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Personal Services Placement and Low-Latency Migration in Edge Computing Environments

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Technologies for 5G support

- Network technologies and architectures are facing a deep revolution in order to meet 5G requirements, such as the support for extreme low latency vertical applications and services.
- To this end, MEC has been widely accepted as one of the most viable solutions.
- By exploiting s NFV and SDN, MEC allows Telco Operators to high degree of personalization enabled by the knowledge of user location and the network data available within the Telco premises.
- Issue: additional management complexity.

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Scope of this Paper

- In this paper, we address the design of an edge computing framework to support personal services for mobile users in an effective and scalable fashion.
- The framework includes a very lightweight heuristic algorithm to orchestrate the autonomic placement of service components close to users, both when the service is subscribed and upon user move.
- Tests have been carried out to analyze the performance and the scalability of the orchestration algorithm.
- Further tests to evaluate the delays in the presence of different software migration technologies.

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Personal Services in the Edge (1)

- We consider a MEC infrastructure to deploy personal services at the edge facilities of telecom operators.
- Personal services designed in the form of a service chain composed of ServiceApps, stored in a service template, and instantiated only upon user subscription.
- ServiceApps can be potentially deployed in different Points of Presence (PoPs).
- The appropriate placement and dynamic (re)allocation is constrained by a proximity class, which represents the maximum allowed distance, from the user or among ServiceApps, able to guarantee the fulfilment of the SLA.

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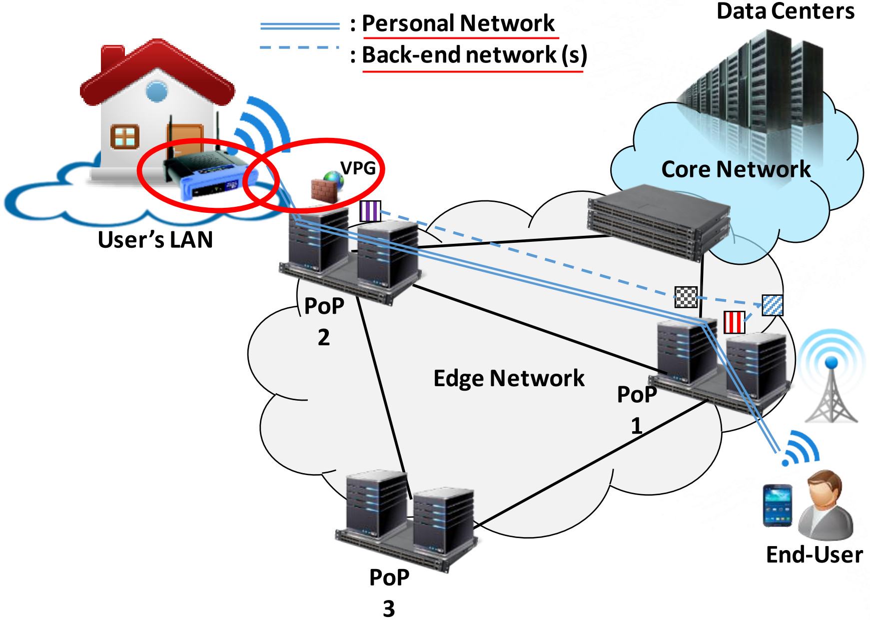
Personal Services in the Edge (2)



Back-end Networks: isolated L2/L3 broadcast network domains used for communication among ServiceApps of the same service.

Personal Network: interconnect the user to the service with the same level of isolation and security available in the LAN independently of the actual user location.

Virtual Personal Gateway (VPG): logically terminate the Personal Network and to offer a management interface to end-users.

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Network and Service Management in MEC (1)

- The deployment of L7 services closer to the mobile subscribers has the clear drawback of added scalability issues.
- The service chains must be migrated according to the actual user position while respecting the SLAs: huge amounts of data might be moved pointlessly in the absence of proper orchestration mechanisms.
- Orchestration algorithm for the autonomic placement of virtual service instances close to users on the move.
- Two phases: first, it is applied to determine the initial placement, and afterwards for the dynamic reallocation of service components.

Network and Service Management in MEC (2)

1. **EVENT**: NEW_USER, **INPUT**: *UserID, UserHomeLocation*
   a)Create and instantiate a new user's Personal Network
2. **EVENT:** NEW_SERVICE_SUBSCRIPTION, **INPUT:** *UserID, UserLocation, ServiceID*
   a)OptDatacenter= Find optimal hosting datacenters for each ServiceApp composing the service
   b)For each ServiceApp, find optimal hosting server in OptDatacenters
   c) Update Personal and Back-End Networks topology

Personal Network creation

Find optimal hosting datacenter for each ServiceApp composing the service

Given the target datacenter for each ServiceApp, find the destination hosting server

Create/update all the required overlay networks between the end-user and related deployed services

Network and Service Management in MEC (3)

3. **EVENT:** NEW_USER_LOCATION,
   INPUT: *UserID, UserLocation*
   a) If required, identify user's services to be migrated
   b) OptDatacenters = Find optimal hosting datacenters for each ServiceApp to be migrated
   c) Find the optimal hosting server for each ServiceApp to be migrated
   d) Update Personal and Back-End Networks topology
4. **EVENT:** SERVICE_UNSUBSCRIBE,
   INPUT: *UserID, ServiceID*
   a) TerminateService(*ServiceID, UserID*)

Check if the proximity levels of the subscribed services are satisfied

If not, repeat procedures as in new service subscription

Upon user unsubscription from a service, terminate the running service components and release the occupied resources

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Software Migration Technologies

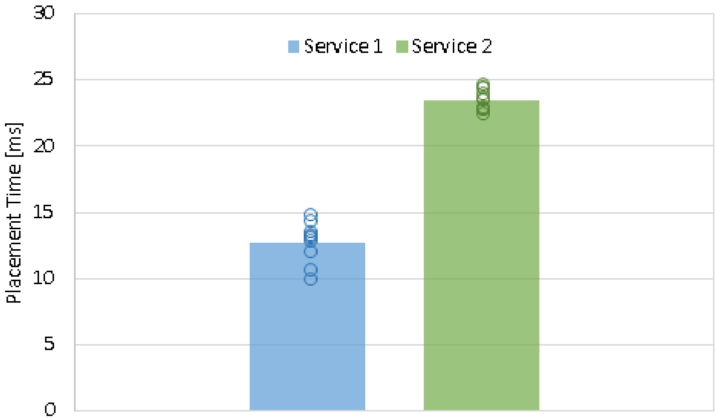
- It is possible to further reduce latency by exploiting the most suitable software migration technology to design Layer-7 services and network functions.
- The choice of a technology over the other must be made taking into account the desired trade-off between ease of migration and ease of access to the physical resources.
- Multi-Context Process (MCP): multiple instances working on different virtualized "contexts" and installed directly on hardware, bypassing both the host operating system and the hypervisor.
- The main difference between VMs and MCPs resides in the size of their virtual image, with the latter sensibly smaller than the former.

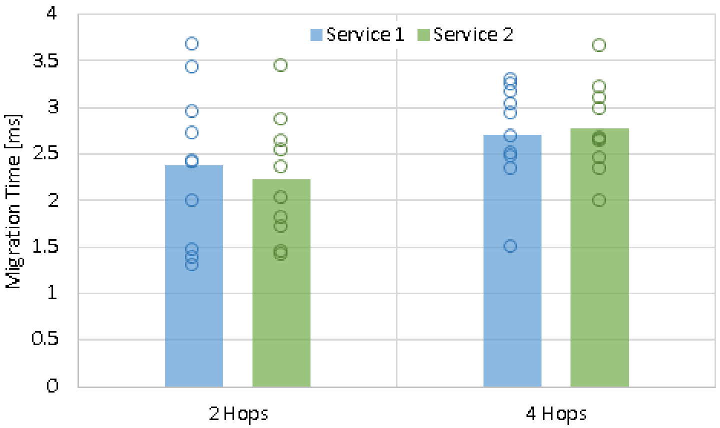
Performance Evaluation

- Goal: analyze the performance of the orchestration algorithm.
- Computation times obtained for the initial placement and migration of two generic service chains.
- Since these results also include the placement and migration of the Virtual Personal Gateway (VPG), further results on the VPG to compare how MCP performs with respect to traditional VMs in terms of latency.

Algorithm Computation Times

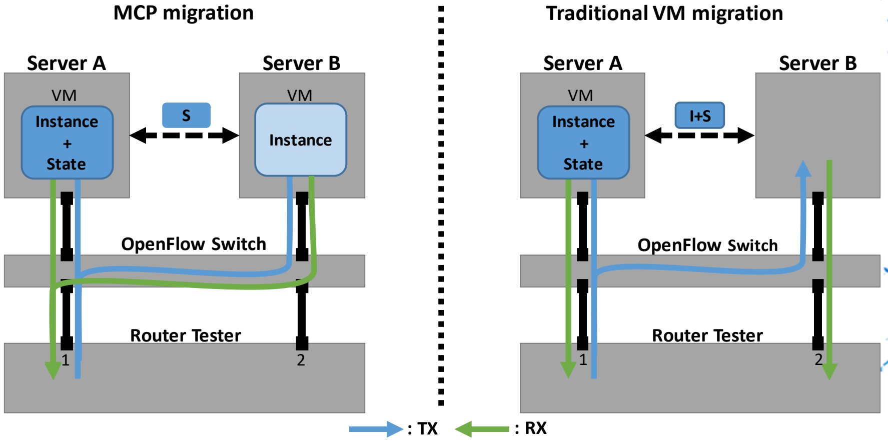
- Two service chains: Service 1 composed of 15 VMs, and Service 2 of 31 VMs.
- Computation times collected for the chains initial placement (left) and for their migration (right).



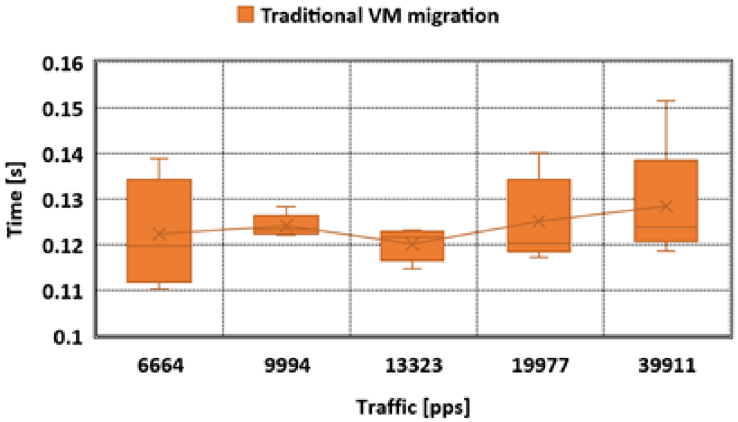


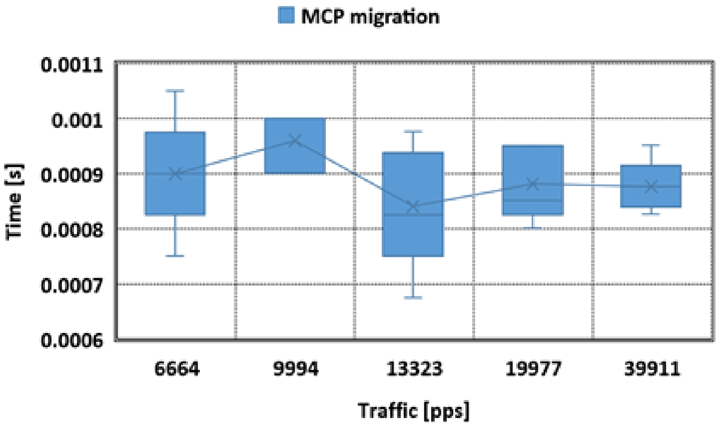
VM and MCP Migration Times (1)

- Goal: compare the service downtime for migrating a NAT VNF when deployed as VM or MCP.
- Testbed: two servers and a router tester.
- During this transmission, the NAT is initially located in Server A, and is then migrated to Server B.



VM and MCP Migration Times (2)





Conclusions

- This paper has considered the design of a comprehensive edge computing framework to support services instantiated on a per-user basis.
- A lightweight heuristic algorithm to orchestrate the autonomic placement of service components close to users.
- Exploitation of the degrees of freedom offered by different software migration technologies.
- Performance evaluation to test real application chains, deployed according to diverse software live migration technologies.
- Test results obtained on a real wide-area topology show that the proposed framework allows to orchestrate the autonomic placement and migration of services instantiated on a per-user basis in few milliseconds (<25 ms).

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Thanks for your kind attention ☺

Any questions?