-time & demonstrates the effectiveness of our solution in a real-world environment.




## Adopted methodologies

- srsRAN-based experimental test-bed with 4 user equipment and an edge host.
- Performance profiling of the virtual Radio Point of Access (RPA) in terms of processing, memory and throughput.
- Prediction of the system behavior

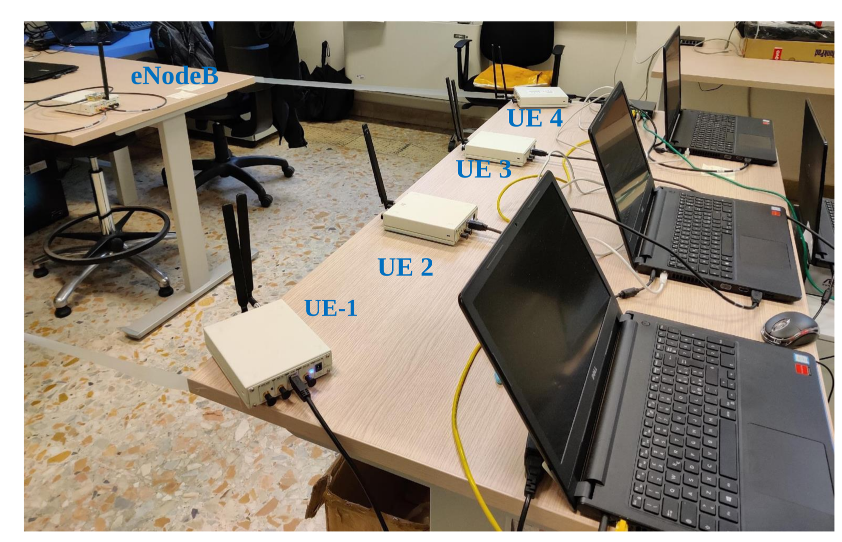



**Fig. 5. Snapshot of our test-bed**

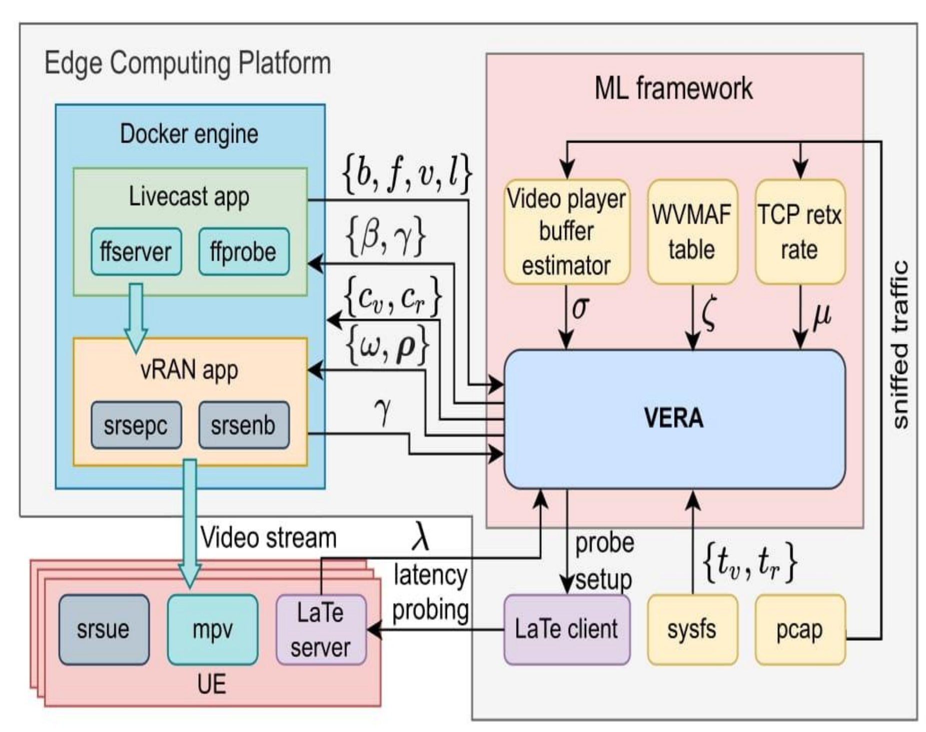



**Fig. 6. VERA IMPLEMENTATION**

- Implemented VERA in the testbed, ffserver (to emulate a livecast video service), and mpv (livecast video client deployed at each UE video player).
- VERA's learning agents receive real-time context information and the reward signal directly from the vRAN, the livecast service, and the edge computing platform.

## Work in progress

- Optimal RAN slicing control strategy
  - ⟶ tends to maximise the expected long-term profit for service providers when resources are scarce while guaranteeing the QoS objectives for the slices, as well as slice isolation.

## List of attended classes

- 01UJBRV- Adversarial training of neural networks (3/6/2021, credits:3)
- 01DTPRV- Connected Vehicles (23/6/2022, credits:4)
- 02SFURV- Programmazione scientifica avanzata in matlab (25/5/2021, credits:6)
- 02QUBRS- Statistical data processing (4/2/2021, credits:4)
- 01UNWRV- Intercultural & interpersonal management(22/6/2022, credits:1)
- Summer School- Complex networks and telecommunications: Towards 6G (5/7/2021, credits:5)
- Summer School-Machine Learning, Sustainable Edge Computing and Networking (11/7/2022, credits:5)