

Cloud Computing

Organisational information, Introduction to Cloud Computing
Slide set 1

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- 1 Organisational Information
- 2 Objectives of the course
- 3 Introduction to Cloud Computing
- 4 Outlook on the course

Semester project

Examination

The examination in the master course **Cloud Computing** will be a cloud transformation over the course of the semester. You need to form groups of **4-5 people** and work on the milestones.

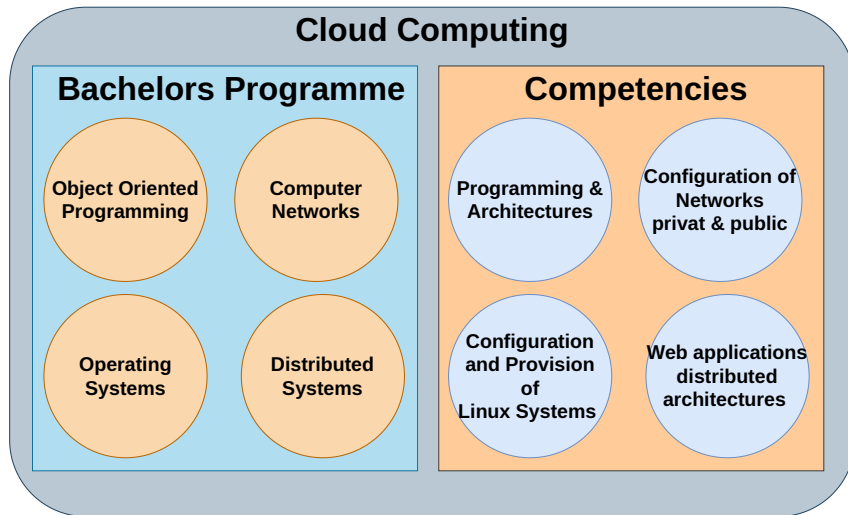
There will be three milestones on the project

- ① Milestone – Technical transformation on-premise
- ② Milestone – Cloud transformation on-premise and public
- ③ Milestone – Implementation of cloud transformation scenario

Details on the semester project

Details on the project will be given in a separate presentation.

What topics are part of Cloud Computing?



Slides of the lecture

Most of the material from the lecture is new and the slides are mostly still work in progress! So whenever you spot mistakes or faults let me know ;-)

What is Cloud Computing?

Group Discussion

- What is Cloud Computing?
- What Cloud Computing offerings do you use?
- How would you define Cloud Computing?

The diagram is organized into three horizontal sections, each representing a key characteristic of cloud computing:

- Deployment Model:** This section shows four cloud types: Public Cloud, Private Cloud, Hybrid Cloud, and Community Cloud, each represented by a cloud icon.
- Service Model:** This section shows three service types: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS), each represented by an octagon icon.
- Service Features:** This section shows four features: On-demand self-service, Broad network access, Rapid elasticity, and Measured service, each represented by a rectangle icon. These features are all underpinned by a single bar labeled "Resource pooling".

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Deployment Model

Private Cloud

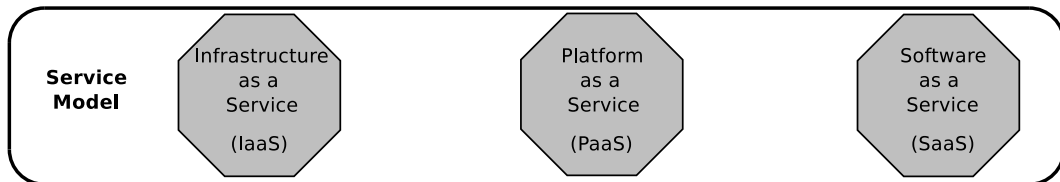
Hybrid Cloud

Community
Cloud

Community Cloud

The cloud infrastructure is provisioned for exclusive use by a specific community.

Service models



Infrastructure as a Service

Provided to provision processing, storage, networks, and other fundamental computing resources.

Platform as a Service

Provided to deploy applications created using programming languages, libraries, services supported.

Software as a Service

Provided to use the provider's applications running on a cloud infrastructure accessible from various devices.

⁰We will discuss more than these service models in this course ;-)

The diagram illustrates the components of Service Features. It consists of a large light gray rounded rectangle containing a horizontal bar at the top labeled "Resource pooling". Below this bar, there are four smaller light gray rectangular boxes arranged horizontally, each containing a service feature: "On-demand self-service", "Broad network access", "Rapid elasticity", and "Measured service".

Service Features	Resource pooling			
	On-demand self-service	Broad network access	Rapid elasticity	Measured service

Computing resources are pooled to serve multiple consumers.

Consumer can provision computing capabilities automatically.

Capabilities are available and accessed over the network.

Capabilities can be elastically provisioned to scale with demand.

Automatically
controlled and
optimized
resources with
metering.

The diagram illustrates the components of cloud service features. It is enclosed in a rounded rectangle. On the left, the text "Service Features" is written vertically. To its right, there is a large horizontal box labeled "Resource pooling". Below this box, there are four smaller boxes arranged horizontally, each containing a feature: "On-demand self-service", "Broad network access", "Rapid elasticity", and "Measured service".

Service Features
Resource pooling
On-demand self-service
Broad network access
Rapid elasticity
Measured service

How can we technically realize the listed features?

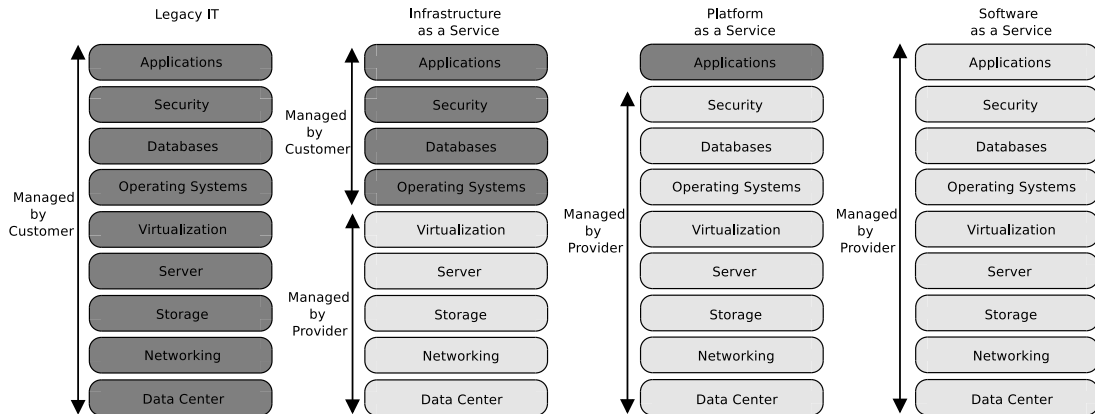
Cloud Computing – Definition

„By using virtualized computing and storage resources and modern web technologies, Cloud Computing provides scalable, network-centric, abstracted IT infrastructures, platforms, and applications as on-demand services. These services are billed on a usage basis.“



- **Part 1:** Fundamental technologies – basis of Cloud Computing
 - **Virtualization** for shared and efficient resource utilization
 - **Web Services** (REST/SOAP) for communicating with the services
- **Part 2:** Cloud services and their characteristics
 - **IaaS, PaaS, SaaS**
 - **scalable** \implies „elastic“
 - **network-centric** \implies services/resources are accessible over the internet
 - **abstracted** \implies independent of the concrete hardware
 - **on-demand** \implies prompt request completion
 - **pay as you go**

Service models – layers



Service offerings in Cloud Computing



Figure: DropBox



Figure: Slack

Google Workspace



Figure: Google Workspace



Figure: Zoom

Question

What is the service model of the presented offering?

Things to keep in mind

Questions when using cloud services

- What about the data privacy?
- Where is the service hosted?
- Who has access to the service and data?
- Who controls the service offering?

Use of Cloud Computing offerings

The previous offerings are public service offerings for customers. But what about the provider perspective?

What do you need to keep in mind if you want to offer a cloud service?

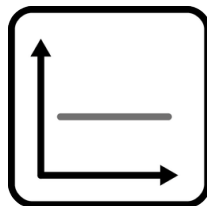
Why use Cloud Computing?

Group discussion

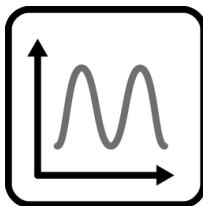
- When should one use Cloud Computing from a company perspective?
- What are the benefits of Cloud Computing for companies?
- Are there scenarios when Cloud Computing is suited for enterprises?

Types of workloads

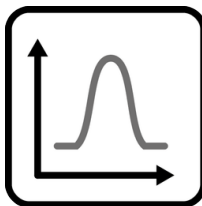
CC-BY:<http://www.cloudcomputingpatterns.org>



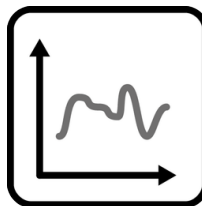
(a) Static



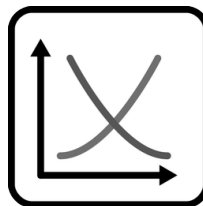
(b) Periodic



(c) Once-in-a-lifetime



(d) Unpredictable



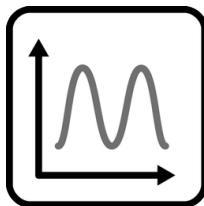
(e) Continuously changing

Question?

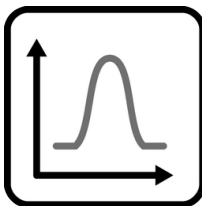
Which of the presented workload types are suitable for a cloud computing setup?

Types of workloads

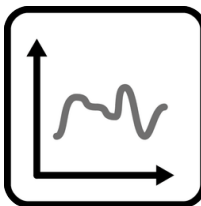
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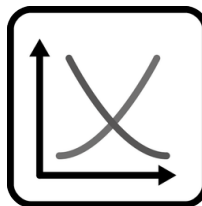
(a) Periodic



(b) Once-in-a-lifetime



(c) Unpredictable



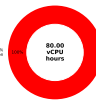
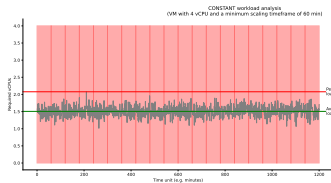
(d) Continuously changing

Answer!

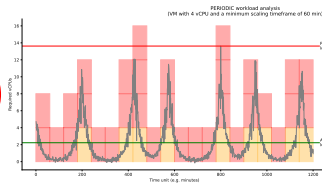
Cloud resources are particularly economical when load fluctuations occur!

Types of workloads

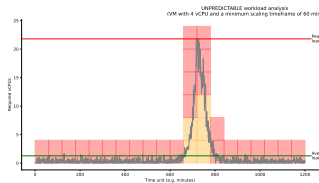
CC-BY:<https://cloud-native-computing.de>



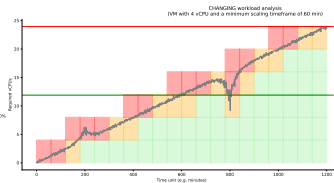
(a) Static



(b) Periodic



(c) Unpredictable



(d) Continuously changing

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¹Source of plots: <https://git.mylab.th-luebeck.de/cloud-native/lab-workload-analysis>

Cloud Computing - economics

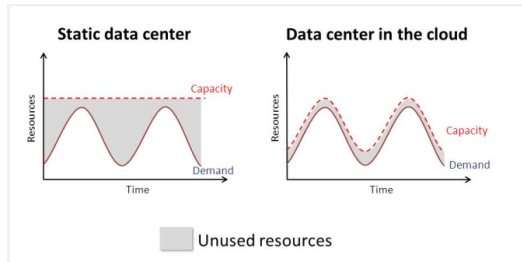


Figure: Static vs. dynamic demand^a

^aSource: <https://www2.eecs.berkeley.edu/Pubs/TechRpts/2009/EECS-2009-28.pdf>

More precise answer!

The costs per cloud resource can even be significantly higher than the in-house costs - as long as the ratio of **cloud** to **in-house** costs does not exceed the ratio of **peak load** to **average load**!

In formula!

$$\frac{\text{cloud cost}}{\text{inhouse expense}} < \frac{\text{peak load}}{\text{average load}}$$

$$\Leftrightarrow$$

$$\text{cloud cost} < \text{inhouse expense} \times \frac{\text{peak load}}{\text{average load}}$$

Pizza as a Service example

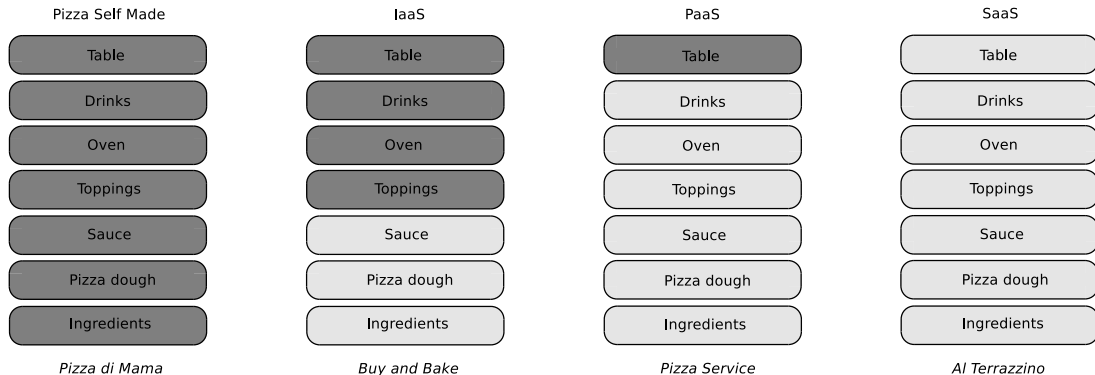
Source:<https://cloud-native-computing.de>

An example using Pizza ;-)

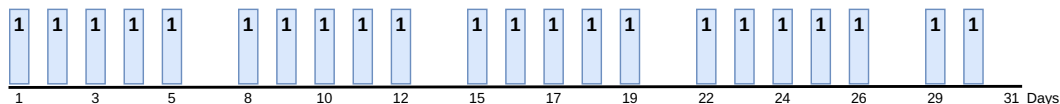
Imagine your family, friends and colleagues come over to your house and want Pizza for dinner. Now you need to investigate on the different types of service offerings you can use to feed your guests!

Pizza as a Service example

Source: <https://cloud-native-computing.de>



Pizza as a Service example – static workload



- You buy yourself a pizza every working day at lunchtime.
- At weekends, of course not.

How much?

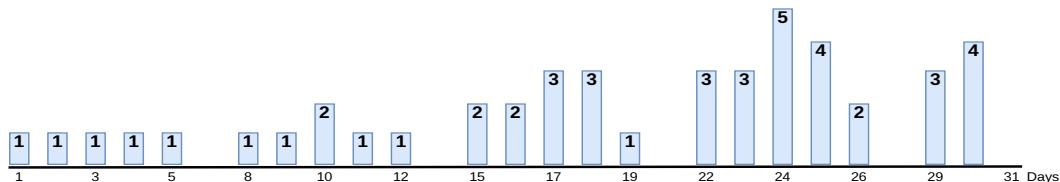
$$peak\ load = 1$$

$$average\ load = \frac{22}{30}$$

$$\frac{peak\ load}{average\ load} = \underline{1.3}$$

The cloud provider could be 30% more expensive than self made!!!

Pizza as a Service example – continuously changing workload



- You always bring your family something from the pizza trolley.
- Word gets around, and week after week you have to get more and more pizza.
- At weekends, of course not.

How much?

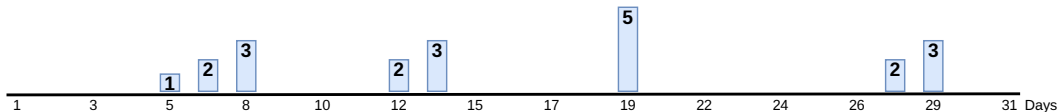
$$\text{peak load} = 5$$

$$\text{average load} = \frac{46}{30}$$

$$\frac{\text{peak load}}{\text{average load}} = \underline{3.2}$$

The cloud provider could be 3-Times more expensive than self made!!!

Pizza as a Service example – periodically changing workload



- You and your family and friends make movie evenings on weekend and watch movies (on-demand ;-)) and serve pizza.
- During the week you do not have time.

How much?

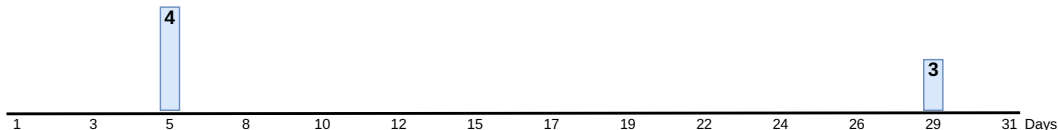
$$peak\ load = 5$$

$$average\ load = \frac{21}{30}$$

$$\frac{peak\ load}{average\ load} = \underline{7.1}$$

The cloud provider could be 7-Times more expensive than self made, because your demand is rarer!!!

Pizza as a Service example – unpredictable workload



- You invite your family on weekends occasionally to a pizzeria.
- During the week you do not have time.

How much?

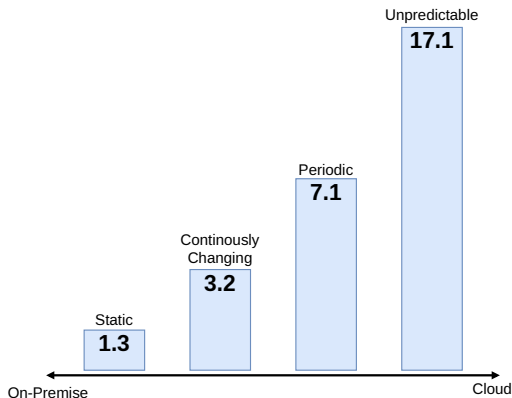
$$peak\ load = 4$$

$$average\ load = \frac{7}{30}$$

$$\frac{peak\ load}{average\ load} = \underline{17.1}$$

The cloud provider could be 17-Times more expensive than self made, because your demand is rarer!!!

Cost advantages in Cloud Computing



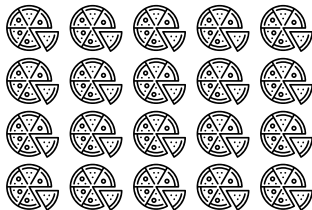
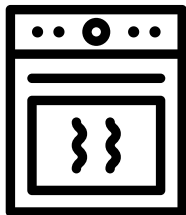
Conclusion

Cost advantages generally arise through the workload and only secondarily by the cost structure of the service.

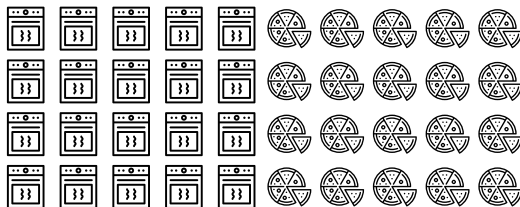
Remarks on the example...

The example has no **inhouse costs!!!**
Reaction to different workloads is in general not an easy task for on-premise setups! (servers, infrastructure, personal, etc.)

Operational costs in Cloud Computing



1 Oven for 20 Pizzas!!!



20 Oven for 20 Pizzas!!!

With which delivery service would you order 20 pizzas?

- The one that delivers in 5 hours and 19 pizzas are cold?
- The one that delivers 20 hot pizzas in 15 minutes?

Operational costs in Cloud Computing

Price and Effort?

- How much extra would that be worth to you?
- How much extra expense does this cost the delivery service?
- How often do you as a delivery service need 20 ovens at the same time?

Answer!

It costs the same. . .

Overall Question?

Do you want to buy and provision the 20 oven on-premise?

So why should we use Cloud Computing?

Questions

- Is Cloud Computing always beneficial?
- Is Cloud Computing the solution to all problems?
- Is using Cloud Computing always cheaper?

Answer

- No scam! It depends on the use case!
- It is beneficial for some use cases!
- It is cheaper if we take things like workload types and peak load into account!

So why should we use Cloud Computing?

Things to take into account

- **Hardware is very expensive!**
- **Personal is very expensive**
- **Housing for hardware and personal is expensive!**
- **Both scale very poorly!**

Outlook on the course

- 1st part: Introduction \Leftarrow *This slide set*
- 2nd part: Technological foundations
- 3rd part: Service models, deployment models
- 4th part: Adoption and strategy
- 5th part: Architectures and applications
- 6th part: Cloud-Native applications
- 7th part: Current and future trends

4th part: Adoption and strategy

Topics of this slide set:

- Cloud adoption
- Cloud strategy
- Multi-Cloud strategy
- Risks and opportunities of Cloud Computing

5th part: Architectures and applications

Topics of this slide set:

- Software architectures in Cloud Computing
- Distributed Systems and Cloud Computing
- Distributed architectures in Cloud Computing
- Properties of distributed architectures
- Decision criteria for distributed architectures

6th part: Cloud-Native applications

Topics of this slide set:

- Cloud-Native Applications
- Components of Cloud-Native Computing
- Architectures and patterns in Cloud-Native Computing
- Benefits and challenges in Cloud-Native Computing

7th part: Current and future trends

Topics of this slide set:

- Current trends in Cloud Computing
- Future trends in Cloud Computing

