

# Cloud Computing

## Adoption and strategy in Cloud Computing Slide set 4

Henry-Norbert Cocos  
cocos@fb2.fra-uas.de

Computer Science  
Department of Computer Science and Engineering  
**Frankfurt University of Applied Sciences**

# Agenda

- 1 Cloud adoption and strategy
- 2 Cloud adoption
- 3 Cloud strategy
- 4 Multi-Cloud Strategy
- 5 Risks and Opportunities
- 6 Summary







# Cloud adoption stages (generic)

Source: *Multi-Cloud Architecture and Governance* by Jeroen Mulder

- ① Defining a business strategy and business case.
- ② Creating your team.
- ③ Defining the architecture.
- ④ Engaging with cloud providers; getting financial controls in place.
- ⑤ Building and configuring the landing zone.
- ⑥ Assessment.
- ⑦ Migrating and transforming.



## Challenges in Cloud Adoption

- **Security and Privacy Concerns:** Managing data security, compliance with regulations, and ensuring data privacy in the cloud.
- **Cost Management:** Avoiding unexpected costs due to pay-as-you-go models and ensuring efficient resource utilization.
- **Vendor Lock-in:** Dependency on a single cloud provider can make it difficult to switch vendors or move workloads.
- **Skill Requirements:** Need for skilled personnel to manage and optimize cloud environments and services.
- **Migration Complexity:** Challenges in moving existing applications and data to the cloud, especially legacy systems.



Source: *Multi-Cloud Architecture and Governance* by Jeroen Mulder

## Cloud Customer Responsibilities

- **Cloud Service Selection and Planning**
  - **Evaluate Needs:** Choose cloud services (IaaS, PaaS, SaaS) and deployment models (public, private, hybrid).
  - **Vendor Evaluation:** Evaluate and select cloud providers.
  - **Strategic Planning:** Develop a cloud adoption strategy, including migration plans and timelines.
- **Resource Management**
  - **Provisioning:** Manage the allocation and configuration of cloud resources.
  - **Scaling:** Adjust resource levels to meet changing demand.
  - **Optimization:** Regularly review and optimize resource usage.

## Cloud Service Provider Responsibilities

- **Service Provisioning and Management**
  - **Infrastructure Management:** Maintain and manage the underlying infrastructure.
  - **Service Delivery:** Ensure that cloud services are available and perform as specified in the SLAs.
  - **Capacity Management:** Plan and manage the capacity of cloud services.
- **Security and Compliance**
  - **Security Implementation:** Implement and manage security measures to protect the cloud infrastructure.
  - **Compliance Assurance:** Comply with relevant regulations and standards.
  - **Data Privacy:** Protect customer data in accordance with privacy laws and policies.

Source: *Multi-Cloud Architecture and Governance* by Jeroen Mulder

## Cloud Customer Responsibilities

- **Security and Compliance**
  - **Data Security:** Implement security measures for data in transit and at rest.
  - **Access Management:** Manage users and permissions using Identity and Access Management (IAM) tools.
  - **Compliance:** Comply with relevant laws, regulations, and industry standards (e.g., GDPR, HIPAA).
- **Application and Data Management**
  - **Application Deployment:** Deploy and manage applications on the cloud.
  - **Data Management:** Handle data backup, recovery, and lifecycle management.
  - **Service Configuration:** Configure and manage cloud services.

## Cloud Service Provider Responsibilities

- **Service Support and Maintenance**
  - **Technical Support:** Provide support services.
  - **Maintenance and Updates:** Perform regular maintenance and updates.
  - **Service Monitoring:** Monitor cloud services.
- **Service Continuity and Availability**
  - **Disaster Recovery:** Implement and maintain disaster recovery.
  - **Redundancy and Failover:** Design and manage redundancy and failover mechanisms.
  - **Uptime Assurance:** Provide guarantees for service availability as specified in SLAs.

Source: *Multi-Cloud Architecture and Governance* by Jeroen Mulder

## Cloud Customer Responsibilities

- **Operational Management**
  - **Monitoring and Reporting:** Continuously monitor cloud services.
  - **Incident Response:** Develop and implement plans for responding to incidents.
  - **Performance Tuning:** Tune applications and infrastructure for optimal performance.

## Cloud Service Provider Responsibilities

- **Billing and Pricing**
  - **Cost Transparency:** Provide clear and transparent pricing models and billing.
  - **Usage Tracking:** Track and report on customer usage of cloud services.
  - **Flexible Pricing Options:** Offer flexible pricing options.

## What about the shared responsibilities?

## Shared Responsibilities

- **Security**

- **Customer:** Responsible for the security "in" the cloud, including securing their data, applications, and configurations.
- **Provider:** Responsible for the security "of" the cloud, including the physical infrastructure and foundational services.

- **Compliance**

- **Customer:** Ensures their usage and configuration of cloud services meet their specific compliance requirements.
- **Provider:** Provides compliance certifications and tools to help customers achieve regulatory compliance.

- **Operational Management**

- **Customer:** Manages their applications, data, and user access within the cloud environment.
- **Provider:** Manages the underlying infrastructure and ensures the availability and performance of cloud services.

In addition to the distinct responsibilities of cloud consumers and providers, there are areas where responsibilities are shared. This often falls under the Shared Responsibility Model, where both parties have roles in ensuring the security and effective management of cloud services.



## Definition

<sup>a</sup>Wikipedia: <https://en.wikipedia.org/wiki/Strategy>

A structured plan to achieve a long-term goal of your business by using cloud computing resources.

What is the structured plan? What are the goals? What are the resources?



# Business principles

## Example business principles

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# Cloud strategy – Formulation of a strategy

## Cloud Strategy

**Cloud Strategy = Plan + Goals + Business Principles**

## Formulation Cloud Strategy

Of course the definition above is very simplistic and is only suitable for this lecture. In practice there are many more things that need to be integrated into a Cloud Strategy (see section 2)!







# Cloud Strategy – Developing and implementing the strategy

## Strategy development

Now that we know how to develop a strategy and what important factors in its development are one question is still important. . .

**Who is developing the strategy?**

## Answer

**The Enterprise Architect!**

## Strategy implementation

**Who is implementing the strategy?**

## Answer

**The Cloud Architect!**



# Enterprise Architecture – Metaphor


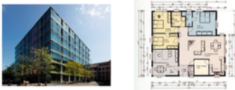
	Enterprise Architecture	Software Architecture
Metaphor	<p>Town Planning</p> 	<p>Individual building</p> 
Scope	Processes and software systems on corporate level	Individual software system
Zoom	<ul style="list-style-type: none"><li>▪ Corporate architecture (whole city)</li><li>▪ Individual organisational unit (district)</li></ul>	<ul style="list-style-type: none"><li>▪ Group of systems (block, campus)</li><li>▪ Single software system (building)</li><li>▪ Software component (roof, wing)</li></ul>
Detail	low / medium	high

Figure: Enterprise architecture vs. software architecture<sup>a</sup>

<sup>a</sup>Source: Jung, J., & Fraunholz, B. (2021). Masterclass Enterprise Architecture Management. Springer International Publishing.  
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# Enterprise Architecture planning 1/4

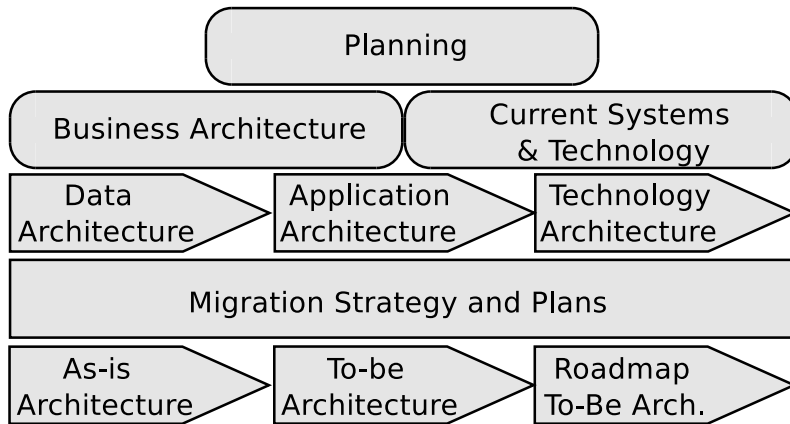
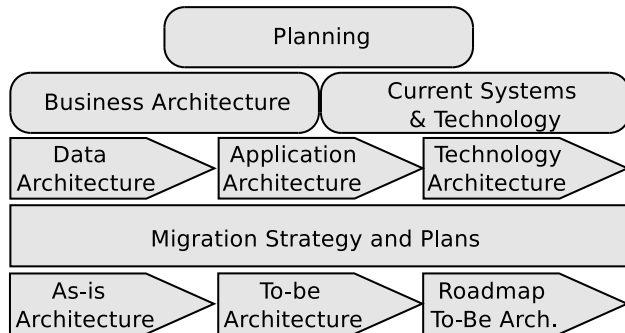


Figure: Enterprise architecture planning (Spewak)<sup>a</sup>

<sup>a</sup>Source: Spewak, S. H., & Devocht, S. (1997). Enterprise Architecture Planning. John Wiley & Sons Canada, Limited, 1997



# Enterprise Architecture planning 2/4



## Planning

- This stage is the foundation for the subsequent stages of processing.
- At this stage, the scope and planning of activities or work plans are defined.

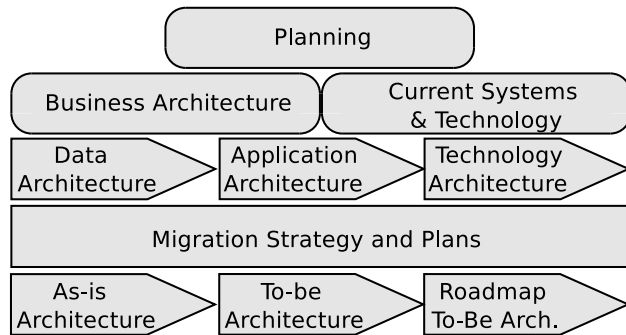
## Business Architecture

- Analysis of business and information used in conducting business activities.
- Develop a business model to derive knowledge for defining architecture and implementation plans.

## Current Systems & Technology

- Detailed List of used systems and technologies
- Usually stored inside an Enterprise Architecture repository

# Enterprise Architecture planning 3/4



## Data Architecture

- Definition of the major kinds of data needed to support the business.

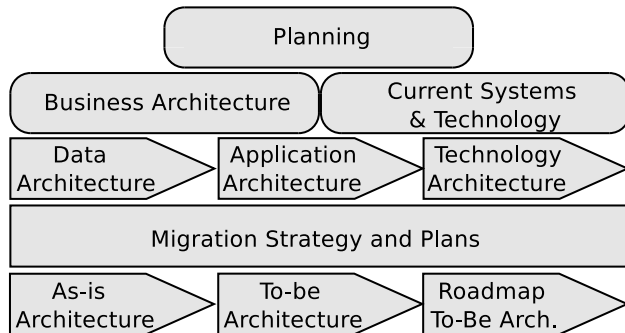
## Application Architecture

- Definition of the major kinds of applications needed to manage data and support the business functions.

## Technology Architecture

- Definition of the technology platforms needed to support the applications that manage the data and support the business functions.

# Enterprise Architecture planning 4/4



## Migration Strategy

- Stages for the implementation of applications, scheduling implementation, analysis of cost and determining a clear path to move from the current position to the desired position in the future.

## As-is Architecture

- Detailed plan of the current architecture.

## To-be Architecture

- Detailed plan of the planned architecture.

## Roadmap

- Detailed plan of the implementation of the migration strategy.

# Enterprise Architecture and Cloud Computing

## Group Discussion

How does Enterprise Architecture fit into the context of Cloud Computing?

# Enterprise Architecture and Cloud Computing (1/2)

The alignment of the two methods has the following benefits:

- **Strategic Alignment**

- **Business Objectives:** EA provides a framework for aligning IT infrastructure with business goals. Cloud computing supports these objectives by offering scalable and flexible IT resources.
- **Innovation and Agility:** Cloud services enable rapid deployment and scaling of applications, aligning with EA's focus on agility and innovation.

- **Operational Efficiency**

- **Cost Management:** EA guides the planning and optimization of IT resources. Cloud computing aligns with this by offering a pay-as-you-go model, reducing capital expenditure.
- **Resource Utilization:** Cloud services optimize resource utilization by allowing enterprises to scale resources up or down based on demand, which is a core principle of EA.

- **Technology Integration and Standardization**

- **Interoperability and Integration:** EA promotes the use of interoperable systems and standards. Cloud computing facilitates this by providing standardized platforms and services.
- **Unified Platforms:** Many cloud providers offer platforms that support a wide range of enterprise needs, aligning with EA's goal of creating a cohesive and unified IT environment.

# Enterprise Architecture and Cloud Computing (2/2)

- **Scalability and Flexibility**

- **Elastic Scalability:** Cloud computing's ability to quickly scale resources aligns with EA's need to support business scalability.
- **Flexible Architectures:** EA's emphasis on building flexible and adaptable architectures is supported by cloud services that offer diverse configurations and capabilities.

- **Security and Compliance**

- **Security Frameworks:** EA includes security policies and frameworks to protect enterprise assets. Cloud computing providers offer robust security features and compliance certifications.
- **Shared Responsibility Model:** In cloud computing, the shared responsibility model delineates security responsibilities between the cloud provider and the consumer.

# Enterprise architect vs Cloud architect

## Enterprise architect

**Focus** on business strategy

**Knowledge** business strategy to IT infrastructure

**Depth** High-Level

**Responsibilities** business processes and strategic planning

## Cloud architect

**Focus** on technological strategy

**Knowledge** Cloud architectures and applications

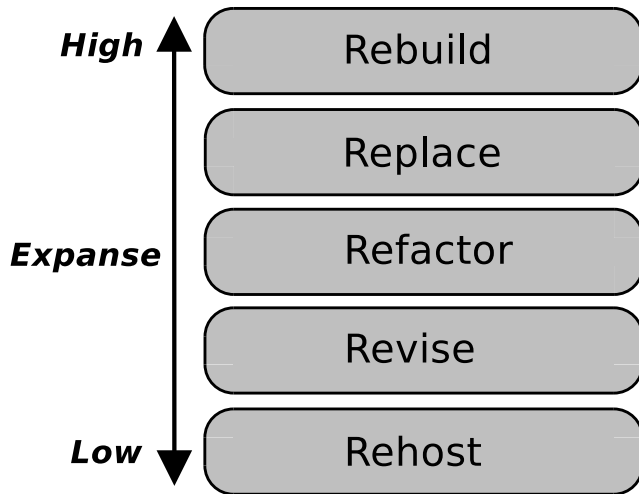
**Depth** Low-Level

**Responsibilities** designing, deploying, and managing applications

### More on Enterprise Architecture

If you are interested there is a compulsory module on **Enterprise Architecture Management** in the masters programme **Wirtschaftsinformatik (M.Sc.)!**

# The 5 R's in Cloud Strategy

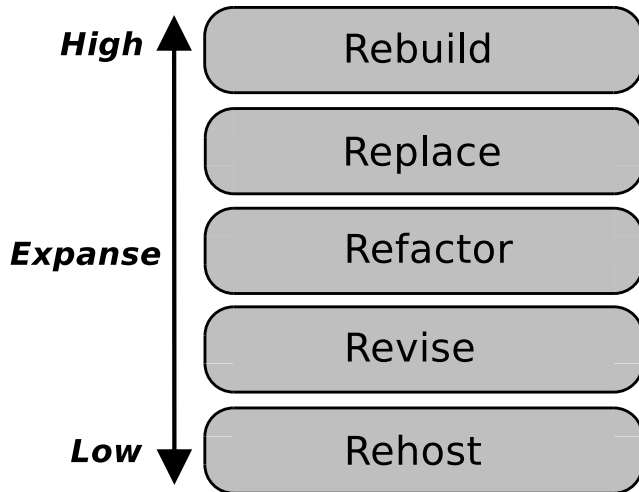


## The 5 R's in Cloud Strategy

The 5 R's is an approach to classifying applications for cloud transformation. It was invented by Gartner around the year 2011. They are also part of Cloud Adoption Frameworks of the popular cloud service providers (see slide 7)



# The 5 R's in Cloud Strategy



## 5 Rebuild

- Developing a new application and discarding the old application.

## 4 Replace

- Replacing the legacy application by a new product (either purchased, rented or open source).

## 3 Refactor

- Modernizing legacy applications for a better cloud alignment.

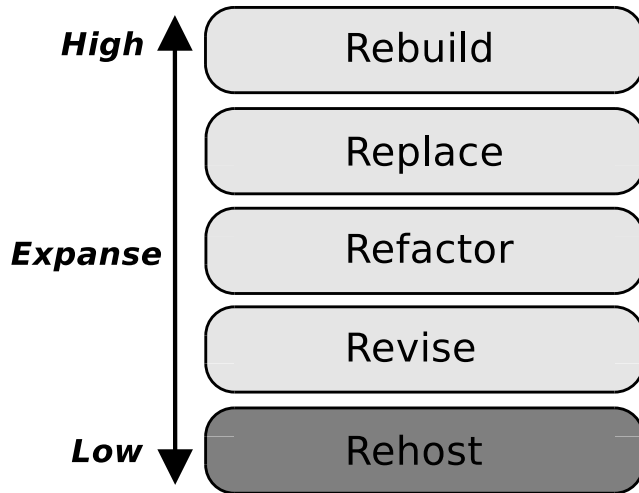
## 2 Revise

- Updating legacy applications to prepare them for a subsequent rehost.

## 1 Rehost

- Migrating legacy applications to the cloud. Also known as Lift & Shift.

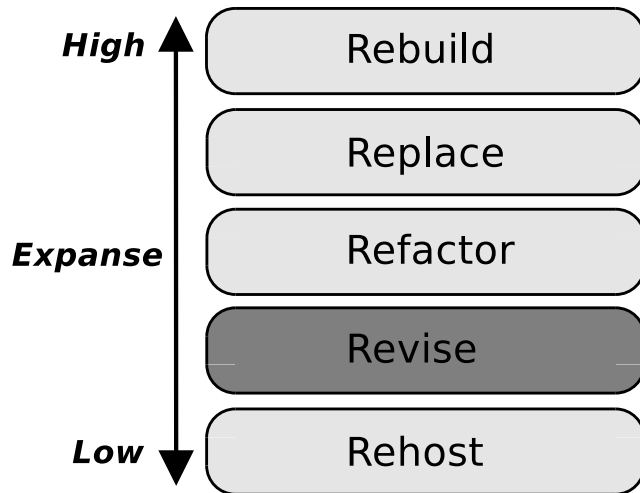
# 1.) Rehost



## Rehost

- Rehosting refers to reformatting an application to a different hardware environment and changing its infrastructural composition.
- Moving to an IaaS offering (so-called "lift and shift"). This is relatively fast and requires minimal modification, but it will not take advantage of cloud characteristics like auto-scaling.

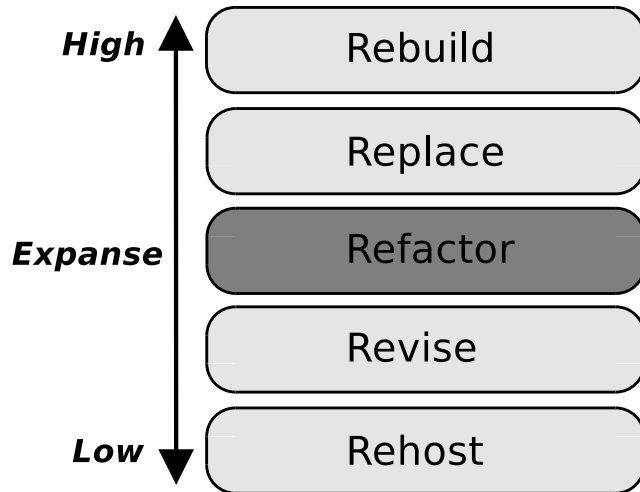
## 2.) Revise



### Revise

- Revision involves altering the existing code. Once the code has been modified to support the needs for legacy modernization, the next goal is to rehost or refactor the options to mobilize to the cloud.

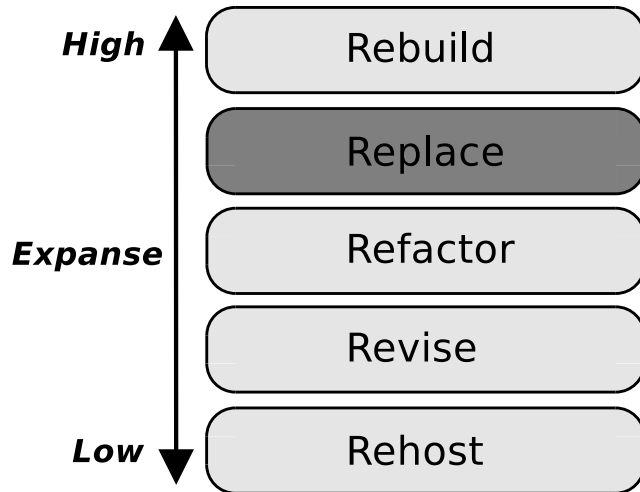
### 3.) Refactor



#### Refactor

- Deploying PaaS suggests that developers can reuse containers, languages, and frameworks that have already seen investment.
- Refactoring involves decoupling and redesigning the application for compatibility with the platform service

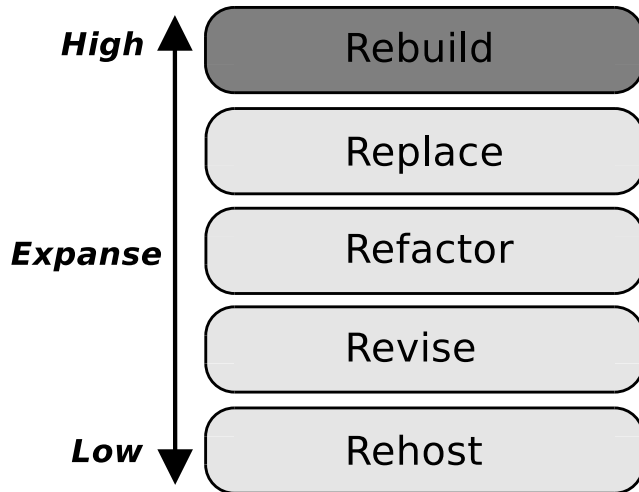
## 4.) Replace



### Replace

- Replacing the legacy application by a new product (either purchased, rented or open source).
- Replace with commercial software and discard the pre-existing application.

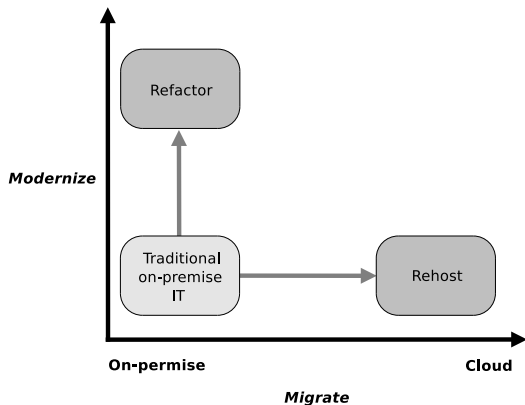
## 5.) Rebuild



### Rebuild

- So far, the initial application's code is discarded, re-architected the application, and now set off to rebuilding solution.
- This guarantees the loss of cognition of the existing codes and frameworks.

# Dimensions in Cloud Migration



## Dimensions

### ① Up – Modernize

- Refactor → Completely redoing an application's deployment architecture. E.g. breaking a monolithic application architecture into microservices.

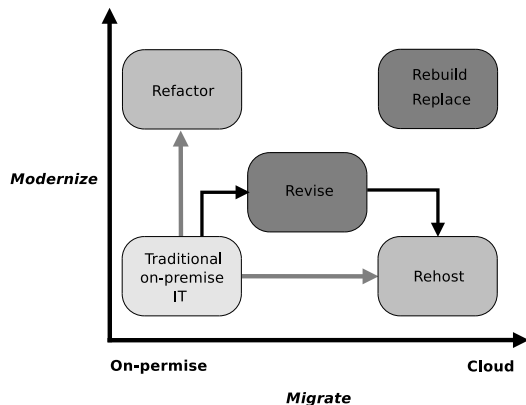
### ② Out – Modernize

- Rehost → Moving the whole VM from on premises to the cloud replacing the physical host!

## Question

What about the other R's? What about Revise, Rebuild and Replace?

# Dimensions in Cloud Migration



## Dimensions

### 1 Up – Modernize

- Rebuild → Rebuilding an application from scratch discontinuing the old application!
- Replace → Replace an application with another more commercially available (or open source) alternative. Usually a SaaS solution.

### 2 Out – Migrate

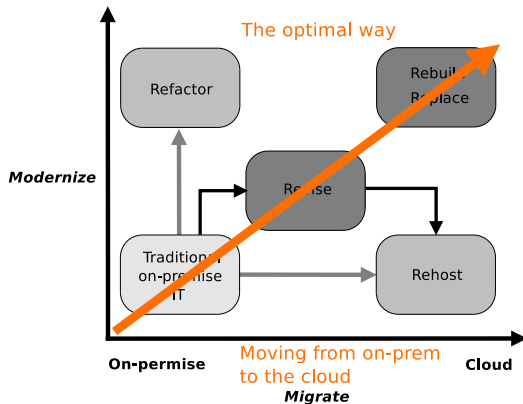
- Revise → Updating legacy applications to prepare them for a subsequent rehost.

## Answer

Revise is an additional step to rehosting an application. Rebuild and Replace move further up the modernization and cloud dimension.



# Dimensions in Cloud Migration – moving up and out



## Moving up – *Modernize*

The dimensions of migration seem simple but there are many things to consider moving up the modernization dimension!

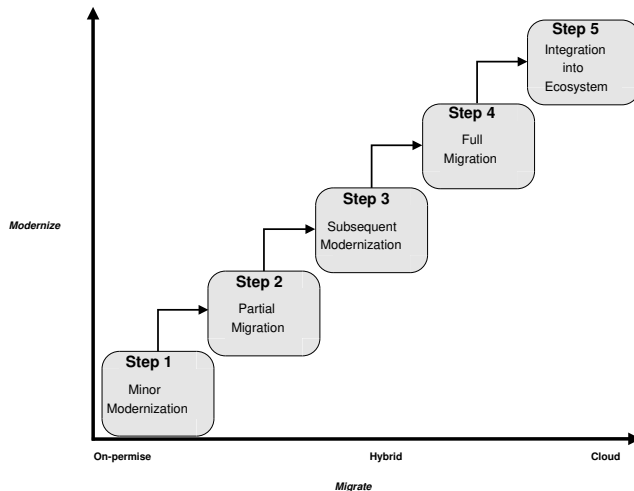
- Platform → Runtime, VM, Container, etc.
- Architecture → Monolithic vs Microservice (more in slide set 5!)
- Deployment → Manual vs automated (more in slide set 6!)

## Moving out – *Migrate*

This dimension has less degrees of freedom, since there are only three locations:

- Private (on-premise) → Running in-house.
- Hybrid → Part in-house/part cloud (e.g back end on-prem, front end in cloud).
- Public → Running in the cloud.

# Exemplary Migration of an application



## ⑤ Integration into Ecosystem

- Integration of the application into the cloud ecosystem (e.g. using DB service, object storage service, etc.).

## ④ Full Migration

- Migration of the whole application to the cloud.

## ③ Subsequent Modernization

- Further Modernization of the application (e.g. porting from one App Server to a cloud compatible framework).

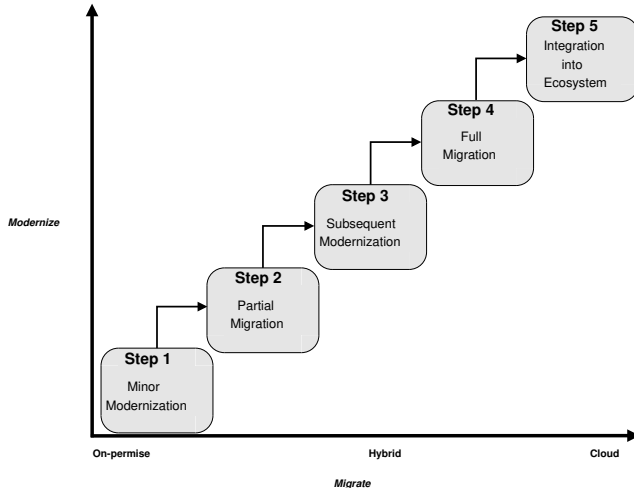
## ② Partial Migration

- Partial relocation of the application with partial operation on-premise (e.g. legacy back end).

## ① Minor Modernization

- Minor modifications on application to move to cloud (e.g. front end).

# Cloud Migration Strategies



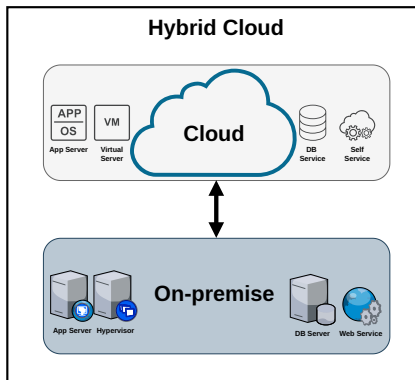
## Bad News...

There is not the one correct **Cloud Migration Strategy**! It always depends on the use case. There are always many factors, which need to be taken into consideration!



Figure: Source: South Park – S 2 Ep 17

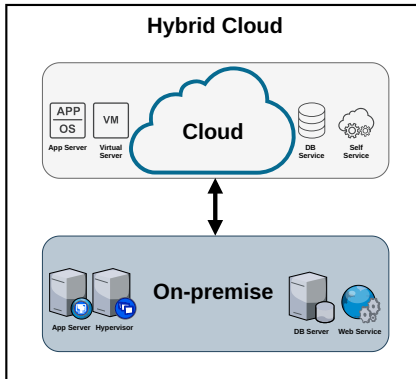
## Hybrid Cloud



## Hybrid Cloud

- Integration of Private and Public Clouds
- Unified Management
- Elastic Resource Use
- Data Mobility – Dynamic Workload Allocation
- Data Movement – Organizations can move data between clouds
- Sensitive Data Protection – Critical or sensitive data can be kept in a private cloud or on-premises

# Hybrid Cloud $\Rightarrow$ Multi-Cloud



## What happens if we use multiple public cloud providers in a hybrid cloud setup?

## Benefits

- **Vendor Diversification:** Avoids reliance on a single cloud provider, mitigating vendor lock-in.
- **Best-of-Breed Services:** Enables organizations to choose the best services from different providers.
- **Resilience:** Increases redundancy and disaster recovery options.
- **No Integration Requirement:** Unlike hybrid clouds, multi-cloud doesn't necessarily require tight integration between the clouds.

# Multi-Cloud Strategy

## Definition by ChatGPT

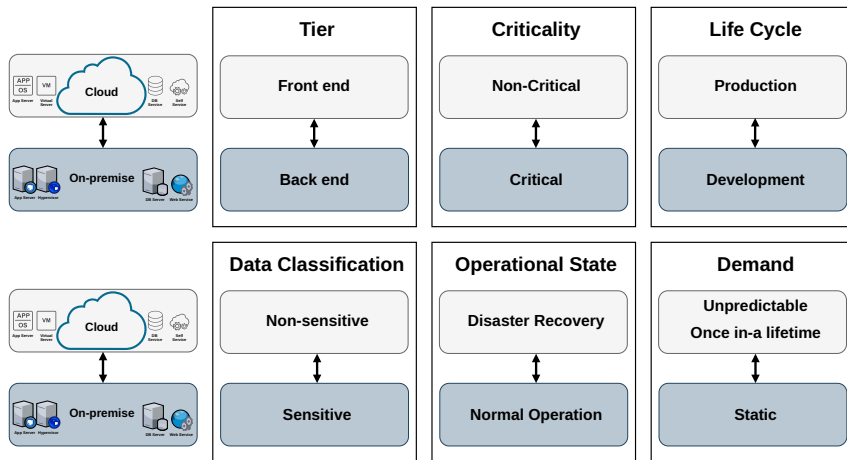
A multi-cloud strategy involves using multiple cloud services from different providers to meet various organizational needs. Unlike a single-cloud approach, which relies on one cloud service provider, a multi-cloud strategy leverages various providers' unique strengths and capabilities to optimize performance, cost, and resilience. This approach offers flexibility, reduces dependency on a single vendor, and can enhance the overall effectiveness of cloud operations.

**Multi-Cloud**

The diagram illustrates a Multi-Cloud architecture where applications and services are distributed across multiple cloud providers. It shows three distinct cloud environments: AWS, Azure, and GCP. Each environment contains its own set of services: App Server (APP/OS), Virtual Server (VM), Cloud (represented by a cloud icon), DB Service (database icon), and Self Service (gears icon).

- Compare pricing across different providers to take advantage.
- Allocate budgets across multiple providers to optimize spending.

## Multi-Cloud segmentation strategies









# Outlook

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

## 5th part: Architectures and applications

## Topics:

- Software Architectures
- Distributed Systems and Cloud Computing
- Distributed Architectures in Cloud Computing
- Properties of Distributed Architectures
- Decision Criteria for Distributed Architectures

# Thank You For Your Attention!

**Henry-Norbert Cocos, M.Sc**  
Frankfurt University of Applied Sciences  
Room 1-230

☎ +49 69 1533-2699

✉ [cocos@fb2.fra-uas.de](mailto:cocos@fb2.fra-uas.de)

🌐 [www.henrycocos.de](http://www.henrycocos.de)

