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Offline-First strategies in heterogeneous, distributed and virtualized infrastructures

Methods for the efficient detection, assignment and use of distributed resources

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Contents

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# Project Virtualization of distributed environments for teaching[1]

Key features of SKILL/VL plattform[2]:

- Hyper converged infrastructure
  (cluster of 12 servers)
- Software Defined Storage
- Software Defined Networking
- QEMU/KVM as virtualization engine
- Strict use of open source software:
  - *Proxmox VE* as hypervisor (*KVM-based*)
  - *Ceph* as distributed object storage
  - *QEMU-Guest Agent* integration for configuration of VMs
  - *VXLAN* (Virtual Extensible LAN) integration for (virtual) network configuration

[1] Original: Strategische Kompetenzplattform - Innovativ Lernen und Lehren – Virtualisierung verteilter Umgebungen für die Lehre
[2] http://www.virtuellelehre.de/

SKILL/VL Architecture
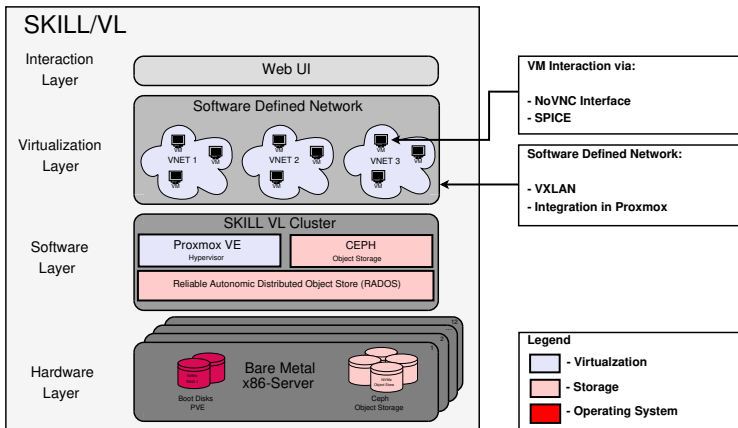
SKILL/VL plattform:

- **Interaction Layer**
  $\implies$ React web UI

- **Virtualization Layer**
  $\implies$ VMs and SDN network environment

- **Software Layer**
  $\implies$ Proxmox VE and Ceph as plattform for virtual resources

- **Hardware Layer**
  $\implies$ x86 Server, physical network and storage

Use Case SKILL/VL

- Students access the SKILL/VL environment over network
- Students use the SKILL/VL environment for lectures
- Students use client hardware to interact with SKILL/VL infrastructure

Problem

The access and use of the SKILL/VL infrastructure generates load on the server infrastructure and network! The network causes latencies in the interaction with the server!

Opportunity

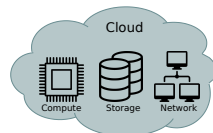The resources accessed by users (virtual machines, networking, software) are virtualized!

Idea

Use client hardware as an enhancement of the service!

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My Thesis project proposal

- Use client infrastructure to enhance cloud service
- Migrate services from cloud to client whenever possible

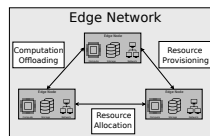### Benefits

- Reduced network latency
- Reduced server load
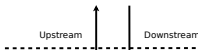- Increased autonomy and resilience
- Increased geographical scalability

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Cloud

Compute   Storage   Network

Cloud Layer

+ Many ressources
+ complex applications possible

- Very high latency
- No real time possible

Upstream   Downstream

Edge Network

Computation Offloading

Edge Node

Resource Provisioning

Edge Node   Edge Node

Resource Allocation

Edge Layer

+ lower latency
+ Real time under bound conditions

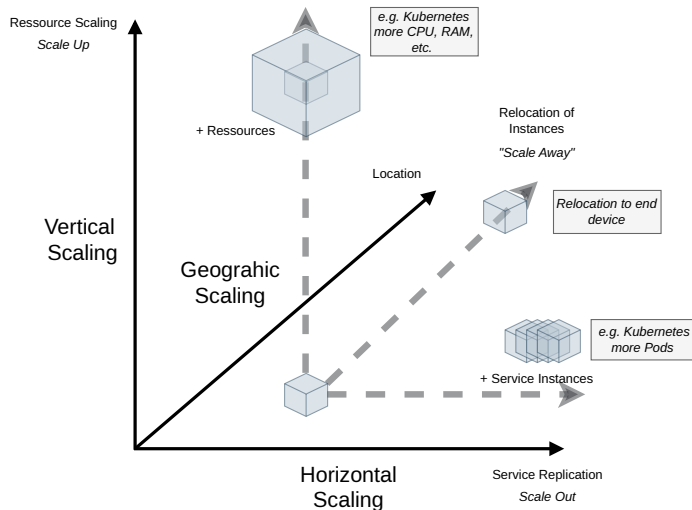- Very heterogeneous infrastructure
- Complex network of devices

Upstream   Downstream

Client

Client

+ Lowest latency
+ Real time possible

- Extremely heterogenous
- network infrastructure variable

User

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Dimension of Scaling

- **Horizontal scaling**
  $\implies$ *Scale out*
  - Adding additional service instances

- **Vertical scaling**
  $\implies$ *Scale up*
  - Adding additional resources to the service instance

- **Geographic scaling**
  $\implies$ *Scale away*
  - Relocating the service instance geographically closer to end user

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Research questions

1 **How can resources on clients be used to save cloud resources and consequently bring applications closer to the end user?**

Using virtualization technologies for compute, storage and networking and extending its base of operation is crucial!

2 **When does the migration to clients make sense and how does it contribute in reducing the load on the core service?**

Whenever the network bandwidth limits the interaction with the service or the service needs offline operation capability!

3 **How does outsourcing services to the client affect the quality of services?**

It affects the operation of the service depending on the resource consumption of the service!

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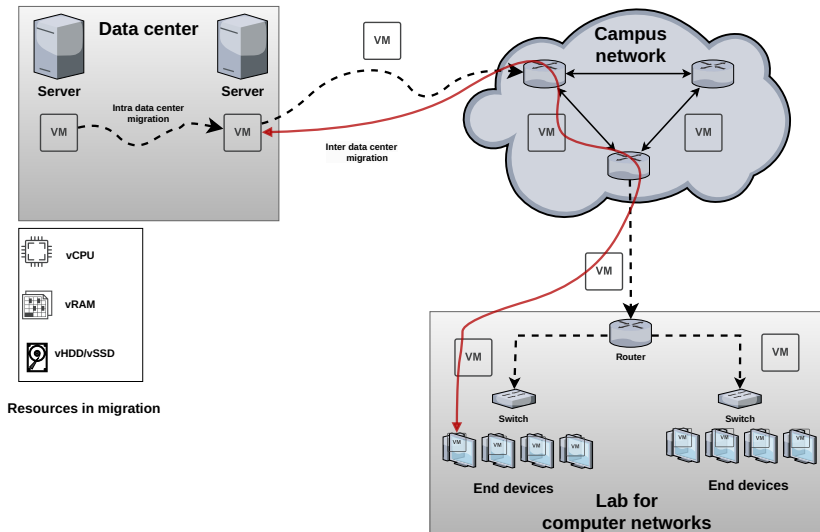UNIVERSITY
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Goals

- **Independence from cloud service** – offline operation.
- **Cooperation with cloud service** – enhancement of cloud service.
- **Multi-dimensional service migration** – dynamic and demand-driven service placement.
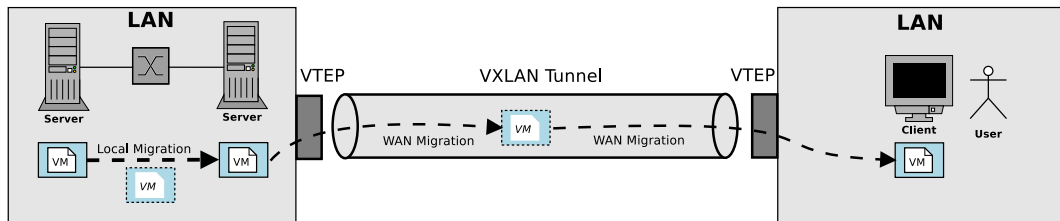- **Service quality awareness** – real time placement decision depending on quality.

Summary

Consideration of the methods and practical possibilities of operating applications beyond the cloud on local end devices. Thus, the local resources should be usable as an extension of the cloud service and provide a resilient service to the end user.

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Field experiment – SKILL/VL

Experimental setup

- Setup a server with Proxmox (QEMU/KVM)
- Setup a network using VXLAN (Virtual Extensible LAN)
- Connect server and client network through tunnel

Real-world experiment

Since the SKILL/VL environment already uses Proxmox (QEMU/KVM) and VXLAN an extension of these components for the experiments is at hand.

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Lab experiment setup – VM migration

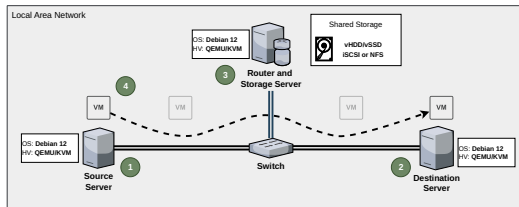Figure: Lab experiment VM migration over LAN

Figure: Lab experiment VM migration over WAN

- Lab experiments to establish a ground truth and a basis for comparison.
- Well defined environment for the experiments.
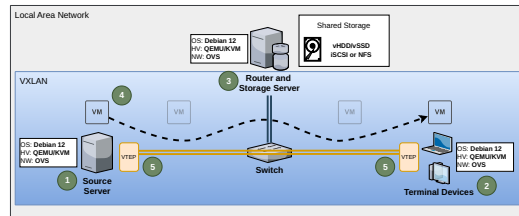- Environment set up with QEMU/KVM and Debian 12.

- Lab experiments to compare VXLAN to LAN setup.
- Well defined environment for the experiments.
- Environment set up with QEMU/KVM, Open vSwitch and Debian 12.

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Experimental setup - Summary

Benefits of the experimental setup

- Transparent and defined conditions.
- Extensible setup for future experimentation.
- Serves as a basis for field experiments.

Common ground for experiments

The presented setup sets the ground for experiments in the infrastructure. This helps in creating comparable conditions for the experiments.

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Summary

The VXLAN setup. . .

- is a potential answer to RQ 1 form slide 9.
- is a beneficial infrastructure setup.
- is a good basis for experiments on migration and performance.
- is a good first start for an Offline-First Strategy.

The experiments. . .

- shall give insights on the applicability of an Offline-First Strategy.
- shall give answers to RQ 2 and 3 form slide 9
    - RQ2 – Application in real-life scenarios from slide 11
    - RQ3 – Measurements of different scenarios
- shall validate the current experimental setup

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Thank You
For Your Attention!

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