

Towards Organic 6G Networks: Virtualization and Live Migration of Core Network Functions

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- Edge computing addresses the major requirement for the (I)IoT:
 - real-time capability through significantly shorter response times
 - the optimal utilization of bandwidth
- Flexibility of process plants is a core feature in the field of Industry 4.0
- In addition to the application, the networks themselves must also be flexible:
 - Network Functions Virtualization (NFV)

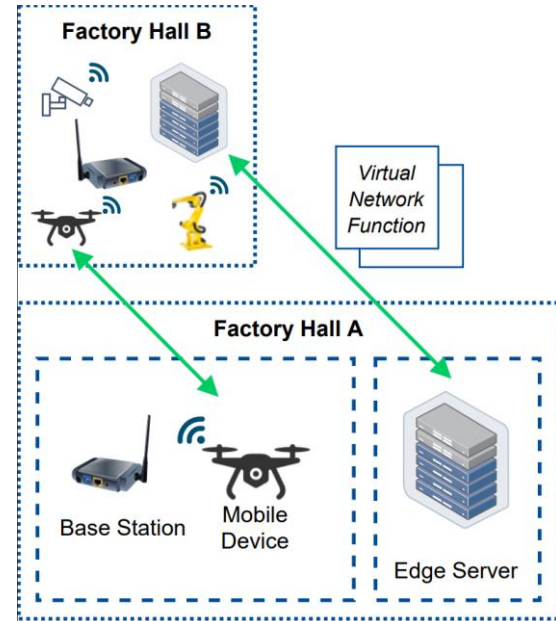


Figure 1: Exemplary use case in an industrial environment

- OS-level virtualization using Linux containers (docker, podman...) is more efficient compared to traditional VMs
- Use of container-virtualization has already been investigated in this context of many industrial applications
- Results can be transferred to Virtual Network Functions (VNFs) for 5GC

Netw. Driver	RTT [μ s]	Networking	Security
Host	522	L2 / L3	-
Bridge	600	L2 / L3	○
Macvlan	520	L2 / L3	○
Ipvlan (L2)	520	L3	○
Ipvlan (L3)	539	L3	○
Overlay	656	(L2) ¹ /L3	+

¹ Only valid for L2 overlay network drivers of K8s.

Table 1: Comparison of standard network drivers for communication between Docker containers

Live Migration introduction

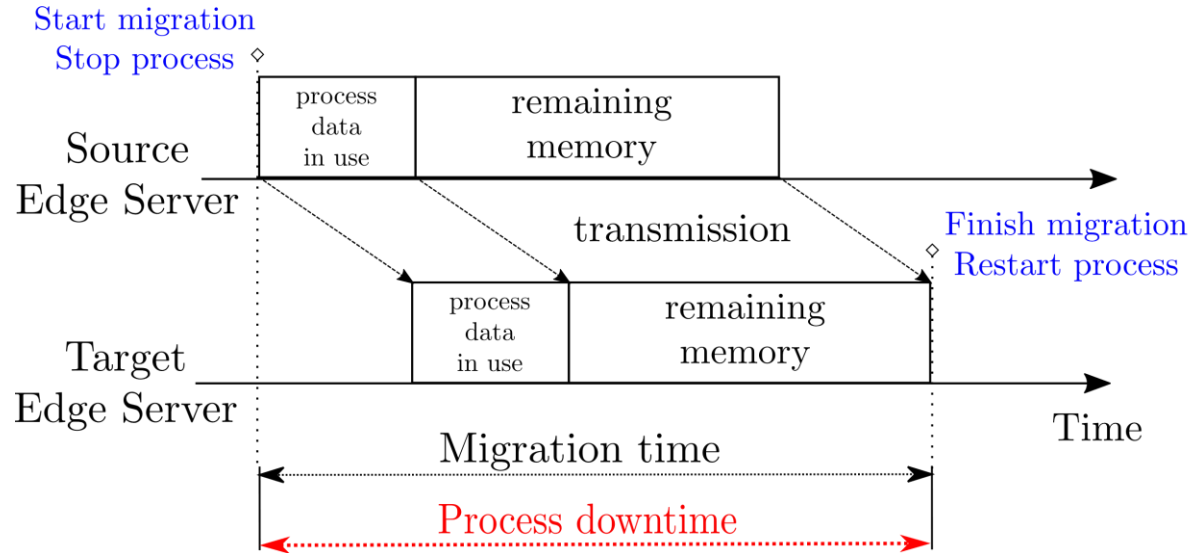


Figure 2: inter-migration procedure

Live Migration

pre- and post-migration

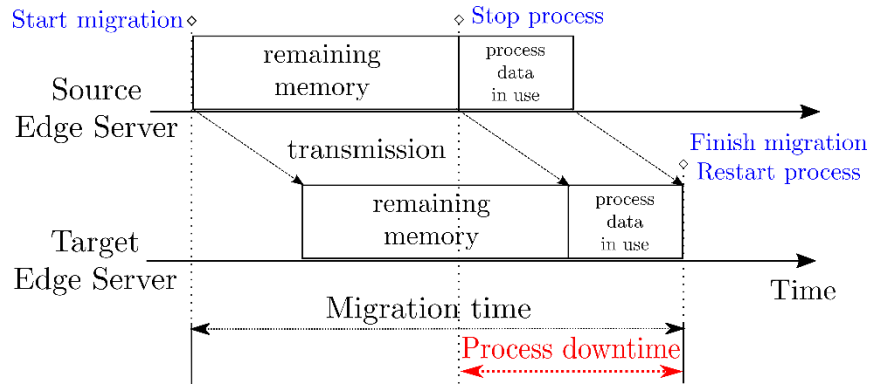


Figure 3: pre-migration procedure

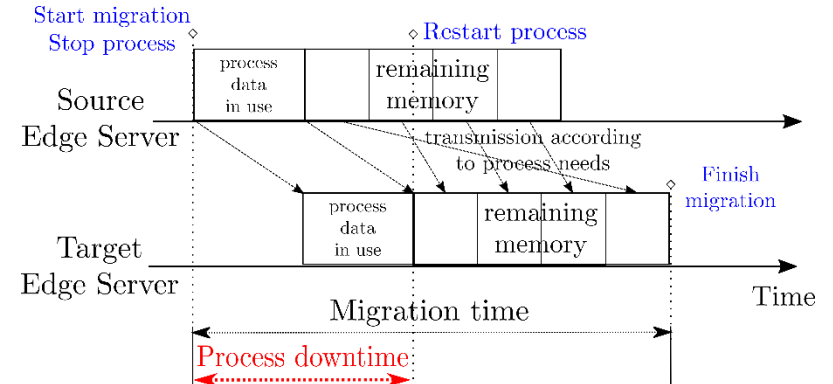


Figure 4: post-migration procedure

Live Migration

parallel process migration (PPM)

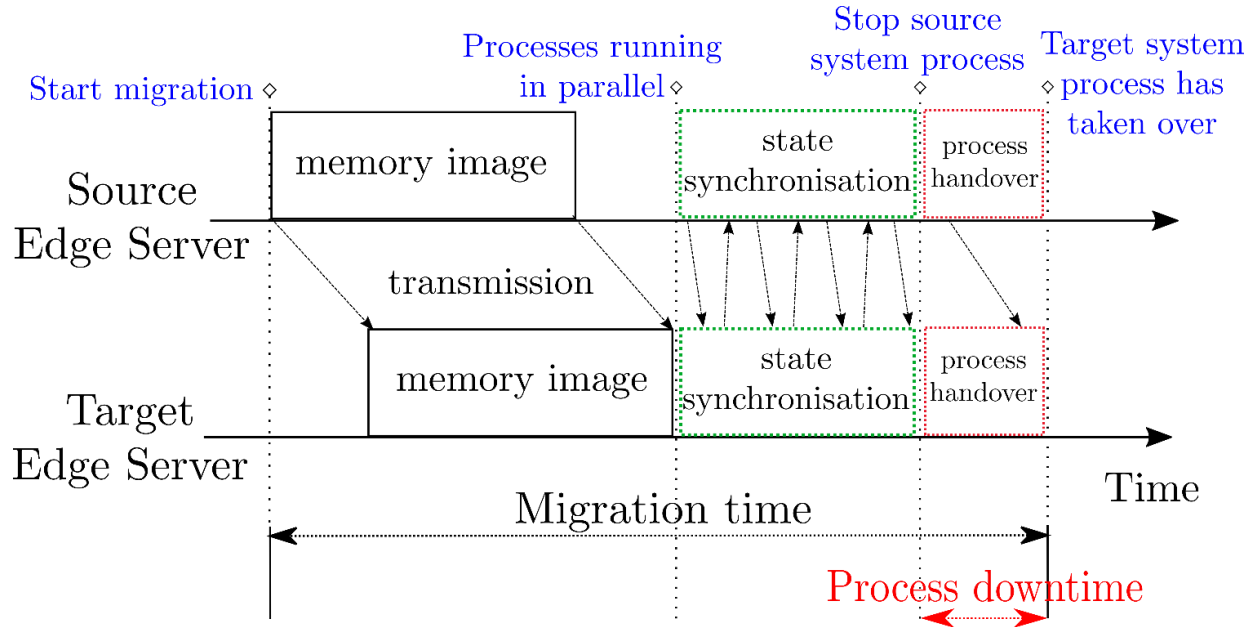


Figure 5: PPM procedure

5G Service Based Architecture (SBA) overview

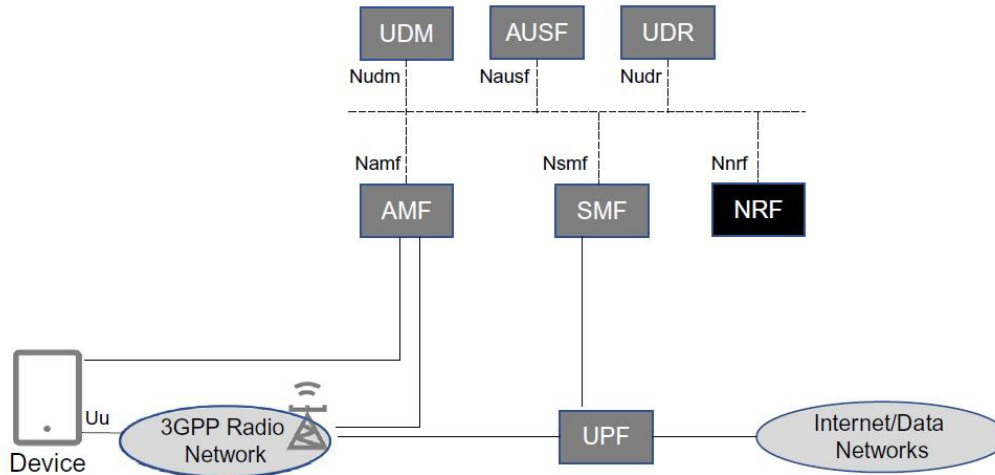


Figure 6: Mandatory components of a 5G network architecture and corresponding interfaces [1, p. 27]

- Functions in figure 6 are either mapped to the user or control plane
- User plane traffic is crucial for end user application
- The control plane functions are necessary for an appropriate operation of the 5G system

5G Service Based Architecture (SBA)

latency and availability analysis

Example 1: User Plane Function (UPF)

- **Main task:** processing and forwarding the user data
- Controlled by the Session Management Function (SMF) to ensure its functionality
- IP packets with a destination address belonging to a UE are always routed from the Internet to the specific UPF
- The UPF can therefore be considered **stateless** (no need of live migration)
 - Still high requirements for latency and availability
- Use of virtualization for automatic deploying and restarting on the hardware nodes
- Deploying multiple instances of an UPF makes practical sense for increased redundancy or optimal load balancing

5G Service Based Architecture (SBA)

latency and availability analysis

Example 2: Access and Mobility Management Function (AMF)

- Responsible for the interaction between
 - the user equipment (UE) via the N1 interface
 - the NG-RAN via the N2 interface
- The AMF is also providing support for the encrypted signaling connections
- All the control layer data between the UE and the 5GC as well as the data between NG-RAN and 5GC is forwarded by the AMF function
- Really high requirements on service availability (also stateful)
 - Application of a suitable Live-Migration procedure is necessary (like PPM)

- The core functionalities partly have very different requirements regarding latency and availability
- Organic network research are dominated primarily by the following trends:
 - Increased use of *container-based virtualization*
 - Adaptation of *container orchestration tools* (like comb. L2/L3 support)
 - Finding suitable *live migration strategies*

Thank you for your attention!

[1] S. Rommer, P. Hedman, M. Olsson, L. Frid, et al., *5G Core Networks: Powering Digitalization*. Academic Press, 2020. **page 27**.