Cloud Computing

Adoption and strategy in Cloud Computing
Slide set 4

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Agenda

1. Cloud adoption and strategy

2. Cloud adoption

3. Cloud strategy

4. Multi-Cloud Strategy

5. Risks and Opportunities

6. Summary

Cloud adoption and strategy

Till now we have discussed the technological (slide set 2) and the organizational (slide set 3) aspects of cloud computing.

What about the business perspective?

Cloud adoption and strategy

The overall goals of a company in using cloud computing are the following:

- **Enhance Agility and Flexibility:** Quickly adapt to changing market conditions and scale resources up or down as needed without the constraints of traditional IT infrastructure.

- **Increase Cost Efficiency:** Reduce capital expenditures and operational costs by using a pay-as-you-go model, which allows for better financial predictability and optimization.

- **Improve Performance and Reliability:** Access robust, high-performance infrastructure and services that provide increased uptime and reliability, supporting critical business operations.

- **Foster Innovation:** Enable rapid development, testing, and deployment of new applications and services, fostering a culture of innovation.

- **Enhance Global Reach and Collaboration:** Enhance collaboration among distributed teams and expand the company's presence globally through accessible, cloud-based services.

Cloud adoption and strategy

To achieve the mentioned goals a company needs to **adopt Cloud Computing** and implement a **strategy**!

Cloud adoption and strategy

Definition by ChatGPT

Cloud adoption is the **strategic process of migrating an organization's IT infrastructure, applications, and services from on-premises to cloud-based environments**. This transition aims to leverage the cloud's benefits, such as enhanced scalability, flexibility, cost savings, and improved collaboration. It involves careful planning and execution, including **assessing current systems, managing migration**, ensuring security and compliance, and optimizing costs. Cloud adoption enables businesses to innovate faster and respond more agilely to changing market demands.

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.

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Cloud adoption frameworks – best practices and specifics

Cloud adoption frameworks

Cloud Adoption Frameworks are structured methodologies that provide best practices, guidelines, and tools to help organizations adopt and manage cloud computing technologies. Every large Cloud service provider offers an adoption framework for their services.

Examples:

- **AWS Cloud Adoption Framework**: LINK CAF PDF
- **Azure Cloud Adoption Framework**:
- **Google Cloud Adoption Framework**: LINK CAF PDF

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.

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Roles and responsibilities in Cloud Computing (1/4)   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.

Roles and responsibilities in Cloud Computing (2/4)   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.

Roles and responsibilities in Cloud Computing (3/4)   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?

Roles and responsibilities in Cloud Computing (4/4)   Source: *Multi-Cloud Architecture and Governance* by Jeroen Mulder

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.

What is a Cloud Strategy?

Definition by ChatGPT

A **cloud strategy** is a detailed plan that outlines how an organization will utilize cloud computing to achieve its business objectives. It defines the **roadmap for adopting cloud services**, including **selecting suitable cloud models** (IaaS, PaaS, SaaS) and **providers**, ensuring alignment with the company's goals. The strategy addresses key aspects such as cost management, security, and compliance, and sets success metrics to measure the effectiveness of cloud initiatives. Ultimately, a cloud strategy aims to enhance agility, drive innovation, and improve operational efficiency.

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Strategy in general

Definition

Strategy [. . .] is a general plan to achieve one or more long-term or overall goals under conditions of uncertainty.[a]

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[a]Wikipedia: `https://en.wikipedia.org/wiki/Strategy`

Cloud Strategy

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

Questions

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

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Goals

SMART

A **SMART** goal is **specific, measurable, attainable, relevant** and **timely**.

Example: **I will be training to run the Berlin half marathon in March in under two hours**.

- **specific:** (Berlin half marathon)
- **measurable:** (in under two hours)
- **attainable:** (two hours is ambitious, but achievable for most runners with the right training) ;-)
- **relevant:** (the person has decided to prepare for the half marathon)
- **timely:** (in March)

Business principles

Business principles

A business needs to define principles that can be formulated by goals and achieved by a strategy.

Example business principles

- Faster deployment of products.
- Faster response times to change.
- More reliability of the service.

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)!

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Cloud strategy – Simple example

Business principle

Faster deployment of business news.

Goal

Deployment of new information to the service for customers within 24 hours.

Plan

Host the service in the cloud.

Strategy

Move the service back end to AWS Lambda and host the front end in AWS Elastic Beanstalk. Configure a deployment pipeline for functional units with GitLab and ship changes automatically to AWS Lambda and AWS Elastic Beanstalk simultaneously.

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The Vendor lock-in

Vendor lock-in

A Vendor lock-in in cloud computing occurs when a company becomes dependent on a single cloud service provider, making it difficult or costly to switch to another provider or move services back on-premises.

Risks of a Vendor Lock-in:

- **High Switching Costs**
  - **Migration Expenses:** Moving applications, data, and workloads to another provider can be expensive.
  - **Retraining Staff:** Employees may need new skills to work with a different provider's tools and services.
- **Limited Flexibility and Innovation**
  - **Service Limitations:** Being tied to one provider may restrict access to advanced features and competitive pricing.
  - **Innovation Barriers:** Organizations might miss out on innovative services or technologies.
- **Performance and Reliability Concerns**
  - **Service Outages:** Dependency on a single provider means that any downtime or service disruption directly impacts the organization's operations.
  - **Vendor Stability:** A risk associated with the vendor's financial stability.

Strategies to mitigate Vendor Lock-in

- **Multi-Cloud Strategy**
  - **Diversify Providers:** Use services from multiple cloud providers.
  - **Interoperability:** Choose solutions that work across different cloud platforms (see section 4).
- **Hybrid Cloud Approach**
  - **Combine Cloud and On-Premises:** Utilize a mix of on-premises infrastructure and cloud services (see section 4).
  - **Cross-Platform Tools:** Implement tools and services that facilitate seamless integration and management.
- **Design for Portability**
  - **Containerization:** Use container technologies like Docker and orchestration tools like Kubernetes (more in slide set 2).
  - **Microservices Architecture:** Break applications into smaller, independent services (more in slide set 6).
- **Adopt Open Standards and APIs**
  - **Standardized Protocols:** Use industry-standard protocols, open-source software, and APIs to avoid proprietary technologies (more in slide set 5).
  - **API-First Development:** Focus on developing applications that are API-driven (more in slide set 5).
- **Abstract and Decouple**
  - **Service Abstraction:** Utilize abstraction layers or platforms.
  - **Loose Coupling:** Architect systems with loose coupling principle (more in slide set 5).

Cloud Strategy – Developing and implementing the strategy

Startegy 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!

Startegy implementation

Who is implementing the strategy?

Answer

The Cloud Architect!

Enterprise Architecture

Definition

Enterprise Architecture (EA) is: „a well-defined practice for conducting enterprise analysis, design, planning, and implementation, using a comprehensive approach at all times, for the successful development and execution of strategy."[a]

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[a]Federation of EA Professional Organisations

Enterprise Architecture – Metaphor

Figure: Enterprise architecture vs. software architecture[a]

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[a]Source: Jung, J., & Fraunholz, B. (2021). Masterclass Enterprise Architecture Management. Springer International Publishing.

Enterprise Architecture planning 1/4
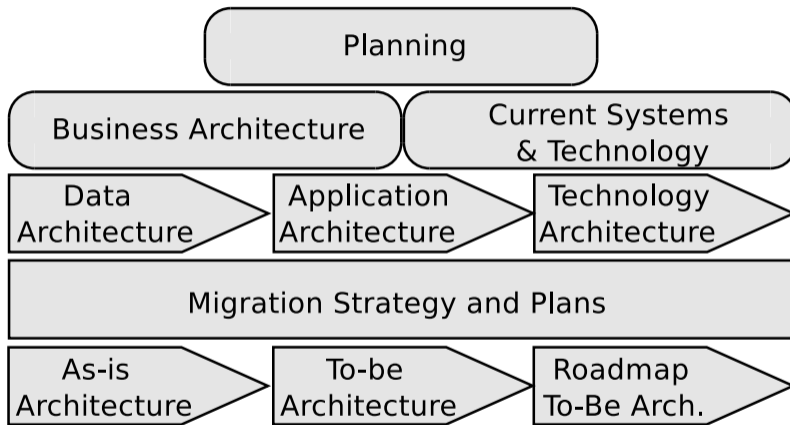
Figure: Enterprise architecture planning (Spewak)[a]

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[a]Source: Spewak, S. H., & Devocht, S. (1997). Enterprise Architecture Planning. John Wiley & Sons Canada, Limited, 1997

Enterprise Architecture planning 2/4
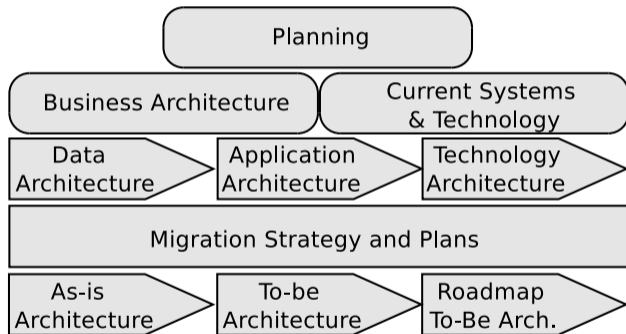
Planning

- 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

Planning

Business Architecture | Current Systems & Technology

Data Architecture | Application Architecture | Technology Architecture

Migration Strategy and Plans

As-is Architecture | To-be Architecture | Roadmap To-Be Arch.
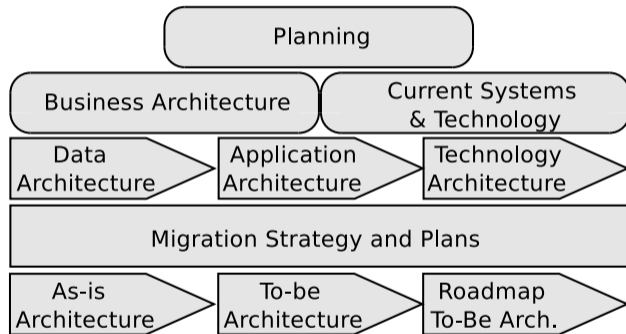
Data Architecture
- Definition of the major kinds of data needed to support the business.

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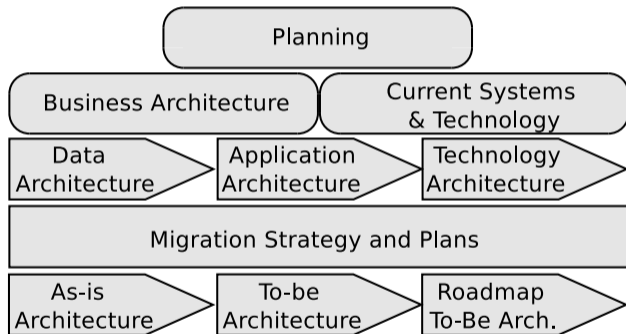
Migration Strategy
- Stages for the implementation of applications, scheduling implementation, analysis of cost and determining a clear path to move from the current position to the desired position in the future.

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?

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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
Responsibilites	business processes and strategic planning

Cloud architect

Focus	on technological strategy
Knowledge	Cloud architectures and applications
Depth	Low-Level
Responsibilites	designing, deploying, and managing applications

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More on Enterprise Architecture

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

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The 5 R's in Cloud Strategy

High

Rebuild

Replace

Expanse

Refactor

Revise

Low

Rehost
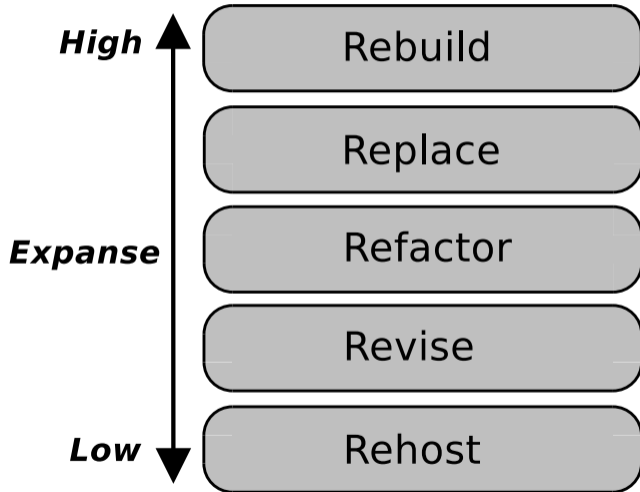
The 5 R's in Cloud Strategy

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

High

Rebuild

Replace

Expanse

Refactor

Revise

Low

Rehost
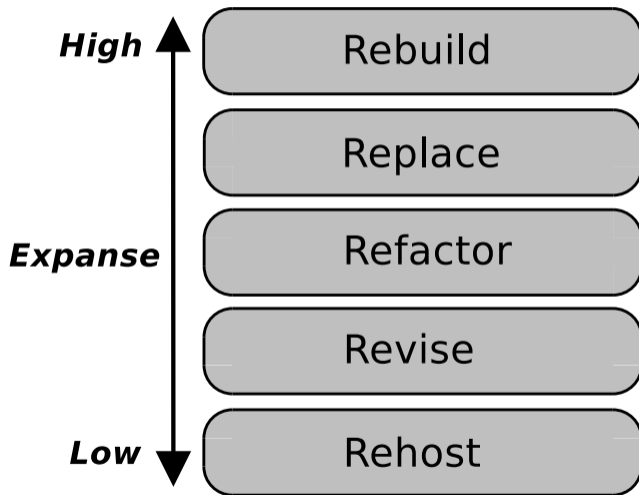
5 **Rebuild**
- Developing a new application and discarding the old application.

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

3 **Refactor**
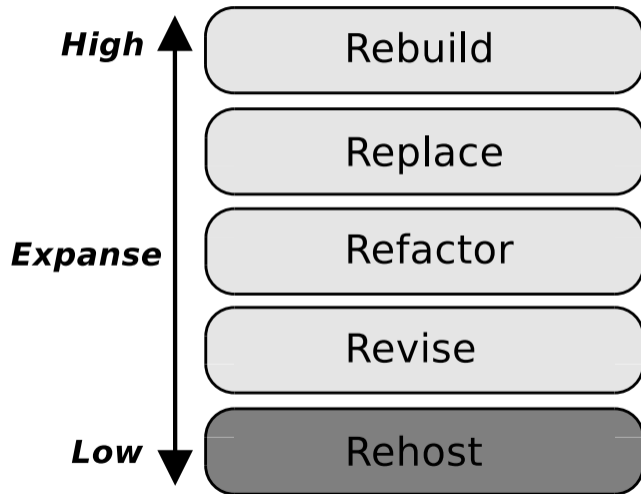- Modernizing legacy applications for a better cloud alignment.

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

High → Rebuild

Replace

**Expanse** | Refactor

Revise

Low → Rehost

Rehost

- Rehosting refers to reformating 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.
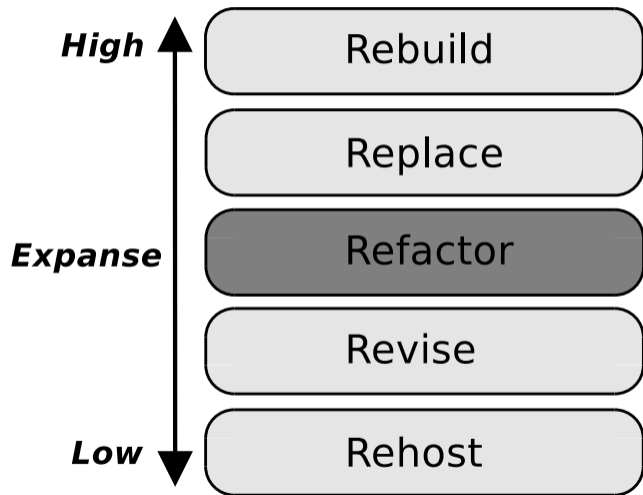
2.) Revise

High → Rebuild

Replace

Expanse | Refactor

Revise

Low → Rehost
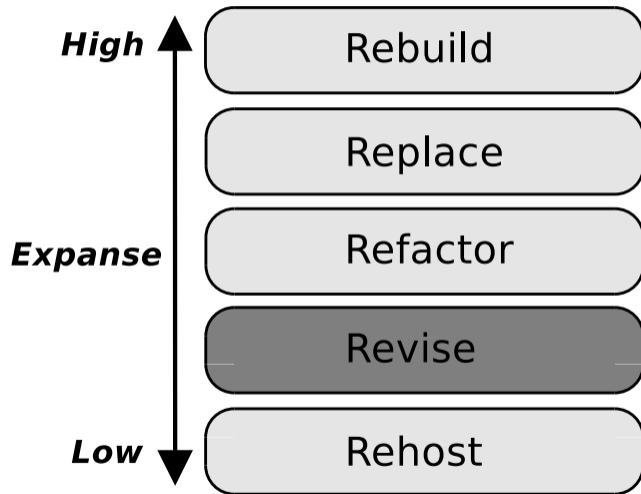
Revise

- 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

High	Rebuild
	Replace
Expanse	Refactor
	Revise
Low	Rehost

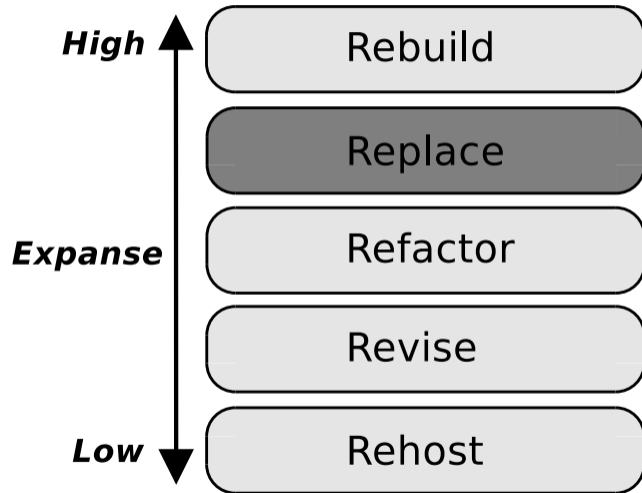**Refactor**

- 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

High — Rebuild

Replace

Expanse — Refactor

Revise

Low — Rehost

Replace

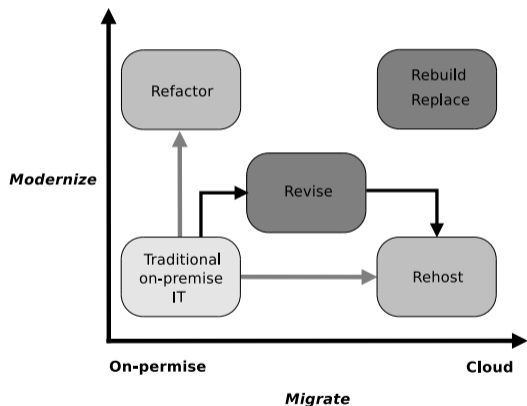- Replacing the legacy application by a new product (either purchased, rented or open source).
- Replace with commercial software and discard the pre-existing application.

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

Modernize

Refactor

Traditional on-premise IT → Rehost

On-premise   **Cloud**

Migrate

Dimensions

1. **Up – Modernize**
   - Refactor → Completely redoing an application's deployment architecture. E.g. breaking a monolithic application architecture into microservices.

2. **Out – Migrate**
   - 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

Modernize

On-permise   Cloud

Migrate

Dimensions

1 **Up – Modernize**

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

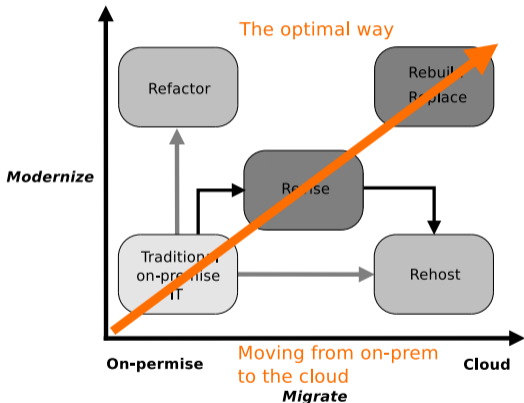**2** **Out – Migrate**

- 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

The optimal way

Modernize

On-permise   Moving from on-prem to the cloud   Cloud

Migrate

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
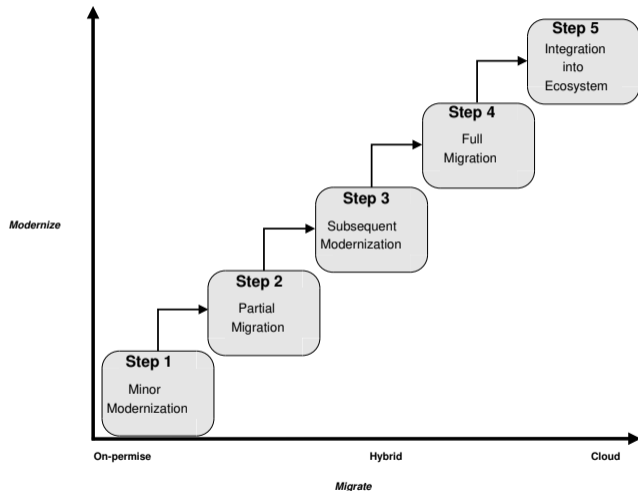
5 **Integration into Ecosystem**

- 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
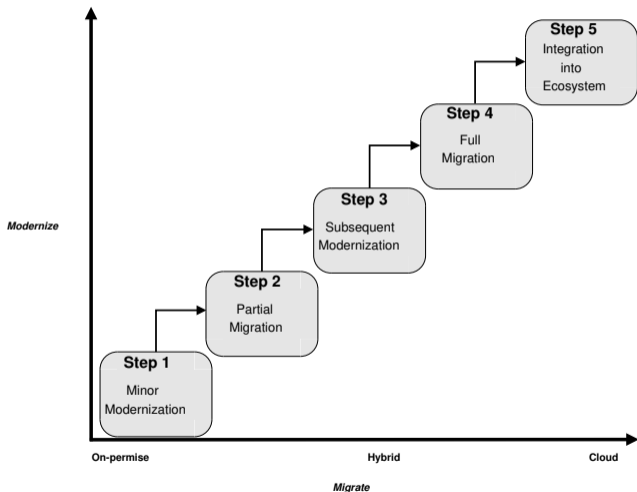
Bad News. . .

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
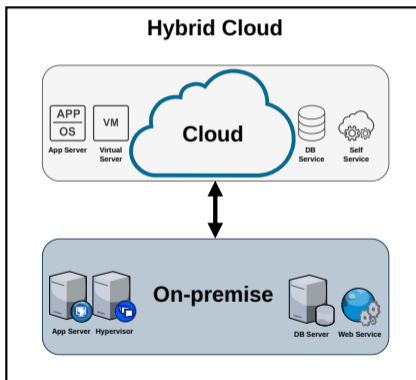
Hybrid Cloud

- 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 $\implies$ 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.

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Multi-Cloud

Multi-Cloud

- Select cloud providers based on their strengths in specific areas (e.g., data storage, machine learning, global reach).
- e.g AWS, Azure, GCP

Workload Optimization

- Deploy workloads on the most suitable cloud platform.
- Use providers that offer optimal performance for specific applications or services.

Cost Management

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

Multi-Cloud segmentation strategies

Risks and Opportunities

Risks

- **Complexity**
    - **Management Overhead:** Managing multiple providers can increase operational complexity.
    - **Skill Requirements:** Staff may need to develop skills across different platforms and technologies.
- **Integration**
    - **Interoperability Issues:** Ensuring smooth integration between services from different providers can be challenging.
    - **Data Consistency:** Maintaining data consistency and synchronization can be difficult.
- **Security**
    - **Unified Security:** Implementing security measures across cloud environments is complex.

Opportunities

- **Flexibility and Choice**
    - **Service Optimization:** Choose the best services from various providers.
    - **Adaptability:** Quickly adapt to changing business needs and technological advancements.
- **Risk Reduction**
    - **Reduced Downtime:** Decrease the likelihood of service interruptions.
    - **Vendor Leverage:** Maintain bargaining power with providers by having the options.
- **Cost Efficiency:**
    - **Competitive Pricing:** Take advantage of competitive pricing and cost structures.
    - **Resource Utilization:** Dynamically allocate workloads to the most cost-effective environments.

Summary

Brief summary over the lecture and focal takeaway points!!!

- The definition and importance of cloud adoption and strategy
- The roles and responsibilities in Cloud Computing and the importance of shared responsibilities
- The Vendor lock-in and how to mitigate it
- Enterprise Architecture and its relation to strategy and Cloud Computing
- The 5 R's in Cloud Strategy and dimensions in Cloud Migration
- Hybrid Cloud setups and its relationship to Multi-Cloud strategies
- Multi-Cloud segmentation strategies and risks and opportunities of such strategies

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Outlook

1st part: ~~Introduction~~

2nd part: ~~Technological foundations~~

3rd part: ~~Service models, deployment models~~

4th part: **Adoption and strategy** $\Longleftarrow$ *This slide set*

5th part: **Architectures and applications**

6th part: **Cloud-Native applications**

7th part: **Current and future trends**

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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

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Thank You
For Your Attention!

Henry-Norbert Cocos, M.Sc

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