# Cloud Computing

Introduction

Organisational information, Introduction to Cloud Computing Slide set 1

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Introduction

## Agenda

- Organisational Information
- Objectives of the course
- Introduction to Cloud Computing
- Outlook on the course



## Organizational Information

- Website:
  - www.henrycocos.de
- F-Mail:
- Office:
  - Room 1-230
- Consultation:
  - Best via E-Mail!
- Course material:
  - Lecture notes (PDF slides) and semester project related information can be found at the course website

Introduction

#### **!!! ATTENTION !!!**

- Beginning WS2021, the cloud computing course does not have a written exam anymore!
- Your grade will depend 100% on your work and the results in the semester project (see the course web page for more information)

## Semester project

Organisation

#### 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

- Milestone Technical transformation on-premise
- Milestone Cloud transformation on-premise and public
- Milestone Implementation of cloud transformation scenario

#### Details on the semester project

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

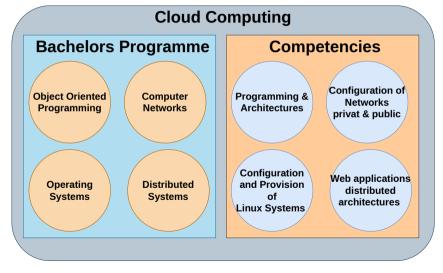
#### Fundamentals from Bachelors courses

- 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-Natve 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.

# What topics are part of Cloud Computing?



# What are prerequisites for the course?

You should have basic knowledge from the bachelors programme on the following topics:

- Computer Programming
  - Java and Python! (object-oriented and functional paradigm)
- Operating Systems
  - Linux, Kernel architectures, command-line, block and file storage, virtualization, ...
- Computer Networks
  - ISO-OSI reference model, Switching, Routing, CIDR, Application layer protocols, ...
- Distributed Systems
  - Definitions, cluster systems, RPC, web technologies, SOAP, REST, ...
- Software Architectures
  - Client/Server Architectures, 3-Tier Architectures, Web applications, ...

#### If you want to read up again

You can read the books under Fundamentals from Bachelors courses on slide 5!

# 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 outook on future trends in Cloud Computing!

Objectives

# What is Cloud Computing?

# Group Discussion

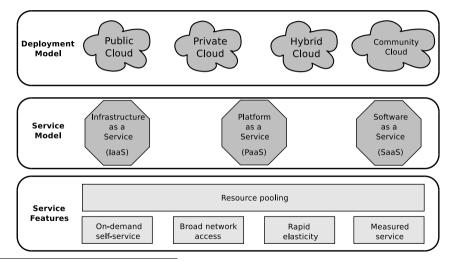
- What is Cloud Computing?
- What Cloud Computing offerings do you use?
- How would you define Cloud Computing?

## 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!

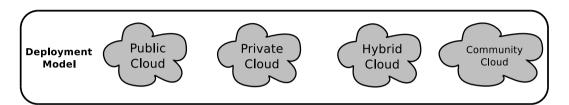
# NIST definition of Cloud Computing



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 $<sup>^{0}</sup> Source: \ \texttt{https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf}$ 

## Deployment models



#### **Public Cloud**

The cloud infrastructure is provisioned for open use by the general public.

#### Private Cloud

The cloud infrastructure is provisioned for exclusive use by a single organization.

#### **Hybrid Cloud**

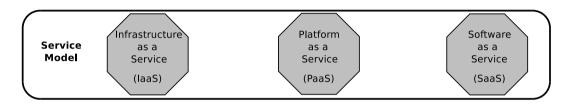
The cloud infrastructure is a composition of two or more distinct cloud infrastructures.

#### Community Cloud

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

### Service models

Organisation



#### Infrastructure as a Service

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

#### Platform as a Service

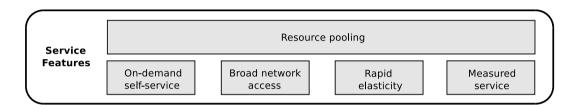
Provided to deploy applications created using programming languages, libraries, services supported.

#### Software as a Service

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

<sup>&</sup>lt;sup>0</sup>We will discuss more than these service models in this course :-)

#### Service Features



# Resource pooling

Computing resources are pooled to serve multiple

# On-demand self-service

Consumer can provision computing capabilities automatically.

### Broad network access

Capabilities are available and accessed over the network.

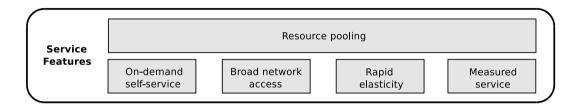
# Rapid elasticity

Capabilities can be elastically provisioned to scale with demand

# Measured service

Automatically controlled and optimized resources with metering.

#### Service Features



#### Question

How can we technically realize the listed features?

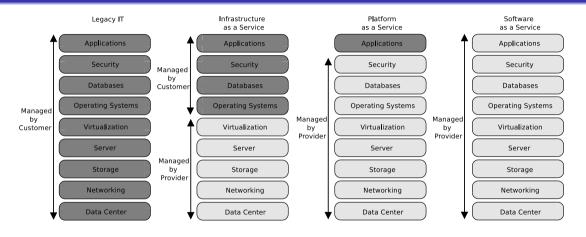
# Cloud Computing – Definition

Organisation

"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 ⇒ ..elastic"
  - network-centric  $\Longrightarrow$  services/resources are accessible over the internet
  - **abstracted**  $\implies$  independent of the concrete hardware
  - on-demand  $\Longrightarrow$  prompt request completion
  - pav as vou go



Introduction

# Service offerings in Cloud Computing



Figure: DropBox



Figure: Slack







Figure: Google Workspace







#### 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?

Introduction

• Who controls the service offering?

# Use of Cloud Computing offerings

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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

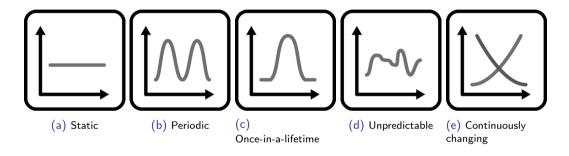
- When should one use Cloud Computing from a company perspective?
- What are the benefits of Cloud Computing for companies?
- Are there scenarios when Cloud Computing is suited for enterprises?

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# Types of workloads

Organisation

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



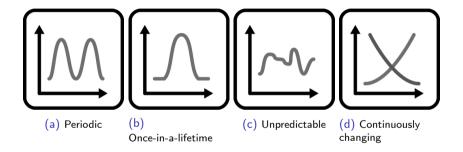
#### Question?

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

# Types of workloads

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

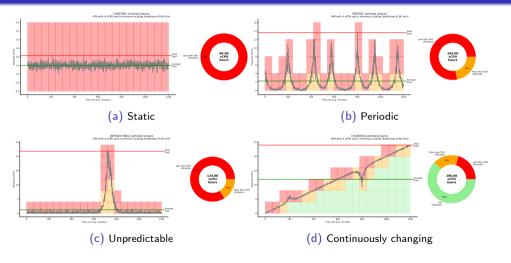


#### Answer!

Cloud resources are particularly economical when load fluctuations occur!

# Types of workloads

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



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

## Cloud Computing - economics

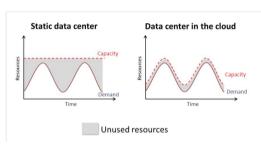


Figure: Static vs. dynamic demand<sup>a</sup>

#### 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!

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

<sup>&</sup>lt;sup>a</sup>Source:https://www2.eecs.berkeley.edu/Pubs/ TechRpts/2009/EECS-2009-28.pdf

# 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

Organisation

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

Pizza Self Made	IaaS	PaaS	SaaS
Table	Table	Table	Table
Drinks	Drinks	Drinks	Drinks
Oven	Oven	Oven	Oven
Toppings	Toppings	Toppings	Toppings
Sauce	Sauce	Sauce	Sauce
Pizza dough	Pizza dough	Pizza dough	Pizza dough
Ingredients	Ingredients	Ingredients	Ingredients
Pizza di Mama	Buy and Bake	Pizza Service	Al Terrazzino

# Pizza as a Service example – static workload

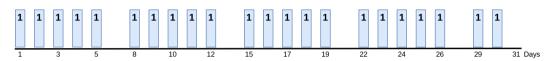


Figure: Static workload

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

#### How much?

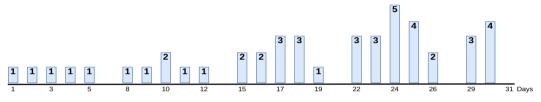
$$peak\ load = 1$$

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

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

30% more expensive than self made!!!

# Pizza as a Service example – continuously changing workload



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- 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?

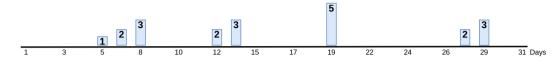
$$peak load = 5$$

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

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

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?

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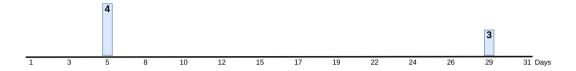
$$peak load = 5$$

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

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

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?

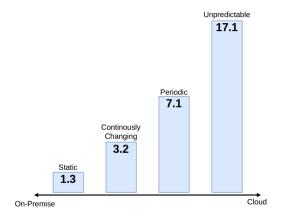
$$peak\ load = 4$$

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

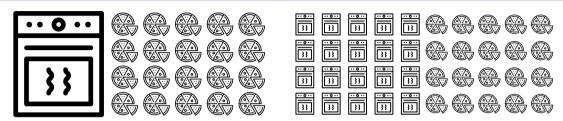
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Cost advantages generally arise through the workload and only secondarily by the cost structure of the service.

#### 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!

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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

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- 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 ← 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

Introduction

# 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

Introduction

# 7th part: Current and future trends

# Thank You For Your Attention!

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