

Cloud Computing

Organisational information, Introduction to Cloud Computing
Slide set 1

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Agenda

- 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.

Literature

Fundamentals from Bachelors courses

- **Operating Systems / Betriebssysteme:**
Bilingual Edition: English - German /
Zweisprachige Ausgabe: Englisch - Deutsch,
Christian Baun, Springer Vieweg (2023), ISBN:
978-3-658-42229-5.
- **Computer Networks / Computernetze:**
Bilingual Edition: English - German /
Zweisprachige Ausgabe: Englisch - Deutsch,
Christian Baun, Springer Vieweg (2022), ISBN:
978-3-658-38892-8.
- **Distributed Systems: Principles and**
Paradigms, *Andrew S. Tanenbaum, Maarten*
van Steen, Pearson (2023), ISBN:
978-1530281756.
- **Foundations of Scalable Systems,** *Ian Gorton*,
O'Reilly (2022), ISBN: 978-1098106065.

Cloud Computing

- **Cloud-Native Computing,** *Nane Kratzke*,
Hanser (2023), ISBN: 978-3-446-47914-2.
German
- **Cloud Strategy: A Decision-based Approach**
to Successful Cloud Migration, *Gregor Hohpe*
(2020), ISBN: 979-8665253046.
- **Multi-Cloud Architecture and Governance,**
Jeroen Mulder, Packt Publishing (2020), ISBN:
978-1800203198.
- **Cloud Computing: Web-Based Dynamic IT**
Services, *Christian Baun, Marcel Kunze, Jens*
Nimis, Stefan Tai, Springer (2011), ISBN:
978-3-642-20916-1.
- **Cloud Application Architectures,** *George*
Reese, O'Reilly (2008), ISBN: 978-0596156367.

Objectives of the course

- Getting an overview on Cloud Computing and cloud services and their importance!
- Getting an overview on the technological foundations for the operation and implementation of cloud services!
- Gaining knowledge on Cloud Computing related topics (service models, features, etc.)!
- Gaining knowledge and understanding strategies for the adoption of Cloud Computing!
- Gaining knowledge on software architectures for the implementation of cloud services!
- Gaining knowledge on Cloud-Native applications and their benefits for the implementation of cloud services!
- An outlook on future trends in Cloud Computing!

What is Cloud Computing?

Group Discussion

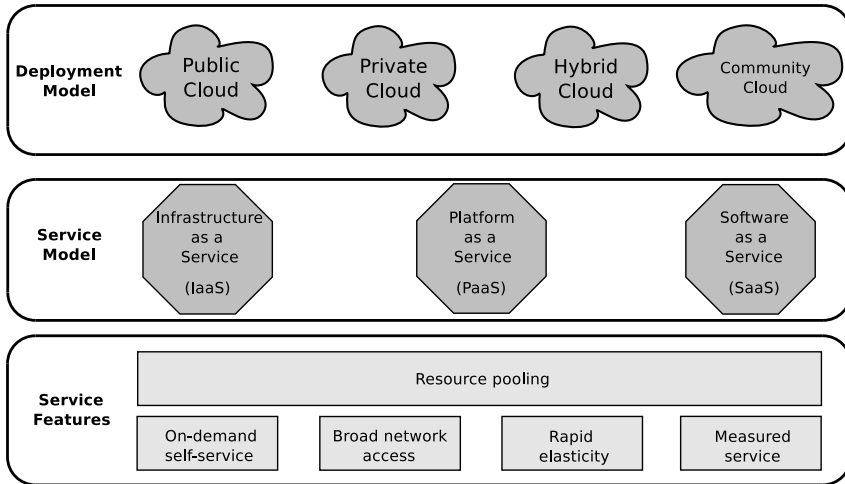
- What is Cloud Computing?
- What Cloud Computing offerings do you use?
- How would you define Cloud Computing?

Computing of the future? – Quote from 1961

“computation may someday be organized as a public utility, just as the telephone system is a public utility. We can envisage computer service companies whose subscribers are connected to them [...]. Each subscriber needs to pay only for the capacity that he actually uses, but he has access to all programming languages characteristic of a very large system.” – John McCarthy

This is pretty close to cloud computing!

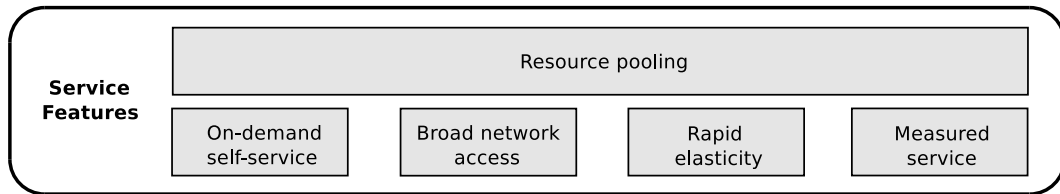
NIST definition of Cloud Computing



⁰ Source: <https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf>

Service Model
Infrastructure as a Service (IaaS)
Platform as a Service (PaaS)
Software as a Service (SaaS)

Service Features



Question

How can we technically realize the listed features?

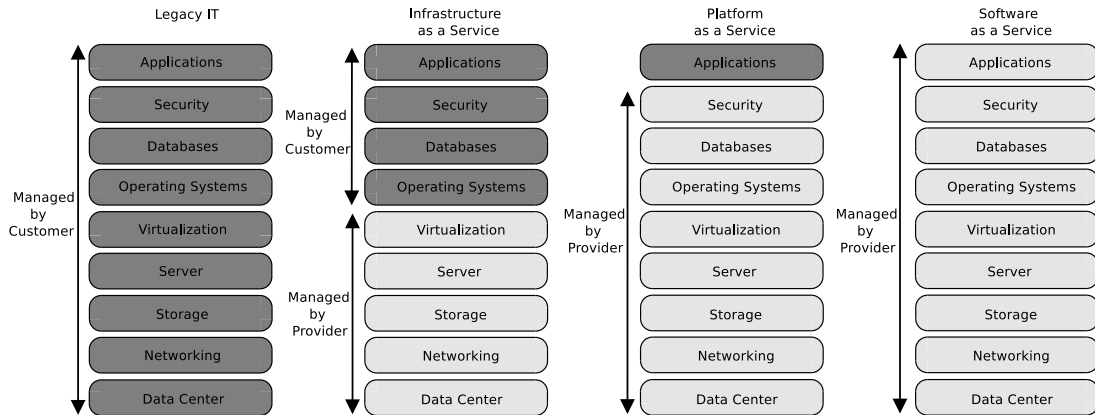
Cloud Computing – Definition

„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?

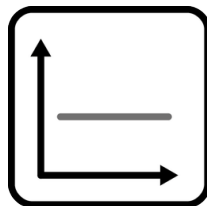
Why use Cloud Computing?

Group discussion

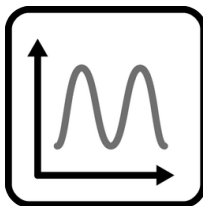
- When should one use Cloud Computing from a company perspective?
- What are the benefits of Cloud Computing for companies?
- Are there scenarios when Cloud Computing is suited for enterprises?

Types of workloads

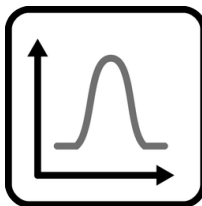
CC-BY:<http://www.cloudcomputingpatterns.org>



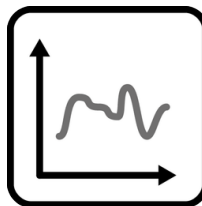
(a) Static



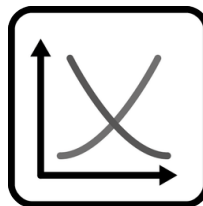
(b) Periodic



(c) Once-in-a-lifetime



(d) Unpredictable



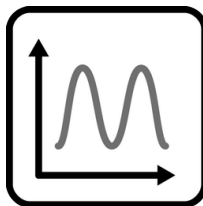
(e) Continuously changing

Question?

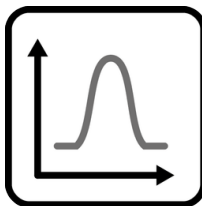
Which of the presented workload types are suitable for a cloud computing setup?

Types of workloads

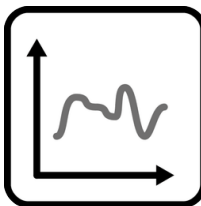
CC-BY: <http://www.cloudcomputingpatterns.org>



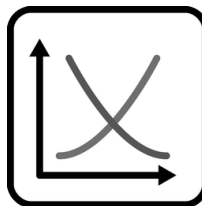
(a) Periodic



(b) Once-in-a-lifetime



(c) Unpredictable



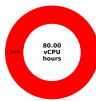
(d) Continuously changing

Answer!

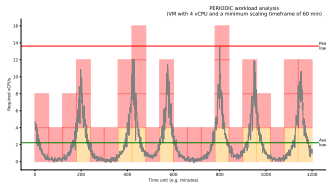
Cloud resources are particularly economical when load fluctuations occur!

Types of workloads

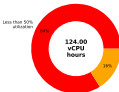
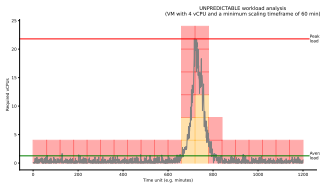
CC-BY:<https://cloud-native-computing.de>



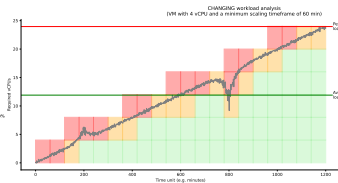
(a) Static



(b) Periodic



(c) Unpredictable



(d) Continuously changing

1

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

Cloud Computing - economics

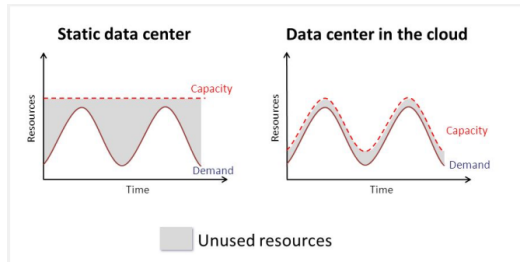


Figure: Static vs. dynamic demand^a

^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

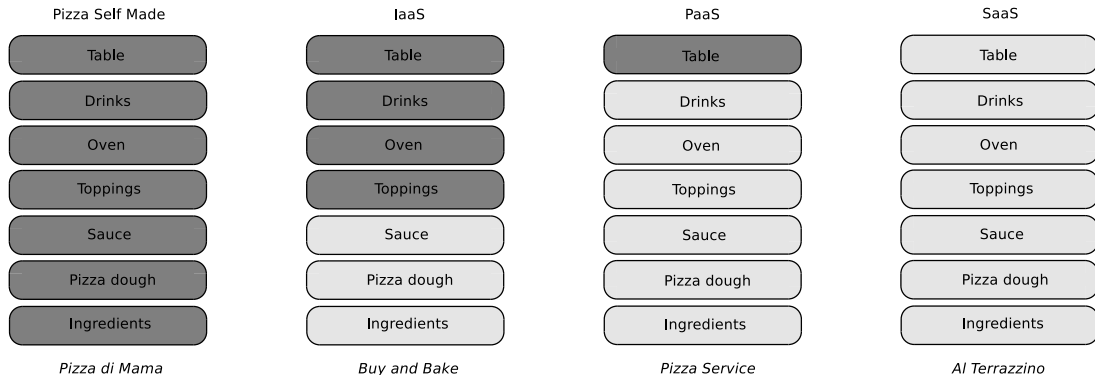
Source: <https://cloud-native-computing.de>

An example using Pizza ;-)

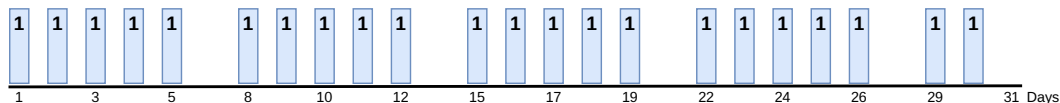
Imagine your family, friends and colleagues come over to your house and want Pizza for dinner. Now you need to investigate on the different types of service offerings you can use to feed your guests!

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?

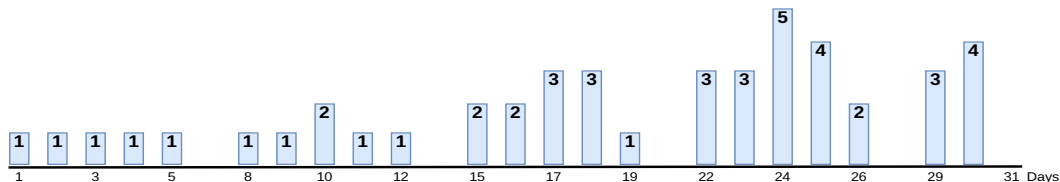
$$peak\ load = 1$$

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

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

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?

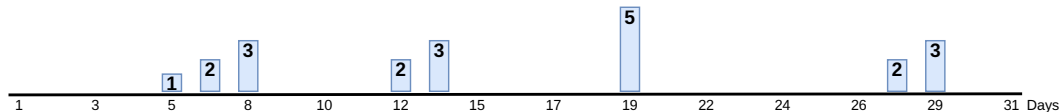
$$\text{peak load} = 5$$

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

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

The cloud provider is 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?

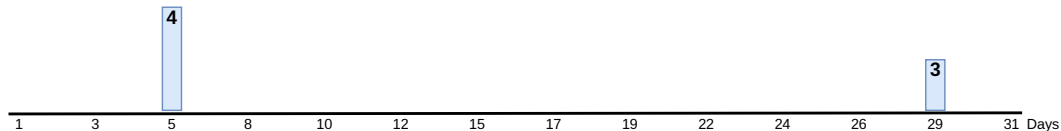
$$peak\ load = 5$$

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

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

The cloud provider is 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?

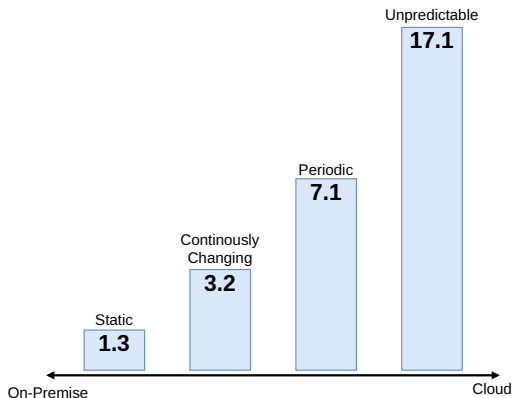
$$peak\ load = 4$$

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

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

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

Cost advantages in Cloud Computing



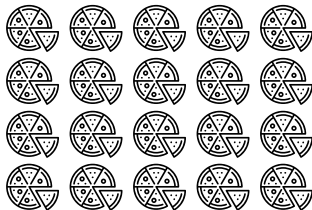
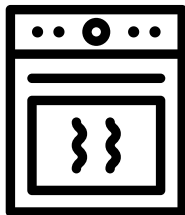
Conclusion

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

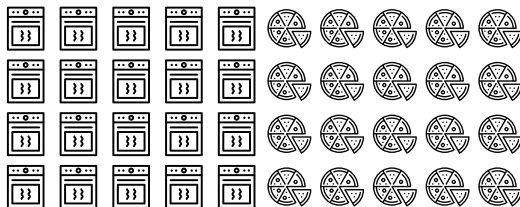
Remarks on the example...

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 a scam?
- Is there no benefit?
- Should Cloud Computing not be cheaper?

Answer

- No scam! It depends on the use case!
- It is beneficial for some use cases!
- It is cheaper if we take some things 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

2nd part: Technological foundations

Topics of this slide set:

- Legacy IT (data centers, servers, networking, etc.)
- Cloud enabling technologies (networking, storage, virtualization, etc.)
- Infrastructure as Code (Vagrant, Terraform, Ansible, etc.)
- Costs of on-prem infrastructures

3rd part: Service models, deployment models

Topics of this slide set:

- Deployment models in Cloud Computing
- Service models in Cloud Computing
- Public Cloud Computing offerings
- Private Cloud Computing offerings

4th part: Adoption and strategy

Topics of this slide set:

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

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

Thank You For Your Attention!

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