Politecnico di Torino
Dipartimento di Automatica e Informatica

PhD in Computer and Control Engineering
XXXVI cycle

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Orchestrating Edge Computing Services with Efficient Data Planes

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1. Edge data centers optimization

With the advent of **Multi-access Edge Computing (MEC)**, telco operators are moving their network functions (NFs) to small, distributed data centers close to the end user to provide **low latency**, **high bandwidth** services. This infrastructure must be shared with low latency applications running at the edge. **Features of edge data centers**:

- **Reduced amount of resources.** Many small edge DCs are needed, spread across different geographical locations.
- **Stringent requirements.** Telco-operators NFs must support the traffic of many users (bandwidth), applications at the edge must reply in short times (latency).

OBJECTIVE: improve flexibility, resource usage and power consumption of edge DCs while guaranteeing satisfaction of requirements.

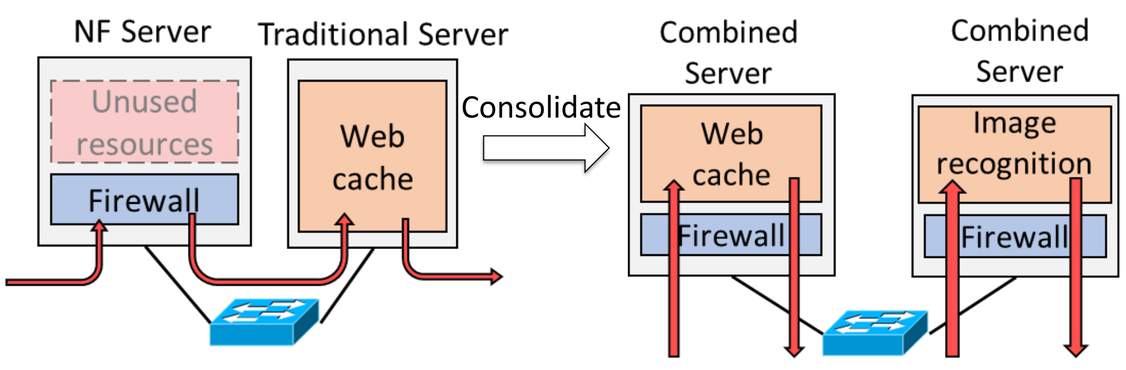
2. Consolidation of network functions and traditional applications

Traditional approach, partitioned data center:

- **NF servers.** Kernel-bypass packet processing framework to deliver packets to NFs (DPDK).
- **Traditional apps servers.** Rely on standard kernel TCP/IP stack to connect applications.

The advantages of **consolidation**:

- **Uniform DC.**
- **Allocate resources of a server to any task.**
- **Reduce east-west traffic.**



How?

- **Kernel-integrated fast packet processing.**
- **eBPF**. Inject custom, safe programs in kernel.
- **XDP.** Run eBPF programs in the NIC driver [1].

4. Secure, responsive virtualization for multi-tenant scenarios

Opportunity to **maximize resource usage** ➔ **Combine workloads from multiple tenants** on the same machines. Example: deploy **O-RAN components** in **multi-tenant edge**.

Requirements:

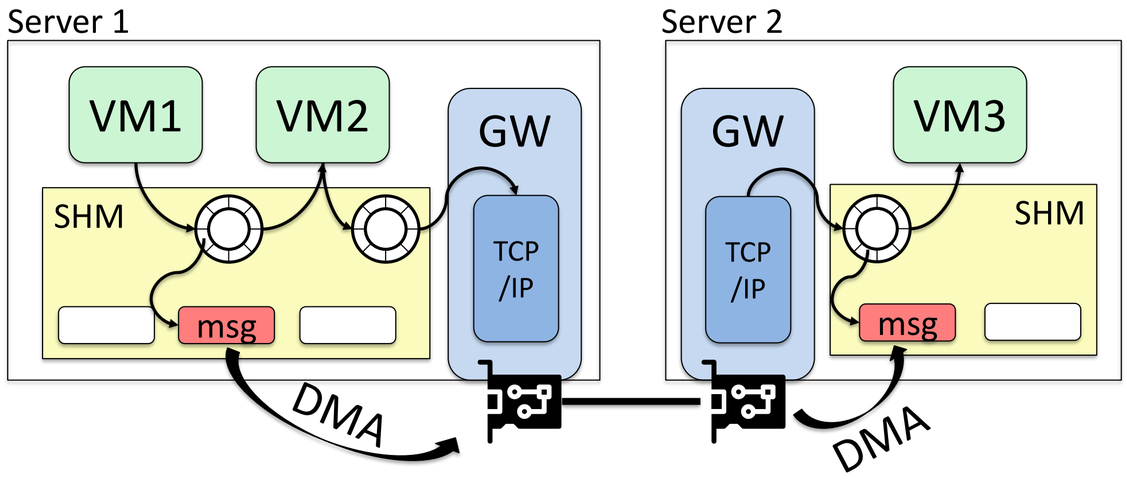
- **Isolation** (network critical components)
- **Networking performance** (microservices)

Current virtualization solutions:

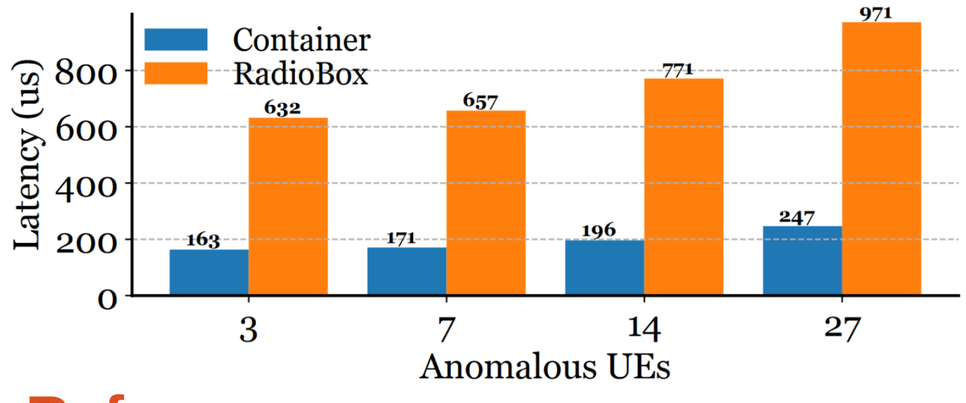
- **Container: low isolation, network overhead.**
- **VM: heavyweight, higher network overhead.**

Our new virtualization solution, **Radiobox**:

- **Lightweight and secure**: Unikernel in a VM.
- **High speed adaptive data plane**
  - TCPless shared memory zero-copy intra-node communication.
  - Zero-copy user space TCP/IP stack for inter-node communication.



- 4 times **lower latency compared to containers** when running O-RAN control loops.



4. References

1. Parola F., Procopio R., Querio R., Risso F., "Comparing User Space and In-Kernel Packet Processing for Edge Data Centers". Computer Communication Review (2023)
2. Parola F., Qi S., Narappa A. B., Ramakrishnan K. K., Risso F., "RadioBox: Lightweight, Responsive, and Secure Virtualization for 5G and Beyond Open Radio Access Networks". Submitted to USENIX NSDI 2024