MASTER OF SCIENCE THESIS

Get ready for the Cloud: Tailoring Enterprise Architecture for Cloud Ecosystems

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Tailoring Enterprise Architecture for Cloud Ecosystems

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Preface

This thesis marks the end of my studies at the University of Twente by obtaining the Master of Science degree in Business Information Technology. The project was carried out at BiZZdesign in Enschede with the collaboration of the University of Twente and The Open Group. Finishing the Master studies is an important achievement; therefore I would like to thank a couple of people.

First I would like to thank my supervising committee, Maria, Luís and Luiz, who provided me with great insights, support and guidance throughout the project. Even though the first meetings with them were quite frustrating, I realized that this is how a real research project feels like. They always motivated me when I was disappointed, while their sharp comments and expertise played a major role on the end result of my research.

Furthermore, I would like to thank some other people from BiZZdesign, Boeing, TheStandard and The Open Group who provided significant input, support and genius ideas to my thesis. Tejpal, Daniel, Jan, Iver, Anastasios, Adina, Agung, Rufina, Prince, Maher, Dick and Henry thank you for that.

Most of all I would like to thank my family, Dimitri, Adamantini, Maki, Kosta, Dimitri, Euaggelia, Kosta, Nectario, Georgia and Electra for giving meaning to my life.

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Executive Summary

Enterprise Architecture describes a high-level design of the structure of the organization, the roles, the processes and the functions, IT systems and IT infrastructure as well as their interrelationships, in order to realize the business goals and objectives. For a robust and coherent Enterprise Architecture it is necessary to use an EA framework. An EA framework is a set of structures for developing Enterprise Architectures. The EA frameworks contain guidelines, tools, common vocabulary and a method for designing the target state of the organization in terms of building blocks. Furthermore, they include a list of recommended standards and compliant products that can be used to implement the building blocks.

Nowadays the Cloud Computing paradigm motivates many organizations to adopt and use Cloud services in order to take advantage of the Cloud inherent characteristics. However there are many challenges and risks that Cloud Computing brings to the consumer organizations by extending significantly their traditional IT landscape and boundaries. Cloud transforms the business goals, operations, service offerings, processes, partnerships, and IT infrastructure, things which need to be addressed in the Enterprise Architecture. As a result Enterprise Architects' community needs to quickly understand the direct and indirect effects of the Cloud to EA. Despite the necessity of a Cloud-enabled EA framework there is not such a thing yet developed.

In this report we propose an EA framework for developing, managing and governing enterprise Cloud Ecosystems. The resulting approach is based on TOGAF (EA framework) and ArchiMate (EA modeling language) because they are the most popular EA approaches, applicable to Cloud Computing.

The resulting approach is called TOGAF for Cloud Ecosystems and is a Cloud-enabled version of TOGAF. The most important elements of the TOGAF for Cloud Ecosystems approach are two reference models and specific guidelines for every Phase of the ADM on how to develop, manage and govern enterprise Cloud Ecosystems with the use of these reference models.

The Cloud Ecosystem Reference Model provides taxonomy of Architecture Building Blocks(ABBs), organizational roles, services and their relationships in the Cloud Ecosystem. This reference model forms a common language to achieve integrity of the architectural descriptions and also it is the base to create architectural viewpoints and diagrams of the enterprise Cloud Ecosystem. By utilizing these ABBs, candidates Cloud services are identified for the enterprise Cloud Ecosystem. The Enterprise Ecosystem Model contains the relationships and dependencies between the different kinds of enterprise frameworks in order to manage the life cycle of these Cloud services. Next to them Cloud-specific guidelines are given for TOGAF ADM, which focus on the Cloud-enabled approach, steps and deliverables of each ADM Phase.

The TOGAF for Cloud Ecosystems approach is demonstrated in the context of the ArchiSurance case study in order to provide information on how to develop, manage and govern an enterprise Cloud Ecosystem with the Cloud Ecosystem Reference Model and Enterprise Ecosystem Model. ArchiMate is used to model the deliverables of every ADM Phase for the ArchiSurance CRM Cloud migration scenario.

Lastly the resulting approach is evaluated by interviewing three experts in the field of Cloud Computing and Enterprise Architecture, from one (1) Dutch and two (2) U.S. multinational companies. The feedback from the interviews is applied to the TOGAF for Cloud Ecosystems approach.

About BiZZdesign

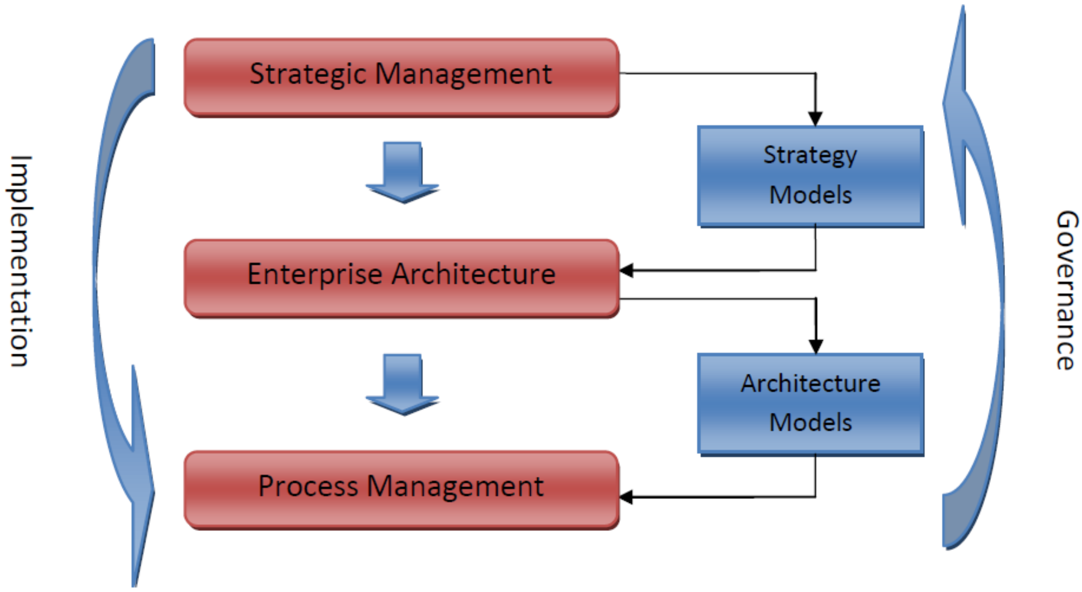
BiZZdesign is a fairly young organization that has managed to become in a short period of time a leader in the domain of Enterprise Architecture. It is a spin-off company of the Telematica Instituut based on the results of Testbed project which took place between 1996 and 2001. This project was ran by the ABP, the Belastingdienst, IBM, the ING Group and the Telematica Instituut and was a virtual environment were business processes were tested. The company has offices in multiple countries all around the world mainly in Europe and North America.

In November 2013 Gartner Inc., a world renowned IT research and advisory organization, has released their Magic Quadrant for Enterprise Architecture Tools. In this Magic Quadrant all organizations are positioned along two axes: ability to execute and completeness of vision. BiZZdesign is positioned in this Quadrant as an organization that has both high ability to execute and high completeness of vision, which puts them in the "leaders" quadrant, alongside other organizations such as IBM, Mega and Software AG.

The main areas of expertise of BiZZdesign are Enterprise Architecture management, business requirements management, business process design and improvement, business process management, and structured implementation and governance.

BiZZdesign offers a complete suite of solutions to its clients that would help them design and improve their business. This complete package contains several *tools* (Arhitect, BiZZdesigner, InSite, RiskManager, GripManager), *business consultancy* (advising, preparing, (re)designing and implementing new business structures, processes, products, services and applications with a starting point in the business strategy and business goals), *best practice models and methods* (architecture drafting and usage, process analysis and design, improving quality – Lean 6-Sigma, implementation) and *trainings* (ArchiMate, TOGAF, Business Process Management, Business Model Management).

One of the models that BiZZdesign uses is the Five Layer Model, which can be seen bellow, which explains the relationships between five aspects: strategic management, enterprise architecture, process management, governance and implementation. A more detailed version of the Five Layer Model will be used in this thesis as a logical reasoning and explanation for how all the models and frameworks chosen are linked to each other.



BiZZdesign has strong collaboration with several other organizations such as The Open Group, Capgemeni, Novay, Solutions4U etc. The Open Group designed the TOGAF (The Open Group Architecture Framework) and ArchiMate standards on which BiZZdesign bases their Architect tool for Enterprise Architecture. The Architect tools will be used in this thesis as a support in the Layer of Enterprise Architecture.

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Chapter 1 - Introduction

The outline of this chapter is the following: Section 1.1 briefly gives the motivation of the present research, Section 1.2 introduces the problem statement, Section 1.3 sets the boundaries of the thesis by stating the research objective and the research questions, Section 1.4 contains the approach that has been followed and Section 1.5 describes the design science research methodology that is applied. Section 1.6 provides the outline of the rest of the report and Section 1.7 concludes the chapter.

1.1 Motivation

The introduction of Cloud Computing transformed the traditional IT landscape by changing completely the way IT is provisioned and used (Hosseini et al. 2010). The benefits of Cloud Computing for its adopters are various and significant. According to Motahari-Nezhad et al. (2009), by using Cloud services an organization can:

- avoid big initial investments for hardware and software acquisition;
- reduce operational and maintenance costs;
- achieve better capacity utilization;
- pay-per-use;
- access various software applications with high availability;
- achieve business agility.

Marston et al. (2011), states also the aforementioned advantages and he adds that Cloud Computing can lower the barriers for IT innovation. In addition, surveys point out that this sector of the IT industry is growing fast and the predictions for the forthcoming years are also promising (Capgemini 2009, Hunter 2011, Simonds 2011). More advantages that Cloud promises to deliver to the potential adopters are discussed thoroughly in the next chapter (Section 2.2).

However, this new concept brings together many challenges and risks that must be taken into account when an organization has to decide whether to migrate to the Cloud. Cloud Computing is changing totally the notion of what is “our system” and “our data” to something diffuse and geographically distributed (Delgado, 2010). As a result, organizations are losing the direct control of their IT landscape (Motahari-Nezhad et al. 2009, Martson et al. 2011). Consequently, new issues arise on how to integrate the on-premise IT infrastructure with the Cloud-based solutions (Motahari-Nezhad et al. 2009, Catteddu & Hogben 2009, Kim et al. 2009, Spinola 2009, Siebeck et al. 2009). The ENISA Cloud Computing risk assessment report (2009) identifies 35 potential risks (Catteddu & Hogben 2009) which can be categorized in the following groups:

- Policy and organizational risks
- Technical risks
- Legal risks
- Risks not specific for the Cloud

Cloud Computing migration may affect ICT management and governance (Hosseini et al. 2010), or in some cases may cause additional costs (e.g., need for more bandwidth) (Kondo et al., 2009). Cloud migration and adoption is not that simple, due to the significant number of risks and challenges that it implies. The managers should consider carefully the benefits, risks and the impact on the organization before making the decision to adopt and use Cloud-based solutions (Hosseini et al. 2010). That is the reason why the scientific community and the practitioners focus on the development of decision making roadmaps, methodologies, frameworks or guidelines (Buyya et al. 2011, Ernst & Young 2012, Simonds 2011, Brunette Mogull 2009, Menzel et al., Marston et al. 2011, Dargha 2010) as well as risk analyses for Cloud Computing (Martens & Teuteberg 2012, Catteddu & Hogben 2009, Janeczko 2011, Horwarth et al. 2012, Zhang et al. 2010, Martens et al., Subashini & Kavitha 2011). Despite the intense interest in this field still a lot of research needs to be performed to delineate these issues.

The Enterprise Architecture (EA) takes into account the whole enterprise by aligning the IT side with the business side. The introduction of Cloud Computing forced the Enterprise Architects community to quickly understand the direct and indirect effects of the Cloud to EA. Cloud Computing is changing the traditional IT landscape and also extending the horizon of the enterprises. Moreover the Cloud paradigm transforms the business goals, operations, service offerings, processes, partnerships, and IT infrastructure (by providing outsourced services) things which need to be fully understood when developing the business strategy and architecture. The extended business environments are changing the roles and responsibilities of the Enterprise Architects which are dynamically changing and are getting more complicated (Mahmood & Hill 2011).

It is proven (Pethuru, 2013) that the EA is widely accepted and used for systematic, sustainable and strategic growth of enterprises. Enterprise Architecture empowers decision makers and executives to structure, simplify, and synchronize the enterprise strategy formulation, roadmap creation, smart execution, effective and efficient administration towards the envisaged result. This is achieved by aligning the business objectives and processes with the IT structures which is the only way to achieve sustainable improvements and cost reductions in developing, maintaining and upgrading IT systems (Pethuru, 2013).

As enterprises adopt Cloud-based solutions, many more issues must be addressed and that makes EA potentially more complex. Consequently, Enterprise Architects are being forced to tailor the EA towards Cloud-based solutions (Mahmood & Hill 2011).

The new challenges enterprises have to face, such as, risks, integration, security, contract management, Cloud service providers' management, show that Cloud Computing does not eliminate the need for robust EA. On the contrary as Polovina (2012) states, Enterprise Architecture approaches must be extended to facilitate Cloud Computing.

The EA frameworks are useful tools for Enterprise Architects, which reduce the workload and complexity of EA programs. Especially with the advent of Cloud Computing whereby enterprises are preparing to modernize and migrate to the service-based, process-centric, event-leveraging and model-driven Cloud Ecosystem, EA frameworks are indispensable. Developing the EA from scratch and with no reference materials can be daunting; that is the reason why corporate houses and industry consortiums collaborate in order to evolve express and encourage easy-to-use and effective EA frameworks. EA frameworks guide the solutions for Enterprise Architects by simplifying the EA engineering task in all areas of architectural engineering (EAdynamics 2012, The OpenGroup 2013). The success of the EA frameworks is attributed to the provisioning of collections of reusable assets and artifacts such as knowledge base, methodology, processes, templates, best practices, guidelines, and metrics that assist the EA development (Pethuru, 2013).

1.2 Problem Statement

Although the benefits of Cloud-enabled EA framework (Thorn 2010, Walker 2012) there is no widely accepted guideline for developing EA for Cloud Ecosystems (Wang et al. 2012). Rimal et al. (2010) argue that the biggest challenge of Cloud Computing is the absence of a de facto or single architectural method which can meet the requirements of enterprise Cloud Ecosystems.

The most widely accepted EA frameworks are the Zachman framework and TOGAF (Polovina 2012, Motahari-Nezhad et al. 2009, Sessions 2007, Feurer 2007). According to Motahari-Nezhad et al. (2009), these frameworks do not consider scenarios where the IT infrastructure and services are residing both on-premises and on the Cloud and they do not consider the impact of Cloud-based solutions on the EA. Many other practitioners and academicians agree with this opinion (Polovina 2012, Wang et al. 2012, Sessions 2007, Pethuru 2013, Thorn 2010).

Consequently the main problem of the Enterprise Architecture is the lack of a framework to meet the requirements of an enterprise Cloud Ecosystem approach. So the problem that initiates and motivates the current project is the following:

There are frameworks for Enterprise Architecture but they do not support the development of enterprise Cloud Ecosystems.

1.3 Objectives

The main research objective of this thesis is to "***Create EA framework support for developing, managing and governing enterprise Cloud Ecosystems".*** The EA framework support should help the organizations accelerate the adoption of Cloud-based solutions and reach sound decisions by designing carefully the enterprise Cloud Ecosystem. In order to meet this research objective it is necessary to search for the most relevant and rigorous EA framework (by comparing the widely used existing EA frameworks) and then analyze and extend it to cope with the development, management and governance of enterprise Cloud Ecosystems. The following research questions are formulated to set the boundaries and guide the research towards the achievement of the research objective.

Research Question 1: Which is the current state of research in the field of Enterprise Architecture and Cloud Computing?

Research Question 2: Which is the most relevant and rigorous Enterprise Architecture framework to develop, manage and govern enterprise Cloud Ecosystems?

Research Question 3: How the Enterprise Architecture framework can be extended/adjusted to develop, manage and govern enterprise Cloud Ecosystems?

Research Question 4: How to evaluate the resulting approach?

1.4 Approach

In order to achieve the aforementioned objective and to answer the research questions the following approach has been taken into consideration:

1. <u>Perform a literature review</u> (Acquire background information & answer RQ1)
   Perform a literature review on EA, EA frameworks and Cloud Computing, by investigating the two subjects independently and then by examining possible synergies between them.

2. Evaluation of the EA frameworks (Answer RQ2)
   The widely used and accepted EA frameworks are compared in order to select the most appropriate EA framework for enterprise Cloud Ecosystems. In this step, we analyzed the strengths, weaknesses and what is missing from the most relevant EA framework.

3. Suggested improvements and development of the approach (Answer RQ3)
   The improvements of the EA framework are presented here, after applying the modifications in it. The aim is to find a way to create an EA framework to develop, manage and govern enterprise Cloud Ecosystems.

4. Demonstration of the approach (Running example)
   The ArchiSurance case study is used as a running example throughout the thesis in order to demonstrate the modifications of the EA framework and also advantages or limitations of the proposed approach.

5. Evaluate the approach (Answer RQ4)
   The evaluation of the proposed improvements has been achieved by performing interview sessions with experts in the field of EA and Cloud Computing from the Netherlands and U.S.A.

1.5 Research Methodology

The current thesis is based on the Design Science Research Methodology (DSRM) (Peffers et al. 2008). Design science was first introduced a few decades ago with the purpose of supporting information science researches. There are many different design science methodologies but the most widely adopted is the Design Science Research Methodology (DSRM) from Peffers et al. (2008). DSRM comprises of six (6) subsequent activities namely: identify problem and motivate, define objectives for a solution, design and development, demonstration, evaluation, and communication. The relationships among these activities are illustrated in Figure 1.

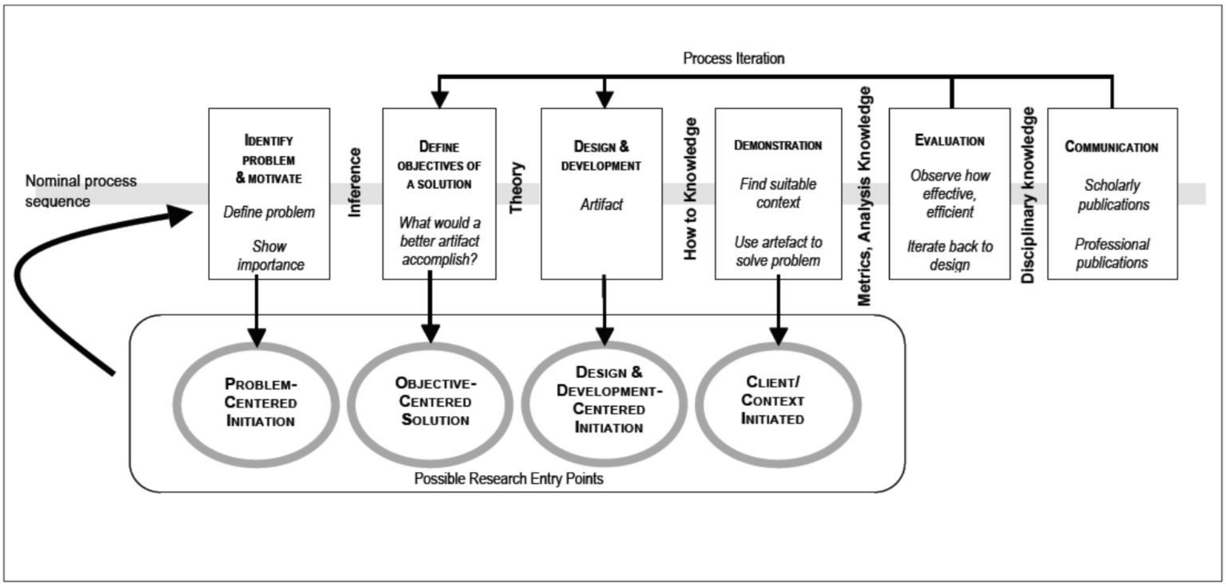

Figure 1: Design Science Research Methodology (DSRM) Process Model (Peffers et al. 2008).

Below we shortly explain each activity and also how these activities relate to the parts and sections of the thesis.

Identify problem and motivate: The research problem is defined together with the proposed solution. In the current project the problem identification and motivation is given in Chapter 1.

Defining the objectives for a solution: The research objectives can be defined based on the problem definition. In order to define the research objectives it is necessary to be knowledgeable on the current state of the field and the proposed solutions. Our research objective (in Chapter 1) can be considered as quantitative since we aim to develop a new architectural approach to accelerate the adoption of Cloud-based solutions. Chapter 2 provides background information about Cloud Computing and Chapter 3 describes the essentials of the Enterprise Architecture and its combination with Cloud Computing. Chapter 4 compares the four most popular Enterprise Architecture approaches (Zachman framework, Federal Enterprise Architecture Framework, The Open Group Framework and the Gartner Enterprise Architecture Framework) based on rigor, relevance and usability.

Design and development: In this activity the design research artifact (any designed object in which a research contribution is embedded in the design) is developed, by determining the functionality and the structure of it. The design and development activity can be mapped with Chapters 5-9 where the theoretical framework which supports the design of a Cloud-enabled EA framework is determined.

Demonstration: The proposed artifact is illustrated with the ArchiSurance case study in order to demonstrate its usability. The case study is presented together with the design and development of the artifact (Chapters 6-9). These two activities are reported together to improve the understanding of the artifact and facilitate the structuring of the document.

Evaluation: The proposed approach evaluated qualitatively for its suitability. This requires comparison between the objectives of the research and with the resulting approach from the demonstration activity and from the interviews. This evaluation activity can be mapped with Chapter 10 and it contains the interview protocol and the interview transcripts. The interviewees have been selected based on their knowledge and expertise in the field of EA and Cloud Computing.

Communication: In this activity the identified problem and the proposed solution in the form of a research publication, such as this master thesis. The current project is in alignment with The Open Group Cloud Computing work group research and the results will be submitted for incorporation in a new version of TOGAF.

1.6 Structure

The remainder of the thesis is structured as follows:

Chapter 2 provides the background information of our research regarding Cloud Computing.

Chapter 3 provides the background information of our research regarding Enterprise Architecture and Cloud Enterprise Architectures.

Chapter 4 compares the most popular EA frameworks and proposes the most suitable to develop, manage and govern enterprise Cloud Ecosystems.

Chapter 5 introduces the resulting approach together with the description of the ArchiSurance case study.

Chapter 6 discusses the activities and the steps that are needed to rationalize the organization's strategy when considering the adoption of Cloud solutions. The Preliminary and Phase A of the framework are demonstrated with the ArchiSurance case study.

Chapter 7 discusses the activities and the steps that are needed to develop the Cloud Enterprise Architecture. Phases B-D are demonstrated with the ArchiSurance case.

Chapter 8 discusses the activities and the steps that are needed to prepare the organization to undergo the change by migrating to the Cloud. Phases E and F are demonstrated with the ArchiSurance case.

Chapter 9 discusses the activities and the steps that are needed to ensure that the change is implemented correctly and works properly according to the requirements. Phases G and H are demonstrated with the ArchiSurance case.

Chapter 10 evaluates qualitatively with interviews the resulting approach.

Chapter 11 concludes this report and gives the limitations of this research with the recommendations for further research and practice.

1.7 Conclusion

Cloud Computing brings many benefits, challenges and a unique way of service provisioning and deployment to organizations. Because of its significance a lot of research is focusing around Cloud Computing but there is little research on developing EA framework support for Cloud Computing. The objective of the thesis is to propose an EA framework to develop enterprise Cloud Ecosystems. This will provide to the practitioners guidance and model-based support to accelerate the adoption of Cloud Computing to various organizations. The methodology that is followed in order to reach this objective is the Design Science Research Methodology from Peffers et al. (2008).

Chapter 2 - Cloud Computing

The outline of this chapter is the following: Section 2.1 provides introductory information about Cloud Computing and Section 2.2 contains the main characteristics of Cloud Computing. Section 2.3 lists the Cloud service models and Section 2.4 the Cloud deployment models. Section 2.5 includes the Cloud Ecosystem Reference Architecture. Lastly Section 2.6 describes the Challenges of Cloud Computing and Section 2.7 concludes the chapter.

2.1 Introduction

Cloud Computing is a new way of delivering and pricing hosted services. The National Institute of Standards and Technology (NIST) define Cloud Computing as (Mell & Grance 2011):

A model for delivering on demand, ubiquitous and configurable IT resources (e.g., networks, servers, storage, applications, and services) from shared infrastructure. What describes Cloud Computing are three (3) service models (Software-as-a-Service, Platform-as-a-Service, Infrastructure-as-a-Service), four (4) deployment models (Hybrid Cloud, Private Cloud, Community Cloud, Public Cloud) and five (5) essential characteristics (On-demand self-service, broad network access, resource pooling, rapid elasticity, measured service).

However the concept of Cloud Computing is not sufficient to describe specialized roles and how they interact in extended business environments. For this reason it is introduced the concept of Cloud Ecosystem. Cloud Ecosystem is a network of participating entities, where each entity has multiple roles in the evolution, provision and consumption of Cloud services. This distributed ecosystem is subject to internal and external factors and the participants are not necessarily aware of all other entities in the Cloud Ecosystem (but they can affect or be affected by them) (The Open Group 2013). Section 2.5 and Section 2.6 aim to delineate grey areas about Cloud Ecosystem by explaining the main roles, relationships and Architecture Building Blocks of it.

2.2 Characteristics & Benefits

The essential characteristics of Cloud Computing are extracted from its definition (Mell & Grance 2011, Mahmood & Hill 2011) and are summarized in the Table 1.

Table 1: Description of the five main characteristics of Cloud Computing.

Characteristic	Description
On demand self-service	Enables the users to access and consume computing capabilities automatically without any interaction between user and service provider.
Broad network access	The computing capabilities are available through the Internet and can be used by heterogeneous users through standard mechanisms.
Resource pooling	Heterogeneous computing resources can be combined and dynamically assigned to serve multiple users based on a multi-tenant model.
Rapid elasticity	Based on the demand, every computing capability can be provisioned rapidly, elastically and/or automatically to scale out or in, to meet the fluctuations of the demand.
Measured service provision	Automatically control and optimize resource usage as well as to provide monitoring, controlling and reporting for billing purpose and transparency between the service provider and the user.

The aforementioned characteristics can imply various benefits for the potential customers. The most important benefits of Cloud Computing are the following:

- **Cost reduction** is achieved by avoiding big initial investments for software and hardware acquisition. The cost for maintenance and training is also reduced. The organization can allocate resources for other activities (e.g., integration of services, R&D) (Motahari-Nezhad et al. 2009, Mahmood & Hill 2011).
- **Business agility** and **scalability** are achieved by adopting Cloud-based solutions, resulting in innovation and change capacity for the organization (Mahmood & Hill 2011).
- **Access to new IT services** that otherwise it would be impossible for a small company to acquire. In that way the rules of competition are changing (Mahmood & Hill 2011).
- The on-premise IT systems are developed in a way to support peak capacity, implying that most of the computing power sits idle. In numbers, 85% of the computing capacity stays idle while the utilization rates range between 12%-18%. Cloud-based solutions provide **efficient capacity utilization** which results again to cost reduction (Motahari-Nezhad et al. 2009).
- Cloud Ecosystems provide **disaster recovery** and **business continuity** (Mahmood & Hill 2011).
- The Cloud services are **highly available** as users can access their resources in a ubiquitous manner. They can access data or applications in any place that they can find Internet connection (Duipmans 2012).

This list is not exhaustive since it will take several pages of this report to include all the benefits that Cloud is promising to deliver.

2.3 Service Models

In the scientific literature the most common service models are Software-as-a-Service (Saas), Platform-as-a-Service (PaaS) and Infrastructure-as-a-Service (IaaS) (Mell & Grance 2011, Zhang et al. 2010). However academia attempted to extend the three main service models by adding other essential components such as security, coordination, management and quality as a service. According to Motahari-Nezhad et al. (2009) we can include database as additional service, while Linthicum (2009) suggests that storage, process and information can be included as well. Figure 2 provides an overview of Cloud architecture and the corresponding service models for each architectural layer.

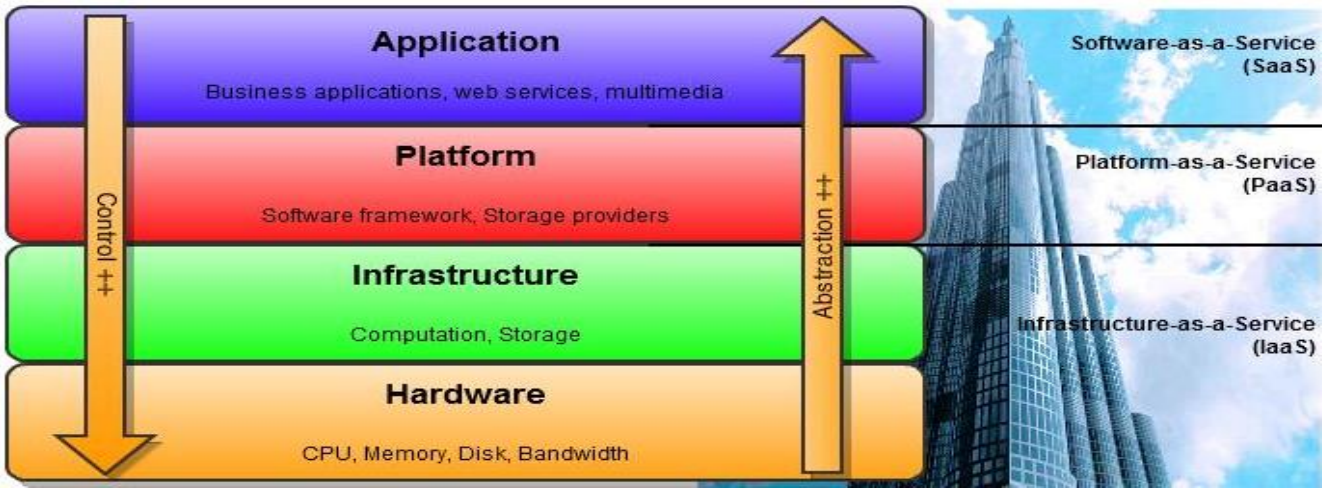

Figure 2: Cloud Computing Architecture and Service Models (Zhang et al. 2010).

The three main Cloud service models are explained in Table 2 and next to them are listed example services in order to increase the understandability of the reader.

Table 2: Cloud Service Models and Example Services.

Service Model	Description	Example Service
Software as a Service (SaaS)	The Cloud Service Providers (CSPs) offer the computing capability which is deployed on a Cloud infrastructure. The consumers can access the applications through a web browser or a program interface. The software is installed in the CSP's servers where they can manage control and update it. Consequently the end user cannot modify the underlying infrastructure; it is only possible to configure some user-specific settings (Mell & Grance 2011).	Google apps (Gmail, Google Docs, YouTube), Facebook, SalesForce.com.
Platform as a Service (PaaS)	The consumers are provided with a Cloud-based platform where they can deploy their applications. The platform provides programming languages, tools and libraries which can be used from the consumers to build and run their own applications or to improve acquired applications. The CSP is responsible to control and manage the underlying Cloud infrastructure (e.g., servers, network, storage, operating system) while the consumer can control and manage only the deployed applications (Mell & Grance 2011). The Platforms are programming language dependent (e.g., Java, Python) and dedicated to a specific domain (e.g., web development).	Google App Engine, AWS (Amazon Web Services), Elastic Beanstalk, Microsoft Azure.
Infrastructure as a Service (IaaS)	The IaaS solutions are comprised from the hardware layer and the infrastructure layer. The consumer is provided with fundamental computing resources such as storage, networks or processing. The consumer can use these computing resources to deploy and run applications or even operating systems. The IaaS provisioning requires a virtualization platform where the consumers install and configure a virtual machine which runs on the servers of the provider. The CSP is responsible to control and manage the underlying Cloud infrastructure (mainly hardware) while the consumer is responsible for the management of the virtual machine (Mell & Grance 2011). The CSP is also responsible for activities such as data replication, networking components (e.g., host firewalls) selection and hardware maintenance.	Amazon's Elastic Compute Cloud (EC2), Windows Azure Virtual Machines, Google Compute Engine.

As we pre-mentioned there are additional service models which extend the basic structure of the Cloud. On the one hand there is a clear distinction among SaaS, PaaS and IaaS. On the other hand, there is significant overlap of Cloud provision among the three layers of the architecture. Specifically a software system (SaaS) may be regarded as a part of a software platform (PaaS). Likewise a component of the software platform may be regarded as a part of the system infrastructure (IaaS). Mahmood and Hill (2011) suggest that the possible extended service models are the following:

- SaaS & PaaS
- SaaS & IaaS
- IaaS & PaaS
- SaaS & PaaS & IaaS

2.4 Deployment Models

In the previous section the most important service models were discussed. These services can be deployed in various ways as you can see in Figure 3. A description of the Cloud deployment models is given in the next paragraphs.

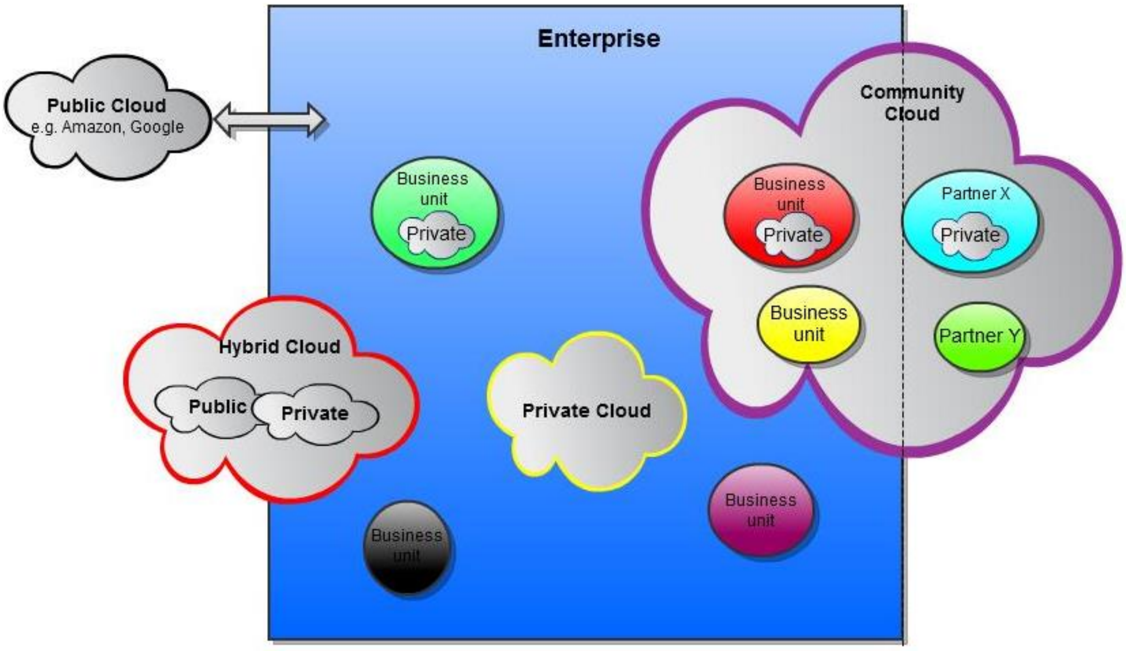

Figure 3: Cloud Deployment Models (Brown 2009).

2.4.1 Private Cloud

The Cloud-based solution is provisioned and used by a single enterprise. The services in a private Cloud are consumed by multiple users, and they are managed operated and owned by the enterprise itself, a third party or a combination between them (Mell & Grance 2011). The private Cloud can be resembled with an on-premise infrastructure. However this is not the case as private Clouds inherit the characteristics of Cloud Computing (e.g., elastic service provisioning, virtualization etcetera) and provide more benefits to the enterprise (Armbrust, et al., 2009).

2.4.2 Community Cloud

The community Cloud is similar to the private Cloud but the community Cloud is shared among a group of organizations. In that way the risks and the costs are shared among the members of the group. It is important that these organizations must share the same concerns such as policy, mission, compliance considerations and security requirements. The services in a community Cloud are consumed by multiple users, and they are managed operated and owned by the enterprise itself, a third party or a combination between them (Mell & Grance 2011).

2.4.3 Public Cloud

The public Cloud is when the provisioning of Cloud-based solutions is publicly available for open use. The services are ubiquitous available through an Internet connection but this deployment model is rising many security and privacy concerns. The services in a public Cloud are consumed by multiple users, and they are managed operated and owned by an enterprise, a governmental organization or a combination between them (Armbrust et al. 2009, Mell & Grance 2011).

2.4.4 Hybrid Cloud

The hybrid Cloud is a combination of at least two distinct deployment models (e.g., public, private or community Cloud) which are tailored to provide data and application portability. In that way some of the resources are residing on-premise while others are outsourced (Mahmood & Hill 2011).

2.4.5 Virtual Private Cloud

The virtual private Cloud emerged to solve the inadequacies of the private and the public Cloud. Basically the CSP uses a public Cloud to build a private Cloud upon it. The private Cloud leverages virtual private network (VPN) connection, in a way to enable the service provider to design the security settings (e.g., firewall rules). The virtual private Cloud virtualizes the servers, communication, network and the applications. This virtualized network layer enables seamless transition from an on-premise service infrastructure to a Cloud infrastructure (Zhang et al. 2010).

2.5 Cloud Ecosystem Reference Architecture

The Cloud Ecosystem Reference Model is a high-level description of business solutions and architectures for an organization. It describes the extended enterprise Cloud Ecosystem by providing secure sharing of business information and digital customer experience regardless the underlying data location (The Open Group 2013). An abstraction of the Cloud Ecosystem Reference Model is given in Figure 4.

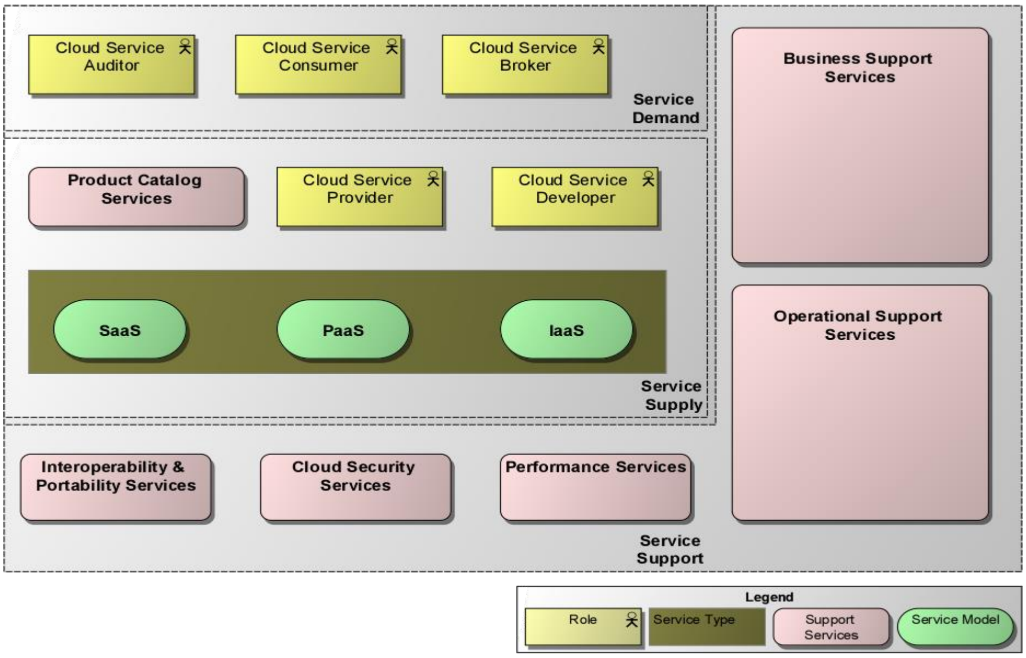

Figure 4: Conceptual View of the Cloud Ecosystem Reference Model.

From Figure 4 we can identify the new organizational roles which participate in the Cloud Ecosystem. The most important organizational roles are given below (Mell & Grance 2011):

- **Cloud Service Provider:** The Cloud service provider is an individual, organization or entity that leverages and deploys the Cloud-based services to the interested parties.

- **Cloud Service Consumer:** The Cloud service consumer is an individual or organization that collaborates with the Cloud service provider in order to use its Cloud-based services.

- **Cloud Service Broker:** The Cloud service broker is the entity that negotiates the relationships between the Cloud service providers and Cloud service consumers and manages the performance, delivery and use of the Cloud-based services.

- **Cloud Service Auditor:** The Cloud service auditor assesses and audits (independently) performance, security, Information System operations and Cloud services of the Cloud implementation.

- **Cloud Service Developer:** The Cloud service developer may belong to the organization of the Cloud service consumer or Cloud service provider and develops the actual Cloud service offering by leveraging tools to develop Cloud-based services.

The Cloud Ecosystem Reference Model ensures consistency and applicability of Cloud Services within a wide variety of Enterprise Architecture management frameworks. Figure 5 contains the relationships and dependencies between the different kinds of enterprise frameworks to manage the life cycle of Cloud Services utilizing the Architecture Building Blocks (ABBs) identified in the Cloud Ecosystem Reference Model to deliver enterprise business solutions (The Open Group 2013).

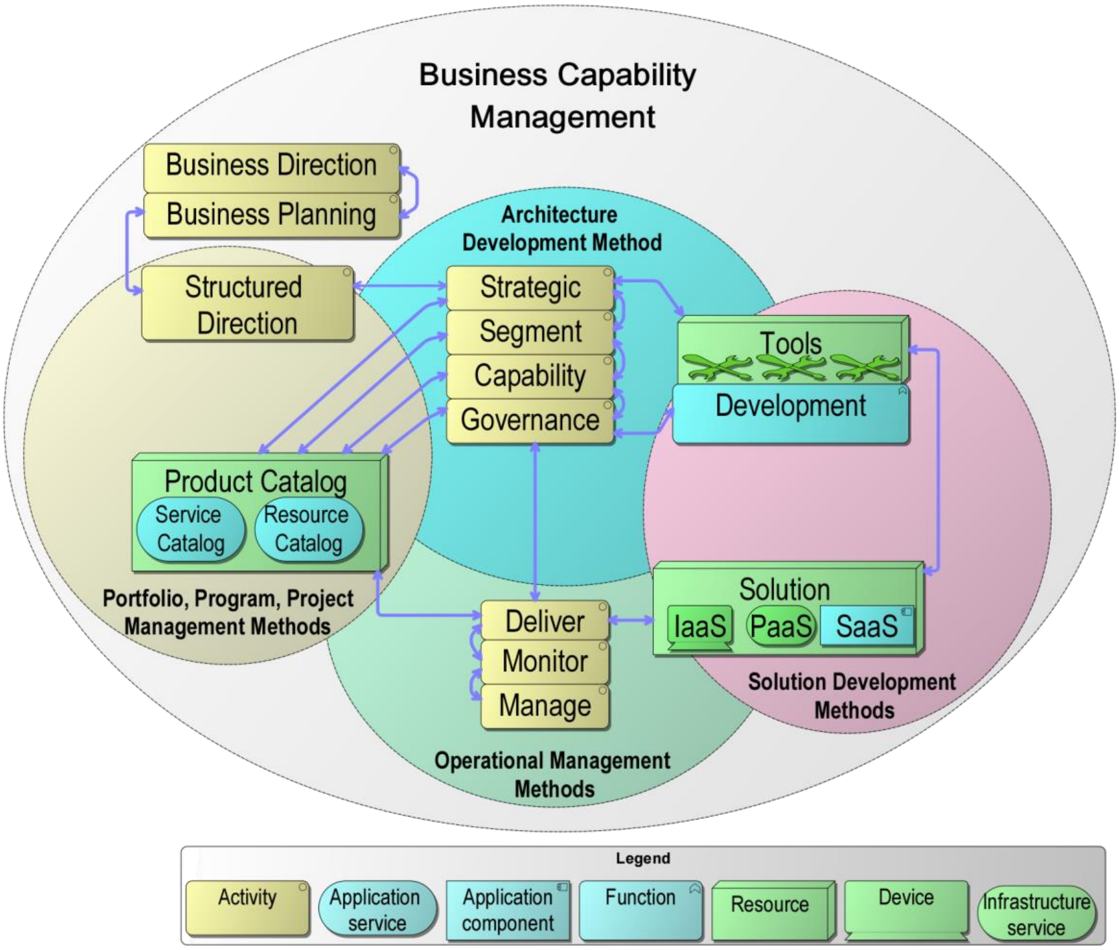

Figure 5: Managing Enterprise Frameworks in Cloud Ecosystems (The Open Group 2013).

The definition of the core concepts and relationships of the Cloud Ecosystem provided all the necessary information to design the Cloud Ecosystem Reference Model which depicts the main Architecture Building

Blocks (ABBs) (explained in Appendix I) and their key relationships with the Cloud Ecosystem entities. Based on Figure 5 the organization can identify capabilities to be realized and facilitated by the participants of the Cloud Ecosystem. The Cloud Ecosystem Reference Model forms a common language to achieve integrity of the architectural descriptions of the enterprise Cloud Ecosystem. It is the base to create architectural viewpoints and diagrams which will guide the organization in the development of the enterprise Cloud Ecosystem. The Cloud Ecosystem Reference Model is an extension of an Enterprise Architecture model and can be used to define architecture by utilizing Solution Building Blocks (SBBs) of the Cloud Ecosystem (The Open Group 2013).

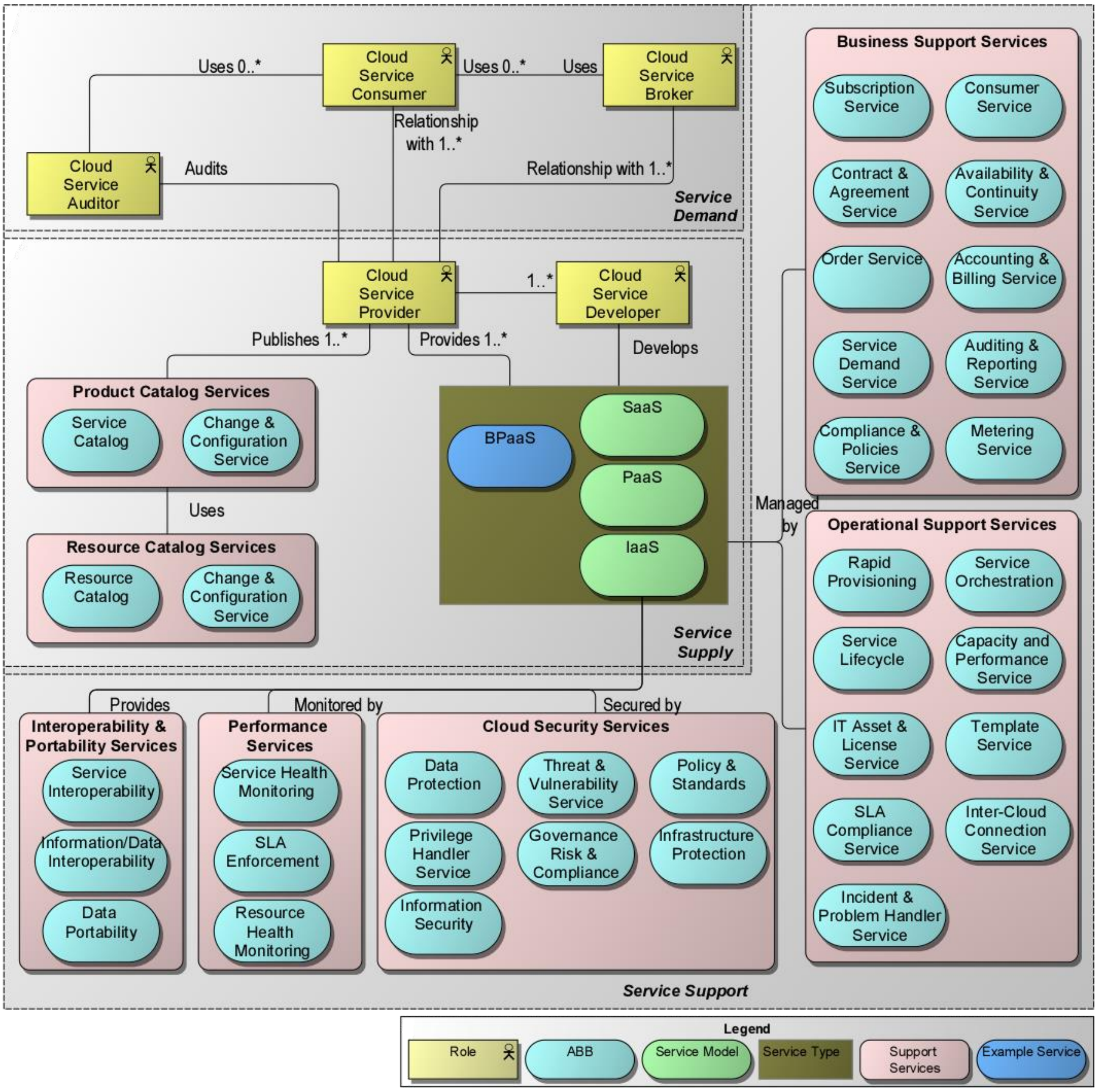

Figure 6: Cloud Ecosystem Reference Model –Illustrated in ArchiMate (The Open Group 2013).

2.6 Challenges

The Cloud Computing paradigm extended organizations' traditional boundaries and security of the enterprise data/information is of utmost importance. Also the trust boundaries are extended and the business operations must optimize the relationships with extended organizations that utilize heterogeneous CSPs. In addition, organizations seek rapid provisioning of Cloud services without big up-front investments in order to achieve business excellence. This can be done by evolving the current business solutions to take advantage of dynamic allocation of resources. Table 3 summarizes what should be considered when an organization desires to adopt Cloud solutions.

Table 3: List of the Cloud-specific considerations.

Focus	Considerations
Business	✓ Business process management in the Cloud. ✓ Seamless collaboration and integration capabilities with partners, suppliers and back office. ✓ SOA enablement & Cloud service portfolio management for modular business solutions. ✓ Standardized, self-service business solutions for cost efficiency. ✓ Enable business agility. ✓ Rapid business service enablement. ✓ Contractual, legal and regulatory considerations. ✓ Portability and Interoperability. ✓ Business capability assessment (what needs to be processed internally and what services can be processed externally.
Operations	✓ Operational excellence (lower operational expenditures and total cost of ownership, higher cash-flow). ✓ Cloud services operational management. ✓ Workforce Management. ✓ Problem and error resolution management. ✓ Service Level Agreements (SLAs). ✓ Licensing and contract management. ✓ Cloud service subscription and lifecycle management. ✓ Capacity and services monitoring. ✓ Migration strategy.
Technical	✓ Common application framework that enables standardized Cloud services capabilities. ✓ Robust integration capabilities. ✓ Network and bandwidth. ✓ Distributed and extended environments.
Security	✓ Intellectual Property and Capital Assets. ✓ Effective management of confidential information and record management. ✓ Policy based service delivery. ✓ Identity, Entitlement and Access Management for Cloud Ecosystem.

However, there are many more risks and concerns that a potential adopter must have in mind. According to Zhen (2008), the major challenges that arise in a Cloud migration scenario are:

- Data governance
- Service management and governance
- Reliability and availability
- Product and process monitoring
- Virtualization security

The ENISA report (Catteddu & Hogben 2009) identifies 35 kinds of risks ranging from policy and organizational risks to technical and legal risks. There are also risks which are not specific for Cloud Ecosystems, but they could affect significantly a Cloud migration scenario. However there are some cases where an obstacle can be overcame by leveraging efficiently the Cloud opportunities. Table 4 is based on the research of Armbrust et al. (2010) and summarizes the obstacles and the corresponding remedies to avoid them.

Table 4: Cloud Computing Obstacles and Remedies.

Obstacle	Remedy	Impact
Service outage/ Provider bankruptcy	→ Use services from multiple CSPs	Cloud adoption
Data lock-in	→ Standardize APIs → Enable a hybrid Cloud	Cloud adoption
Data confidentiality	→ Messages encryption → Virtual LANs → Firewalls	Cloud adoption
Data transfer	→ Increase bandwidth → Send the disks to the provider (physical not virtual)	Cloud growth
Performance unpredictability	→ Improve virtual machine support → Supporting flash memory → Scheduling of the virtual machines	Cloud growth
Scalable storage	→ Invent scalable storage	Cloud growth
Bugs in large distributed systems	→ Invent debugger for distributed virtual machines	Cloud growth
Software licensing	→ Pay per use licenses	Enterprise policy

Of course this section does not list all the challenges of Cloud Computing because it is out of the scope of the present research. The decision makers should consider all kinds of risks and obstacles that Cloud Computing insinuates. Assiduous risk assessment is more than necessary because a potential risk may turn out to be a great opportunity for the organization. For example, on the one hand, computing resource concentration is regarded as a major threat for Cloud adoption, because of the security issues that rises. On the other hand it provides cheaper application of security measures and processes (Catteddu & Hogben 2009).

2.7 Conclusion

Cloud Computing transformed the traditional IT landscape of every organization by changing completely how IT services are provisioned and priced. The prominent benefit is cost reduction; though you must be aware of the indirect costs (e.g., need for more bandwidth) caused by the Cloud (Kondo et al. 2009).

Other equally important benefits are increased capacity utilization, increased innovation capacity and business agility.

Despite all the significant benefits Cloud Computing implies many challenges; that is the reason why the decision makers must be very careful before deciding to migrate to the Cloud. You must consider carefully which deployment model (or combinations between them) to choose. The selection of the appropriate Cloud model depends on the business scenario and the business goals. For example, applications that require significant computing capacity is preferable to deploy them on public Cloud for cost efficiency (Zhang et al. 2010). It also is expected (Zhang et al. 2010), that certain deployment model would be more successful (e.g., hybrid Clouds) than others. Moreover, a detailed risk assessment is a must for a successful Cloud migration. Lastly the Cloud Ecosystem Reference Model can be used to identify core architecture building block, key relationships and roles to guide the design of architectural viewpoints and diagrams to assist the development of the enterprise Cloud Ecosystem.

Chapter 3 - Enterprise Architecture

The outline of this chapter is the following: Section 3.1 provides introductory information about Enterprise Architecture and Section 3.2 explains the role of it. Section 3.3 provides a brief introduction to the architectural frameworks and to the modeling languages for the Enterprise Architecture. Lastly, Section 3.4 presents the relation of Cloud Computing and Enterprise Architecture and Section 3.5 concludes Chapter 5.

3.1 Introduction

Enterprise Architecture attracted a lot of interest both from academia and practitioners in the last decades. Enterprise Architecture is of utmost importance for the organizations, as it helps them adequately adapt to the fast changing business ecosystems. It is also a way to implement a certain differentiation strategy which eventually integrates the business processes, applications and technology. In that way, the organization can be transformed into a dynamic organization where the business side is aligned with the IT side. Furthermore, Enterprise Architecture is a formal way to document and communicate the quintessence of the business, Information Systems and IT infrastructure by involving all kinds of stakeholders (Iacob et al. 2012).

There are different interpretations of Enterprise Architecture resulting in different definitions. Our perspective refers to the Enterprise Architecture as an inherent organization of enterprises and their systems. According to the ISO/IEC 42010:2007 (also known as ANSI/IEEE 1471-2000) standard, Enterprise Architecture is: *"The fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution".*

3.2 Rationale

Every successful enterprise is built upon an appropriate business strategy. Despite how effective the business strategy is, there is always a gap between the strategy and its implementation in the organization. Business strategies create business models based on how the organization *"creates, delivers and captures value".* The business model describes what the organization offers (value proposition, delivery channels, revenue stream, customer segments and relationships) to the customers and also the necessary infrastructure (key resources, activities, partners) to realize the offer (Iacob et al. 2012).

Enterprise Architecture models are used to translate the business strategy and business model into the systems' design and organizational structure. Consequently, the strategic decisions are linked to design decisions and business operations. Specifically Enterprise Architecture describes a high-level design of the structure of the organization, the roles, the processes and the functions, IT systems and IT infrastructure as well as their interrelationships, in order to realize the business goals and objectives. These must be designed according to the guidelines and requirements which are set already at the business strategy and business model. Moreover Enterprise Architecture supports the organizational governance and guides the implementation of the business strategy (Iacob et al 2012).

Enterprise Architecture is focusing more on the essentials of business and IT rather than specific solutions. Specific solutions change rapidly, based on the problems they intend to solve, but the essentials stay the same for longer. The business side defines the Target Architecture. Consequently the architecture should contribute to reach the essential business objectives which have been set before. If the architectural and design choices of IT and business are aligned with the business objectives then the Enterprise Architecture is characterized by quality. Although the essentials are not meant to change in short-term, Enterprise Architecture must facilitate organizational change (Lankhorst 2013).

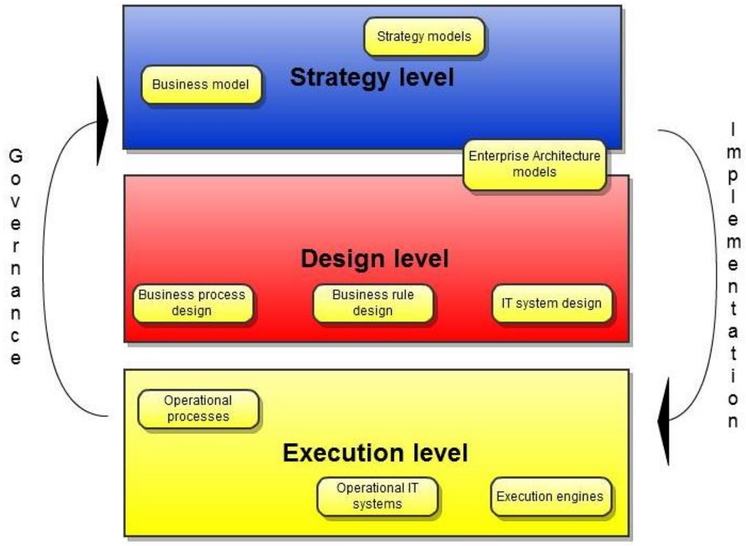

Figure 7: Enterprise Architecture and the relation with strategy and design level (Iacob et al. 2012).

It is suggested (Mahmood & Hill 2011) that the business strategy drives the IT strategy in terms of enterprise vision. Following the IT strategy guides the development of the Enterprise Architecture. In turn the Enterprise Architecture attempts to address the issues given below:

- Aligning business with IT
- Organizing IT and Information System infrastructure
- Improving decision making
- Enterprise strategic goals and objectives
- Meeting stakeholders' requirements
- Improving operational efficiency
- Increasing organizational change capacity
- Integration of business systems, processes and data sharing
- Reduced complexity of business processes and functions
- Timeliness enterprise-wide data
- Ensuring data integrity, quality, consistency and security

Enterprise Architecture is an inter-discipline subject where people with different educational backgrounds can communicate. As Lankhorst (2013) states, *"this requires an integrated set of methods and techniques for the specification, analysis and communication of enterprise architecture that fulfills the needs of the different types of stakeholders involved".*

So the purpose of Enterprise Architecture is to fill the communication gap among stakeholders, architects and programmers. This is achieved by devising architecture models, analyses, presentations and views. For example Enterprise Architecture guides the business side to design the business processes and the IT side to build the applications, aligned at the same time with the business policy and objectives. This process aims to reach a common understanding among developers, managers, architects and stakeholders. The architecture process must also adhere to the continuously changing business and IT environment by maintaining the architecture.

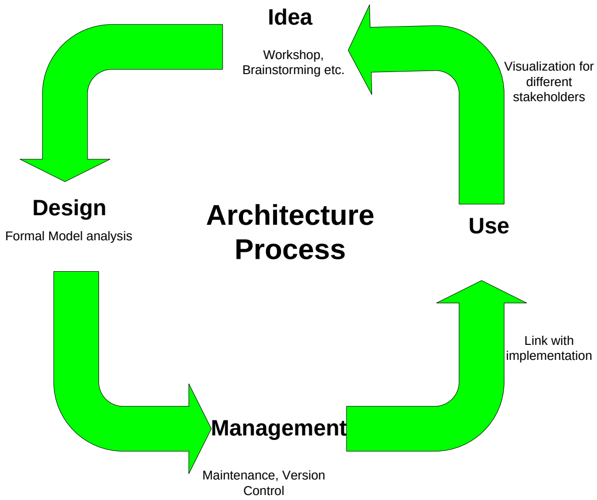

Figure 8: The Enterprise Architecture life-cycle (Lankhorst 2013).

Figure 8 depicts the main steps of the architecture process. In all steps of the process there must be clear communication between the stakeholders. Overall the Enterprise Architecture provides a high-level description of the information-related components, together with the relationships and interactions among them.

3.3 Frameworks and Modeling Languages for Enterprise Architecture

A common characteristic of modern enterprises is complexity, and that makes the realization of a Target Business Architecture challenging (Mahmood & Hill, 2011). In order to achieve and maintain a more agile target state for the enterprise, a number of frameworks have been developed to support the realization of the Enterprise Architecture. Below is given a brief introduction of the most popular frameworks (Feurer 2007, Mahmood & Hill 2007) while a more in-depth analysis and comparison is provided in Chapter 4.

Table 5: Six (6) popular EA frameworks.

EA Framework Name	Short Description
Zachman Framework	The Zachman Framework (http://www.zifa.com/) was the first attempt to align business with IT through a certain process. This important piece of research was adopted by the United States of America's Department of Defense and the Technical Architecture for Information Management (TAFIM) was based upon it.
Federal Enterprise Architecture Framework (FEAF)	Due to the great importance and significance of the Zachman Framework, the United States Federal Government developed its own interpretation of Enterprise Architecture based on it.
The Open Group Architecture Framework (TOGAF®)	TOGAF® is based on TAFIM and has been developed by the Open Group (http://www3.opengroup.org/) .
Gartner EA Framework	The Gartner EAF is a practice-oriented, vendor specific EA framework.
The Oracle Enterprise Architecture Framework	Oracle developed its own framework which is based on TOGAF®, FEAF and others.
SAP Enterprise Architecture Framework (SAP EAF)	This framework is also TOGAF®-based tailored of the SAP products.

A modeling language is a way to express how information/data, people and/or systems are structured based on a consistent set of rules. Specifically for Enterprise Architecture modeling, a language is a mean to specify how the organizational actors, processes and systems should operate and interact together. The modeling language should also describe and visualize the business, Information Systems and IT infrastructure by providing at the same time alignment among them. In order to succeed this, it is necessary to define the semantics of the modeling concepts as well as a set of architectural views in order to relate these concepts with the Enterprise Architecture context (Sousa et al. 2005).

UML is a widely accepted modeling language which focuses on modeling software designs. However the scope of UML is different from that of Enterprise Architecture as UML is suitable for designing the actual systems and applications. It is possible to design the Business Architecture with UML, but the models will not be “austere” notated. With ArchiMate it is possible as it is a standard modeling language, with a standard abstract syntax, a concrete syntax and semantic definitions for all its constructs. It is based on UML and it is the only modeling language which complies with the Enterprise Architecture (Iacob et al. 2012).

Apart from UML and ArchiMate there are commercial architecture modeling tools for Enterprise Architecture modeling such as ARIS EA. The drawback of these modeling tools is that they make use of proprietary architecture modeling languages and may have limited suitability as an industry standard (Iacob et al. 2012).

It is also worth mentioning that **ArchiMate, complements TOGAF** (The Open Group, 2011) by providing a vendor-independent set of concepts and relationships, together with a graphical representation, which enables the creation and the visualization of a consistent and integrated Enterprise Architecture model (Jonkers et al. 2012).

3.4 Cloud Computing and Enterprise Architecture

Enterprise Architecture essentially presents a high level view of the organization by answering the questions (Zachman 1987, Mahmood & Hill 2011):

- What determines the business objects, data and materials?
- How to establish control flows, business functions and procedures?
- Who are the stakeholders, employees and their responsibilities?
- Why a decision is made, based on the enterprise mission and objectives?

These four questions describe numerous specific architectural models. These architectural models may refer to the organizational missions and goals, to the business processes and to the Information Systems. Consequently, this means that Enterprise Architecture employs numerous tightly-coupled architectures (Business Architectures, Information System Architecture, Technology Architecture) as a multi-tier model to describe all these perspectives. Enterprise Architecture should also go hand in hand with the strategic vision of the organization (Mahmood & Hill 2011).

Based on existing research (Zachman 1987, Iacob et al.2012) and the previous comments, the core set of the architectural layers is given in the sequel:

- **Business Architecture:** The Business Architecture describes the value proposition, business mission and strategy and the working model (business processes, business functions and governance) of the organization.
- **Application Architecture**: The value proposition (Business Architecture) is realized by delivering services from the application to the Business Architecture. The applications are meant to support the business processes of the upper architecture.
- **Data Architecture:** The applications make use of the data which reside in this architecture layer. The applications must exchange information among them and ensure consistent data management.
- **Technical Architecture:** The applications (application architecture) are realized by consuming services from the Technology Architecture. This architecture layer is the actual technical infrastructure of the enterprise and its main components are networks, communication lines, nodes and devices.

The aforementioned architectural representations of an Enterprise Architecture also apply to Cloud Computing (Natis 2008, Mahmood & Hill 2011). As the computing resources of an Enterprise Architecture are layered, multi-tenant[1] applications (Cloud-based) can be implemented in any of the underlying layers (Natis 2008). For example, when an Enterprise Architecture is in a mature state then the architectural representations are loosely coupled and the specific architectures (e.g., business, application, data and technology) can be tailored to include Cloud-based solutions. This can be done in the following ways:

- **Business layer:** This layer is mapped to the Cloud offerings such as Management-as-a Service or Coordination-as-a-Service. It is of utmost importance to keep the business strategy, vision and the governance control within the organization.
- **Application layer:** This layer is mapped to the Cloud offering SaaS. The services are provisioned as complete software applications and can be used ubiquitously under request.
- **Data layer**: This layer is mapped to the Cloud offerings of IaaS. Apart from that there are more specialized Cloud-based solutions (e.g., Database-as-a-Service) which make Cloud-based virtual storage and servers.
- **Technical layer:** This layer is mapped to the use the Cloud offerings of IaaS and PaaS. If the organization outsources the technical infrastructure, it does not have to worry about the maintenance, dependences, governance and training of the on-premise IT landscape.

Table 6 summarizes these four points and adds also some insights from the research of Mahmood (2011).

Table 6: Mapping of architecture layer offerings to Cloud Computing (Mahmood 2011).

Business layer	Process-as-a-Service Governance-as-a-Service Management-as-a-Service …and more
Applications layer	SaaS Integration-as-a-Service Testing-as-a-Service …and more

Data layer	Information-as-a-Service Database-as-a-Service Security-as-a-Service …and more
Technology layer	Storage-as-a-Service IaaS PaaS …and more

3.4.1 Cloud Architectures and Enterprise Architecture

In traditional Enterprise Architecture, applications are deployed and used on the premises of the organization. The computing capabilities are built in a way to respond to peak loads; if new users have to be supported then the system must be upgraded with additional computing resources (Capgemini, 2009). This results in complex and costly systems, which most of the times do not solve adequately the business problems. The advantage of the traditional IT landscape is that the organization has complete control of the computing resources (both software and hardware) (Pethuru, 2013).

In the isolated tenancy paradigm, the tenants **share nothing** among them. As a result each organization has its own stack of resources hosted off-premise. Consequently, the on-premise applications can be migrated off-premise without much effort. On the one hand, a potential downside of this architecture is that the organizations are isolated. On the other hand, this architecture may reduce the operational costs (Natis 2008).

In the elastic virtualization paradigm, the tenants[2] **share the hardware** from a shared pool (virtualization). The computing capabilities are provisioned under demand and are priced-per-use. The cost savings (mainly hardware maintenance, upfront investments for hardware and training) are prominent in this example. However, in order to achieve virtualization and elasticity the applications must be redesigned, which may cause some indirect costs (Dihman 2010).

In the **shared process** architecture, the organizations share all layers except the data platform. Shared computing capabilities are allocated to shared applications, while the data control and ownership are kept within the organization. However, the applications make use of these data off-premise and that raises security issues.

Another drawback is that this architecture needs redesign and coding to achieve efficient resource allocation among the organizations and at the same time to ensure the data platform isolation (Mell & Grance 2011).

In the **shared everything** example all the layers are shared. The organizations make use of standard applications which ensure also data integrity and isolation. Additionally, customization and tenant isolation is also handled at the application level. Again security issues arise together with data privacy and control (Dihman 2010).

[1.] Multi-tenancy: is an architecture principle (see also Appendix II – Architecture Principles: Multi-tenancy) describing the situation where a single instance of the software runs on a server, serving multiple client-organizations. With a multitenant architecture, a software application is designed to virtually partition its data and configuration, and each client organization works with a customized virtual application instance.

[2.] Tenant: is a client-organization or an individual which consumes software services from the software provider organization.

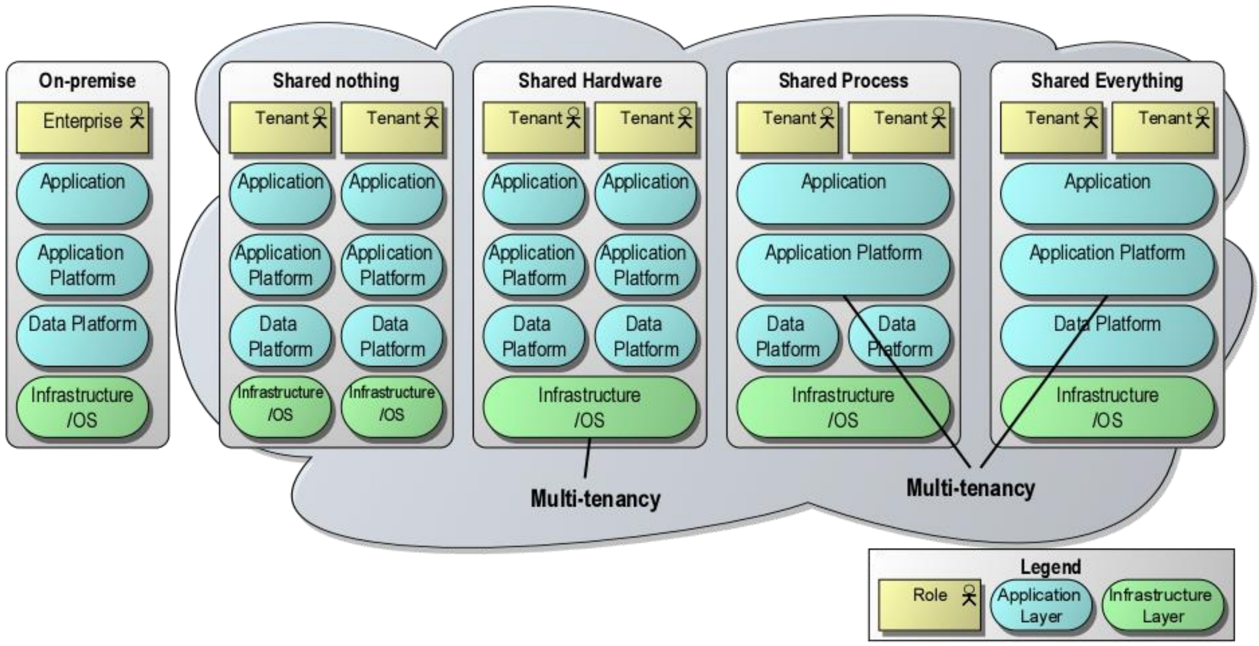

Figure 9: Cloud Reference Architecture (Natis 2008)-Illustrated in ArchiMate.

Furthermore there are synergies between Enterprise Architecture and Cloud-based solutions which can provide multiple benefits for the organization. The organization improves its flexibility, scalability and availability by providing IT services and resources through an outsourced environment (Mahmood & Hill 2011).

However it is slightly supported that Cloud Computing eliminates the need for Enterprise Architecture. Cloud Computing can reduce significantly the worries of the back-end process, especially when it has to do with technical implementation issues. Apart from that, there is still the need to effectively create a differentiated strategy and also to “orchestrate” people, processes, systems and Cloud components to achieve business continuity (Pethuru, 2013).

3.5 Conclusion

This chapter provides an introduction to the subject of this thesis by defining and explaining the role of the Enterprise Architecture. To summarize, Enterprise Architecture translates the business strategy into systems’ design and organizational structure (Iacob et al. 2012). It also provides techniques (e.g.,, modeling language) and a process to develop, document and communicate the architecture models between all stakeholders.

A brief introduction in the architecture frameworks and modeling languages was also provided. The important finding here is the complementarity of TOGAF (framework) with ArchiMate (modeling language) (The Open Group 2011, Jonkers et al. 2012). Furthermore some of the frameworks (i.e. the Oracle Enterprise Architecture Framework and the SAP Enterprise Architecture Framework) are TOGAF – based. These facts place TOGAF as an important candidate for facilitating Cloud migration analysis and modeling.

Finally it is examined the convergence between Cloud Computing and Enterprise Architectures. The last section concludes that the architectural representations of the Enterprise Architecture do apply to Cloud Computing (Natis 2008, Mahmood & Hill 2011). As the computing resources of an Enterprise Architecture are layered, multi-tenant applications (Cloud-based) can be implemented in any of the underlying layers (Natis 2008). Lastly, it is provided a comparison between the Cloud architectures and the Enterprise Architecture.

Chapter 4 – Enterprise Architecture Frameworks

The outline of this chapter is the following: Section 4.1 introduces the concept of Enterprise Architecture frameworks and Section 4.2 contains the most popular EA frameworks. Section 4.3 describes the general requirements that an EA framework for Cloud Ecosystems should have and Section 4.4 provides the reasoning for choosing TOGAF. Section 4.5 presents the related work in the field and Section 4.6 concludes Chapter 4.

4.1 Introduction

The Enterprise Architecture encompasses different aspects and viewpoints and provides high-level description (based on a certain business strategy) of the organization by involving all stakeholders (Iacob et al. 2012, Lankhorst 2013). The architecture frameworks identify and relate different viewpoints and they also provide a structure for the architectural descriptions and modeling techniques (Lankhorst 2013).

According to The Open Group definition (2011) an architecture framework is a set of structures for developing architectures. EA frameworks contain guidelines, tools, common vocabulary and a method for designing the target state of the organization in terms of building blocks. Lastly they include a list of recommended standards and compliant products that can be used to implement the building blocks.

This chapter aims to identify the most suitable EA framework to model and analyze enterprise Cloud Ecosystems. To do so, the four most popular Enterprise Architecture frameworks are analyzed and compared, namely the Zachman Framework for Enterprise Architectures, The Open Group Architecture Framework (TOGAF), the Federal Enterprise Architecture Framework (FEAF), and Gartner EA framework (formerly, the Meta Framework) (Sessions 2007, Feurer 2007). The requirements, which an EA framework for Cloud Ecosystems should have, are given in the next section.

4.2 The Most Popular Enterprise Architecture Frameworks

This section summarizes the important aspects of the most popular (in terms of usage and adoption) EA frameworks. This information is vital for comparing the frameworks and choosing the most appropriate in the next sections.

4.2.1 The Zachman framework

The Zachman framework (Zachman 1987) is the first framework for Enterprise Architecture and it is still widely used. The Zachman framework is a *"logical structure for classifying and organizing the descriptive representations of an enterprise"* that are significant for the management and modeling of the EA (Sousa et al. 2005, Lankhorst 2013).

The framework is structured as a matrix, visualizing the subjects and models which are necessary to develop, document and communicate the Enterprise Architecture. The horizontal axis is a classification of the various architecture descriptions and the vertical axis consists of the multiple perspectives of the overall architecture. These perspectives are analyzed below (Sousa et al. 2005):

- Scope – Planner: this perspective includes the context, scope and environment of the enterprise together with the business strategy.

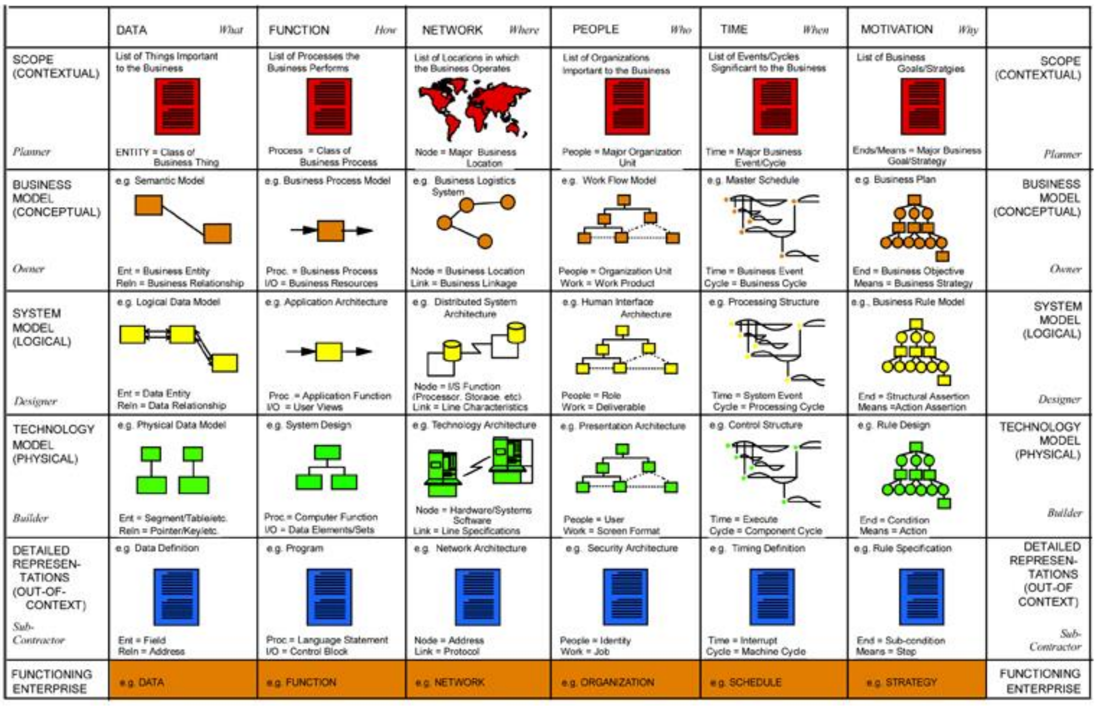

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Figure 10: The Zachman framework (Zachman 1987).

- Business Model – Owner: this is the business perspective and basically refers to how the enterprise captures, creates and delivers value to its customers.
- System Model – Designer: this perspective refers to the systems of the enterprise and also the way they fulfill the stakeholders' expectations.
- Technology Model – Builder: this perspective refers to the technology infrastructure used to support the systems of the enterprise.
- Detailed Representations – Subcontractor: this perspective refers to the specifications of the system components.

The matrix structure of the framework provides an overview of the design artifacts together with the convergence between the product abstractions and roles (Lankhorst 2013). The different domains of the overall architecture are the following (Sousa et al. 2005, Lankhorst 2013):

- Data – What the architecture is made of?
  - This question aims to provide a definition and understanding of the enterprise's information.
- Function – How the process works?
  - This question describes the translation of the organization's mission into business processes and operations.
- Network – Where the different components are?
  - This question provides the topological and geographical distribution of the organizational components together with the relationship among them.

- People – Who does what in the enterprise?
    - This question provides information to map roles and artifacts of the enterprise. For high-level analysis and modeling the "who" refers to business units while for the low levels it refers to the employee roles in the system.

- Time – When do things happen?
    - This question helps create a timeliness organogram for each artifact.

- Motivation – Why are these choices made?
    - This question helps translate the high-level goals into lower level actions and objectives.

As we can observe in Figure 10, each cell of the framework suggests appropriate deliverables for each phase (Zachman 1987). However, the Zachman framework does not have dedicated techniques or methodologies to develop these deliverables. Furthermore, the framework does not have an integrated meta-model to assign meaning and integrate the information of every cell (step or phase in other frameworks), which is essential for a robust analysis and modeling (Sousa et al. 2005). The poor-defined relations among the cells together with the large number of the cells hinder systematic use of the framework. Despite the disadvantages the Zachman framework can be easily understood and it is used to analyze and model the enterprise as a whole (Lankhorst 2013).

4.2.2 The Open Group Architecture Framework (TOGAF)

TOGAF, The Open Group Architecture Framework (The Open Group 2011), is an industry standard architecture framework. TOGAF provides tools and methods to develop Enterprise Architecture descriptions. The architecture descriptions assist "*the acceptance, production, use and maintenance of an Enterprise Architecture*". It enables designing, evaluating, and building the architecture based on an iterative process which makes use of best practices and reusable architectural descriptions (The Open Group 2011, Sousa et al. 2005).

TOGAF distinguishes four architecture domains of the overall architecture which are (The Open Group 2011):

- **Business Architecture**: a description of the structure and interaction between the business strategy, organization, functions, business processes, and information needs.

- **Application Architecture**: a description of the structure and interaction of the applications as groups of capabilities that provide key business functions and manage the data assets.

- **Data Architecture**: a description of the structure and interaction of the enterprise's major types and sources of data, logical data assets, physical data assets, and data management resources.

- **Technology Architecture**: a description of the structure and interaction of the platform services, and logical and physical technology components.

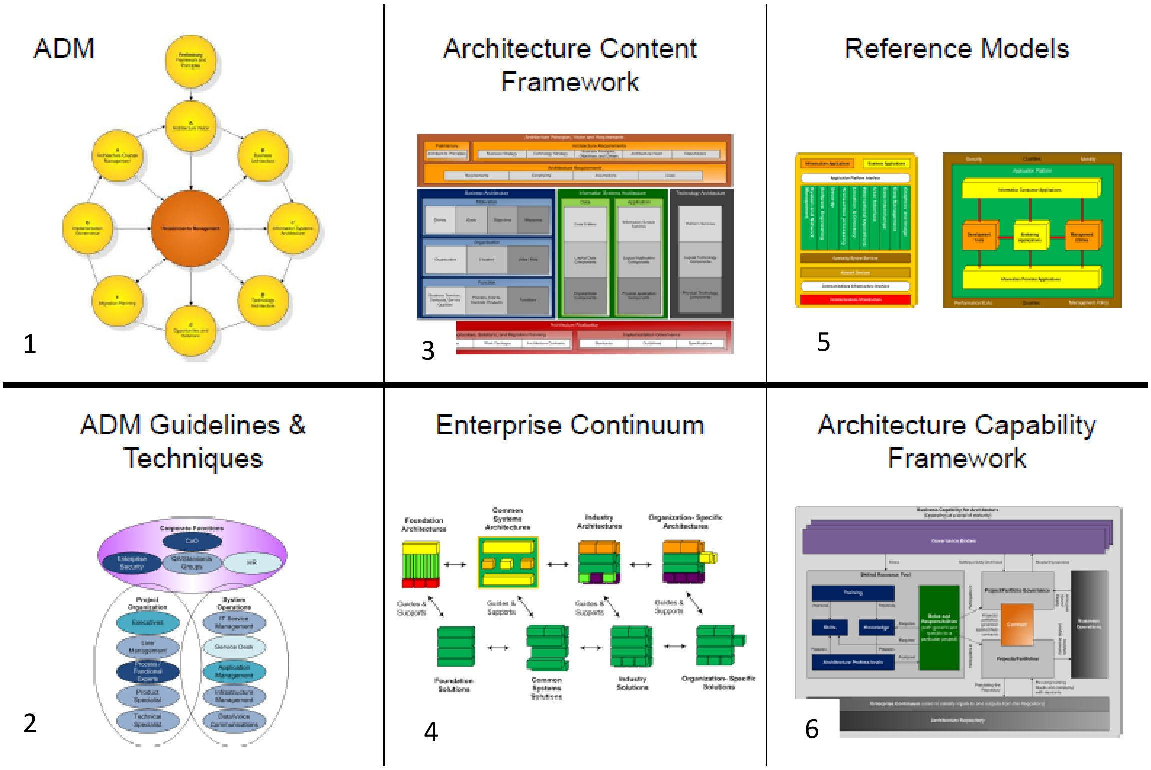


Figure 11: TOGAF core concepts (The Open Group 2011).

Next to Figure 11, a brief description of each core concept provided in TOGAF is provided below (The Open Group 2011):

1. The **Architecture Development Method (ADM)** is a step-wise iterative approach for the development and implementation of Enterprise Architecture. It is considered to be the corner stone of TOGAF. TOGAF distinguishes the four aforementioned architectures and phases A to D deal with the development of them. The combination of Data Architecture and Application Architecture is called the Information Systems Architecture. Phases E-F prepare the organization to undergo the transformation and Phases G-H ensure that the delivery and the governance of the Target Architecture adheres to the requirements and realizes the business objectives and goals. Every phase of the ADM has specific objectives, steps, inputs and outputs as well as constraints and guidelines for the order in which these are performed.

2. An assortment of **Guidelines and Techniques** is needed to support the application of the ADM. On the one hand, the guidelines address adjustment of the ADM to deal with a number of usage scenarios, including various process styles (e.g.,, the use of iteration) and also specific specialist architectures (e.g.,, security). On the other hand, the techniques support specific tasks within the ADM such as establishing principles, carrying out gap analysis, migration planning and risk management.

3. A complete model of architectural work products is provided by the **Architecture Content Framework**. The model includes deliverables, artifacts within deliverables and the ABB the deliverables represent. Even though a description of a meta-model of possible building blocks is included in the content framework, a complete language is not defined and it does not provide (graphical) representations for the different types of building blocks.

4. A view of the architecture repository and methods for classifying architecture and solution artifacts are described and provided by the **Enterprise Continuum**. This is based on two components architectures (in the Architecture Continuum) and solutions (in the Solutions Continuum) that exist within the enterprise and in the industry at large.

5. Two **reference models** for possible inclusion in the enterprise's Enterprise Continuum: the TOGAF Technical Reference Model (TRM) and the Integrated Information Infrastructure Reference Model (III-RM).

6. The **Architecture Capability Framework** consists of a collection of resources, guidelines, templates and background information provided to assist the architect in establishing an architecture practice within the organization.

TOGAF ADM is a repeatable step-wise process for developing EA. The main activities of ADM are establishing an architecture framework, developing architecture content, transitioning, and governing the realization of architectures. An ADM iteration cycle includes all these activities which aim in continuous architecture definition and realization that allows organizations to transform their performance in response to business goals and objectives (The Open Group 2011). The phases of the ADM are the following (The Open Group 2011):

- The **Preliminary Phase** prepares the organization to undergo the architecture program and to determine and establish the desired Architecture Capability. This includes also customization of the framework (TOGAF) and definition of Principles.
- The **Architecture Vision** (Phase A) provides information about developing high-level vision of business value and enabling capabilities that the proposed EA should have. It also scopes the architecture development initiative and obtains approval to proceed with the architecture development.
- The **Business Architecture** (Phase B) includes the development of the Target Business Architecture in order to realize the Architecture Vision.
- The **Information Systems Architectures** (Phase C) includes the development of the Target Information Systems Architectures (Data and Application Architectures) in order to realize the Architecture Vision.
- The **Technology Architecture** (Phase D) includes the development of the Target Technology Architecture in order to realize the Architecture Vision.
- **Opportunities & Solutions** (Phase E) creates a first draft of the Implementation and Migration Plan and the identification of delivery vehicles for the Target Architecture (developed in Phases B-D).
- **Migration Planning** (Phase F) finalizes the Implementation and Migration Plan by describing the migration from the Baseline to the Target Architectures.
- **Implementation Governance** (Phase G) provides governance and steering for the implementation of the Target Architecture.
- **Architecture Change Management** (Phase H) establishes a change mechanism to manage the new architecture.
- **Requirements Management** includes the process of identifying, managing and maintaining architecture requirements throughout the ADM.

When considering an Architecture Development Process there are different kinds of views to be modeled. It is up to the architect to choose and develop a set of views that will enable the architecture to be understood by all the stakeholders and will allow them to verify whether Target Architecture will address their concerns. The TOGAF taxonomy of views and viewpoints is compliant with the ISO/IEC 42010:2007standard (also known as ANSI/IEEE 1471-2000)(Lankhorst 2013):

- **Business Architecture Views:** The Business Architecture views are describing the information flow which is exchanged between business processes and people.

- **Engineering Views:** The engineering views address the concerns of the engineers who are responsible for the development and integration of the system and software components.

- **Enterprise Manageability Views:** The enterprise manageability views are high level views, mainly used to address issues of system managers, administrators and operators.

- **Acquirers Views:** The acquirers' views are used mainly from the IT procurement personnel. These views are useful to identify the building blocks of the Enterprise Architecture that can be purchased from a software or hardware vendor.

TOGAF defines various inputs and outputs for each phase of the ADM. However there are no specification documents to describe the output and also it is not specified in which phase of the ADM the documents have to be generated (Sousa et al. 2005). Version 9.1 of TOGAF addresses this problem where the Architecture Content Framework provides a consistent model of the outputs which must be created by the ADM. The new version of the framework offers improved usability and also a broader perspective on enterprise change (The Open Group 2011).

4.2.3 Federal Enterprise Architecture Framework (FEAF)

The Federal Enterprise Architecture Framework initiated by the United States (U.S.) government as an attempt to connect all kinds of federal agencies under a common architecture. It is quite new framework and is mainly used by the U.S. government and is not widely accepted by private enterprises yet (Sessions 2007). The main purposes of FEAF are (Sayles 2003):

- Managing the development and maintenance of the architecture descriptions.
- Organizing the federal resources.
- Managing the FEAF activities.

In order to achieve that, FEAF organizes the enterprise-wide information into different levels, frames or references. Level 1 is the highest-level view and level 4 is the most detailed view of the framework. The components for each level are the same; what changes is the level of detail for each component in the different levels (Sayles 2003). The main elements of FEAF are illustrated in Figure 12 and are explained in the sequel (The CIO council 1999):

- **Architecture drivers** are external drivers which create the need to change the Enterprise Architecture.

- **Strategic direction** provides guidance for the Target Architecture based on the vision, goals, principles and objectives.

- **Current architecture** describes the Baseline Business Architecture and current design architectures.

- **Target Architecture** describes the Target Business Architecture and target design architectures. It is a formal description of the future capabilities to support the needs which result from the changing business environment.

- **Transitional process** is the migration planning from the current to the Target Architecture.

- **Architectural segments** represent segments of the overall architecture and can be compared with the views (for TOGAF) or domains (for the Zachman framework) from the aforementioned frameworks. FEAF considers an architectural segment as an enterprise.

- **Architectural models** are the various models (business or design models) which are used to describe the segments of the architecture.

- **Standards**, guidelines or best practices that the architecture must comply with.

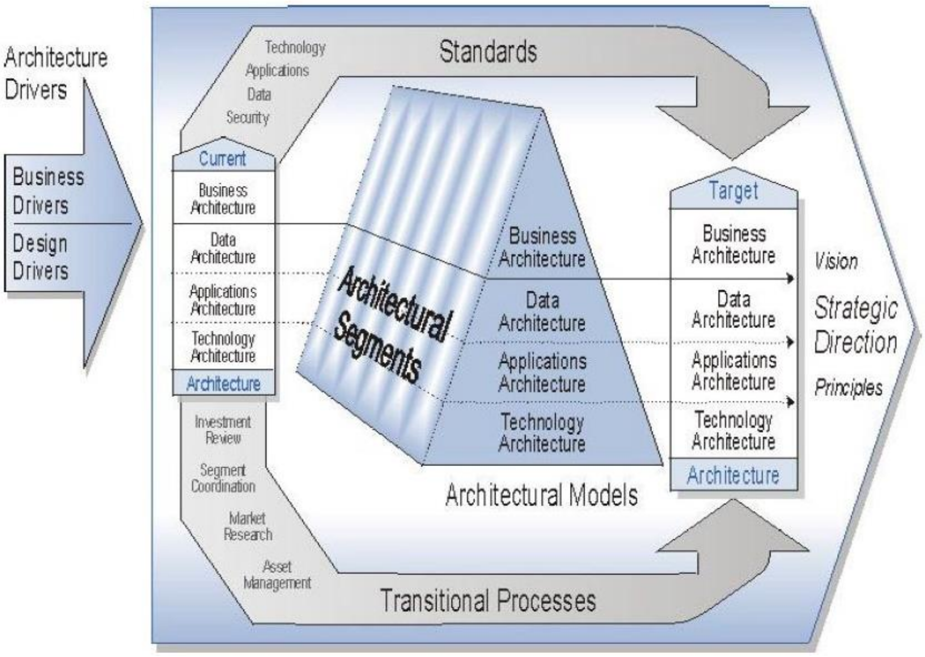


Figure 12: Federal Enterprise Architecture Framework Level 3 (The CIO council 1999).

Apart from these we can claim that FEAF is a standard process for developing an Enterprise Architecture. It utilizes a set of reference models namely the business, service, components, technical and data. These reference models provide different perspectives of the Enterprise Architecture. In addition FEAF includes an approach which measures the ability of the Enterprise Architecture to deliver value to the organization (Sessions 2007).

The major advantage of FEAF is that is offers a holistic approach on the development of Enterprise Architecture. It is based on the idea that the enterprise is built of segments and distinguishes core mission-area segments and business-services segments.

The FEAF process is a process to create the segments architectures that contribute to the realization of the overall architecture and can be compared with the ADM in TOGAF. The process is depicted in Figure 13.

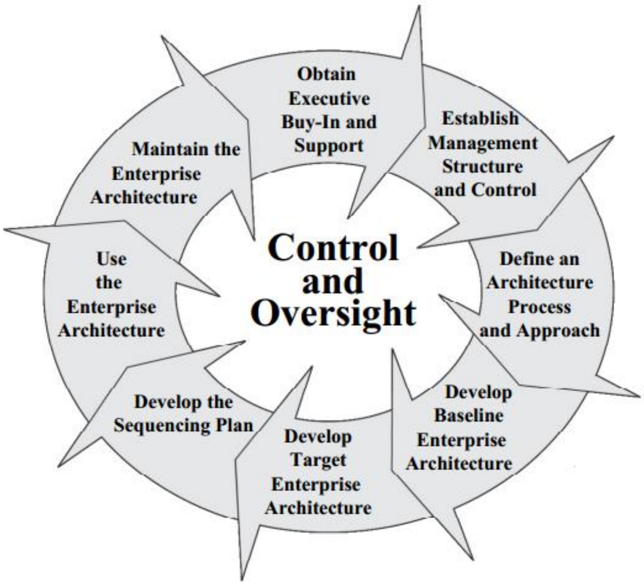


Figure 13: The FEAF process (The CIO council 1999).

The eight steps of the FEAF process can be combined into the four following higher-level groups (Sessions 2007):

- *Architectural Analysis:* for each segment a concrete vision is defined which must be aligned with the organizational plan.
- *Architectural Definition:* at this phase the actual architecture is defined by developing the Enterprise Architecture of each segment together with possible design alternatives and the performance goals of the architecture.
- *Investment and Funding Strategy:* this phase refers to the financial aspects of the projects.
- *Program-Management Plan and Execute Projects:* mainly refers to project management activities such managing the project, setting milestones, performance measures etcetera.

Even though this framework works efficiently for the public sector, it needs to be adapted for the private sector as well (Sessions 2007). The orientation of FEAF towards the public sector creates additional bottlenecks when applied in the private sector. First of all, governmental Enterprise Architecture projects do not require effort and investments to justify why an EA project is necessary. If a governmental legislation mandates an EA program then the motivation and the rationale of the Enterprise Architecture would be this legislation. Other frameworks (e.g., TOGAF) devote much effort on *"getting the organization committed and involved"* (Iacob et al. 2012) and also to gain approvals and funding. This process is an evolutionary pressure which is necessary to focus on activities that realize value.

4.2.4 Gartner

The Gartner Enterprise Architecture Framework is a vendor-specific approach for the Enterprise Architecture. In this top-down approach the Enterprise Architecture is driven by the business strategy. The Gartner EA framework utilizes three architecture viewpoints where each viewpoint is described by three levels of abstraction (Feurer 2007):

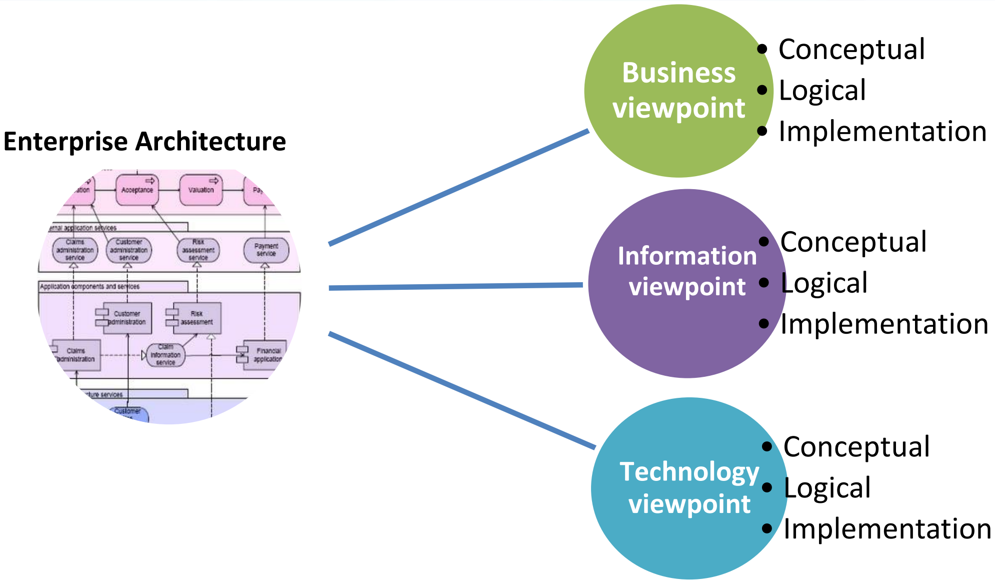


Figure 14: Gartner EA framework viewpoints and levels of abstraction.

In that way it is possible to decompose the architecture from the conceptual plan to a detailed implementation of the system. So the main focus of this framework is also to bridge the gap between the business and the IT side and to create the roadmap for the enterprise. The requirements are elicited from the business goals, drivers and policy. Following the requirements are translated to architecture and infrastructure design (Figure 15).

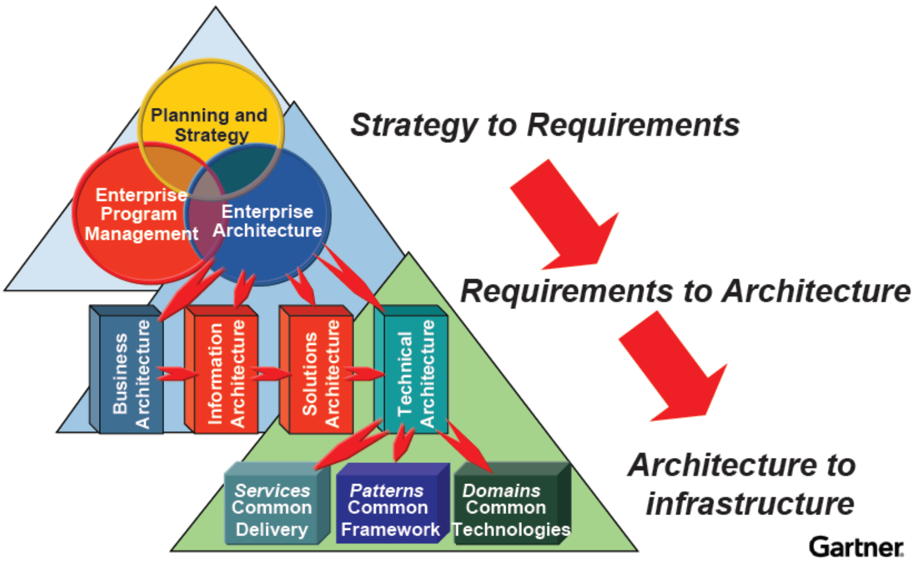


Figure 15: From strategy to system infrastructure (Gartner 2005).

In order to realize the architecture and infrastructure design from the business strategy the Gartner EA framework has an integrated EA process model for developing the Enterprise Architecture. The Gartner's EA process model resulted from the combination of best practice research as a logical approach to develop the Enterprise Architecture. *"It is a multiphase, iterative and nonlinear model, focused on EA process development, evolution and migration, and governance, organizational and management sub-processes"* (Bittler & Kreizman 2005). The governance is addressed during the phase "develop principles" where a consistent set of architectural principles supports IT investment decision making (Feurer 2007).

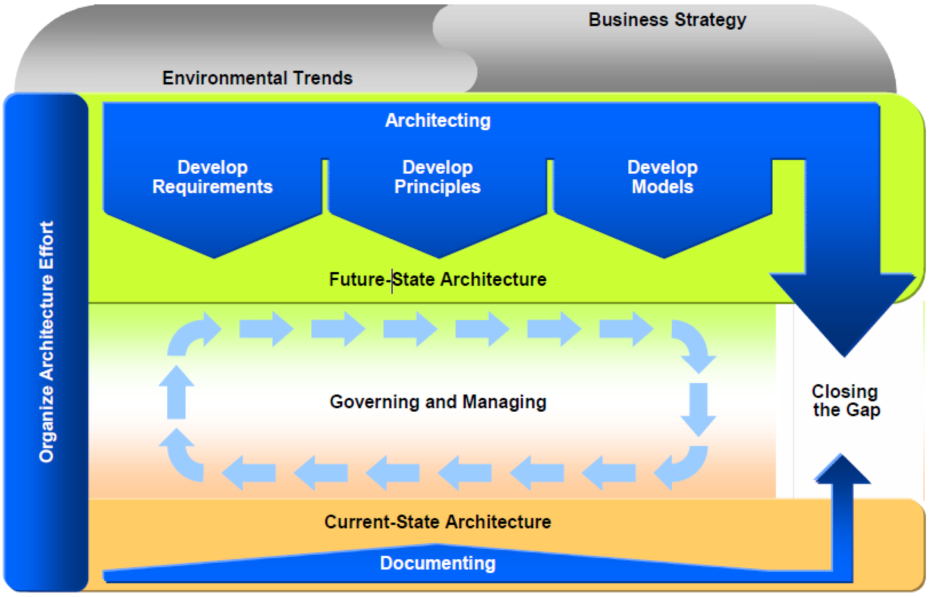


Figure 16: Gartner Enterprise Architecture Process Model (Bittler & Kreizman 2005).

The heart of the Gartner EA process model is a basic cycle which describes the future with the current situation together with a gap analysis for these states. Next to that the portfolio management is guided by the gap analysis and recommendations from past cases (Bittler & Kreizman 2005).

Like every EA framework it has its drawbacks and benefits. The Gartner EA framework integrates a complete EA process model with strong business focus and practice guidance. However it does not provide adequate reference model guidance and its taxonomy is incomplete (Sessions 2007).

4.3 Requirements for the most appropriate EA Framework for Cloud Ecosystems

In the previous sections the main components of the dominant EA frameworks are analyzed and described. The Zachman framework, TOGAF, FEAF and the Gartner EA framework are chosen because are the most accepted and used frameworks for Enterprise Architecture analysis and modeling (Sessions 2007, Feurer 2007). However none of these frameworks do support modeling and analysis of enterprise Cloud Ecosystems (Polovina 2012, Motahari-Nezhad et al. 2007). In the present section these four frameworks are compared and contrasted; and the most appropriate framework for Cloud Ecosystems is being picked.

A complete approach for Enterprise Architecture must include the following aspects (Iacob et al. 2012):

- **Framework**, which divides the architecture in various subdomains and explains the relations between the domains.
- **Modeling language**, which is a graphical representation (most of the times) of the concepts describing the architecture.
- **Process**, to guide the development of the architectural descriptions and the way of working.

Next to that an EA framework must describe a method for creating the architecture. This method could include (Iacob et al. 2012):

- An explicit or inexplicit **process** with the steps or phases to be performed, accompanied by their guidelines and order.
- The **guidelines** and **best practices** which help the architect applying the process.
- The **techniques** which are used during the process (e.g., modeling techniques, analysis techniques).

The chosen framework must include a **modeling language**, in order to create uniform architectural descriptions. A modeling language is necessary to define and represent the concepts and relationships between the different architectural domains. Moreover the EA framework must devise different **viewpoints** for the development and/or communication of the architectures as well as for addressing the stakeholders' concerns. It is also important that the framework reuses architectural assets. Storing and retrieving the architectural assets requires **reference models** and a **repository** (Iacob et al 2012).

Another subjective opinion is the research of Roger Sessions (2007). In this analysis (Sessions 2007) the four aforementioned EA methodologies are compared and contrasted based on several criteria: taxonomy completeness, process completeness, reference-model guidance, practice guidance, maturity model, business focus, governance guidance, partitioning guidance, prescriptive catalogue, vendor neutrality, information availability, and time to value. The results of the analysis (Sessions 2007) are listed below:

Table 7: Quantitative evaluation of the most popular EA frameworks (Sessions 2007).

Criteria	Zachman	TOGAF	FEAF	Gartner
Taxonomy completeness	4	2	2	1
Process completeness	1	4	2	3
Reference model guidance	1	3	4	1
Practice guidance	1	2	2	4
Maturity model	1	1	3	2
Business focus	1	2	1	4
Governance guidance	1	2	3	3
Partitioning guidance	1	2	4	3
Prescriptive catalogue	1	2	4	2
Vendor neutrality	2	4	3	1
Information availability	2	4	2	1
Time to value	1	3	1	4
Total score	**17**	**31**	**31**	**29**

1=poor, 2=inadequate, 3=acceptable, 4=very good

The most suitable framework for Cloud Ecosystems should have the best possible match with the aforementioned characteristics.

4.4 Why TOGAF ?

In this section it is presented the motivation for choosing TOGAF as the most appropriate EA framework to facilitate modeling and analysis for Cloud Ecosystems. The decision is taken based on criteria (qualitative and quantitative criteria) that the EA framework should have.

Based on the results of Roger Sessions (2007) it can be concluded that TOGAF and FEAF are the methodologies that are the most complete and do the best job based on the criteria that they are evaluated on. Since the total score for both the frameworks is 31, the most suitable framework can be chosen based on the other qualitative characteristics which are set in the previous section.

It is argued that the only modeling language which corresponds with the Enterprise Architecture approach is ArchiMate (Iacob et al. 2012). It is also proved that TOGAF complements ArchiMate (The Open Group 2011, Iacob et al. 2012); where TOGAF provides a method, a process, guidelines and techniques to steer the Enterprise Architecture development; and ArchiMate is a concrete modeling language. ArchiMate and TOGAF also share the concept of viewpoints, which allow different views of the same model (Iacob et al. 2012). Even though other frameworks can be combined with ArchiMate (to respond to the requirement of the modeling language) the result is not the same because there is no clear alignment between them.

Many IT companies tried to develop their own Enterprise Architecture approach influenced by others. For example the Oracle Enterprise Architecture Framework and the SAP Enterprise Architecture Framework are TOGAF based. If we take into account the diffusion of the SAP and Oracle systems worldwide together with the fact that most large systems need to interact with many smaller ones; then TOGAF tends to be the reference Enterprise Architecture approach (Mahmood and Hill 2011). Surveys also support that the most widely accepted and used framework is TOGAF (Feurer 2007).

The acceptance of TOGAF is attributed to its applicability to various environments (The Open Group 2011). IT specialists trust and use TOGAF because it is an open and generic approach for Enterprise Architecture. The rest of the EA frameworks focus on which deliverables should be produced for every phase but TOGAF emphasizes upon the method by which the architecture deliverables are produced (Hill et al. 2013). The content framework specifies a set of generic deliverables which can be applied in different situations. TOGAF can also be integrated with other frameworks namely ITIL, MMI, COBIT, PRINCE2, PMBOK, and MSP (The Open Group 2011). Consequently TOGAF can be used with any number of specific deliverables required from other frameworks, thus TOGAF is relevant to all Enterprise Architecture scenarios (Hill et al. 2013).

For any sector or size of enterprise, TOGAF is able to define business objectives, processes, structures, data, systems and interfaces (while FEAF is applicable mainly to the public sector). Furthermore it supports vertical integration of the business domains, horizontal integration of the technological domains and/or integration of the application domains (The Open Group 2011).

Of course this section does not aim to prove that TOGAF is the ultimate Enterprise Architecture approach. Every approach has its weaknesses and strengths and in some instances TOGAF may be disadvantageous compared to another approach (e.g., Gartner EA framework has better practice guidance and business focus than TOGAF) (Sessions 2007). Albeit this section shows the suitability of TOGAF to develop, manage and govern enterprise Cloud Ecosystems.

4.5 Related work

The purpose of this section is to identify related work on tailoring TOGAF for Cloud Ecosystems. Despite the importance of a methodological/framework support for Cloud usage and migration there is not developed such thing yet. However academia and practitioners are quite active in this topic. The Open Group has already started a joint program (Cloud Computing Work Group and the Architecture Forum) for this purpose (https://collaboration.opengroup.org/projects/togaf-ce/).

The TOGAF approach includes a process and a model to identify and integrate business and IT requirements into the Enterprise Architecture. The ADM vision defines several tasks which are necessary for Cloud empowerment (The Open Group 2011, Mahmood & Hill 2011):

- Getting the organization committed
- Confirm and elaborate architecture and business principles
- Define scope
- Identify stakeholders and business requirements
- Define solutions
- Establish the architecture project

Modern enterprises utilize business processes that are tightly coupled with the underlying Cloud services. Consequently the design of the Cloud applications should be based on a top-down approach. The ADM is a top-down approach for Cloud enablement. However the architectural views need to be tailored in order to facilitate Cloud usage and migration (Mahmood & Hill 2011).

The Business Architecture includes the various business goals, processes, and components. The difficulty here is how to realize the business goals through business processes. The architecture should also be flexible to respond to the business changing environments. The Business Architecture is important because it directly impacts the business users (Mahmood & Hill 2011).

In a traditional IT landscape the applications are accessible through the on-premise server machines. The Cloud Computing paradigm mandates that the various business services and applications are deployed and delivered through the CSP's servers. This may sound simple but in practice it is not. First the applications must be reprogrammed to be Cloud-ready and to synchronize the enterprise resources with the Cloud-based solutions. In parallel the Business Architecture should consider the non-functional requirements (e.g., security, privacy, governance, visibility, and controllability) of the Cloud-based solutions (Pethuru 2013).

The Data Architecture should devise the appropriate views for the system engineers, database designers and administrators. These views should address concerns regarding the database components development and integration. The entity relationship (ER) models of the Cloud-based applications should match with the corresponding ER models of the on-premise applications. Of course the multi-tenancy characteristics of the Cloud applications impact the logical data model. In addition the data security process models (for Cloud-based applications) will be completely different from the on-premise ones (Pethuru 2013).

The Application Architecture should device the appropriate views for the system and software engineers. These views should address concerns regarding the development and integration of the application software components. The application architecture views should include the conversion of commercial off-the-self (COTS) to SaaS. The corresponding stakeholders are the procurement personnel, system administrators, managers and operations staff (Mahmood & Hill 2011).

In case that the enterprise adopts PaaS solutions then the application architecture views will be impacted more than any other view. In a PaaS adoption scenario most of the on-premise components are simplified due to virtualized servers (including storage) and on-demand service provisioning. The new Everything-as-a-Service (XaaS) architecture is aligned with the Business, Information System and Technology Architectures which materialize the possibility for a distributed Enterprise Architecture (Pethuru 2013).

Despite the significance of the topic there is not yet published any scientific work. Although there are several respectable practitioners with sharp ideas, their work is not validated so we cannot consider it as scientific research. However there are two credible practitioners (Walker 2012, Thorn 2010) who did quite some useful work in the field and their insights could be used as a starting point for this thesis.

According to Walker (2012), TOGAF should be chosen as the framework for Cloud usage and migration for various reasons. First TOGAF is widely accepted and used due to the convergence with Service Oriented Architectures (SOA) and Cloud Computing (Mahmood & Hill 2011). Moreover The Open Group (2013) is quite active in integrating the TOGAF standards with Cloud standards. Also the generality of TOGAF makes the framework applicable to various situations as well as to Cloud Computing. As a result there is no need to reinvent models or strategy methods, but it needs to specify these general purpose methods and models (Walker 2012). Having all these as drivers Walker (2012) proposed the Cloud Strategy and Planning (CSP) framework which is comprised from three phases and seven activities as you can see in Figure 17.

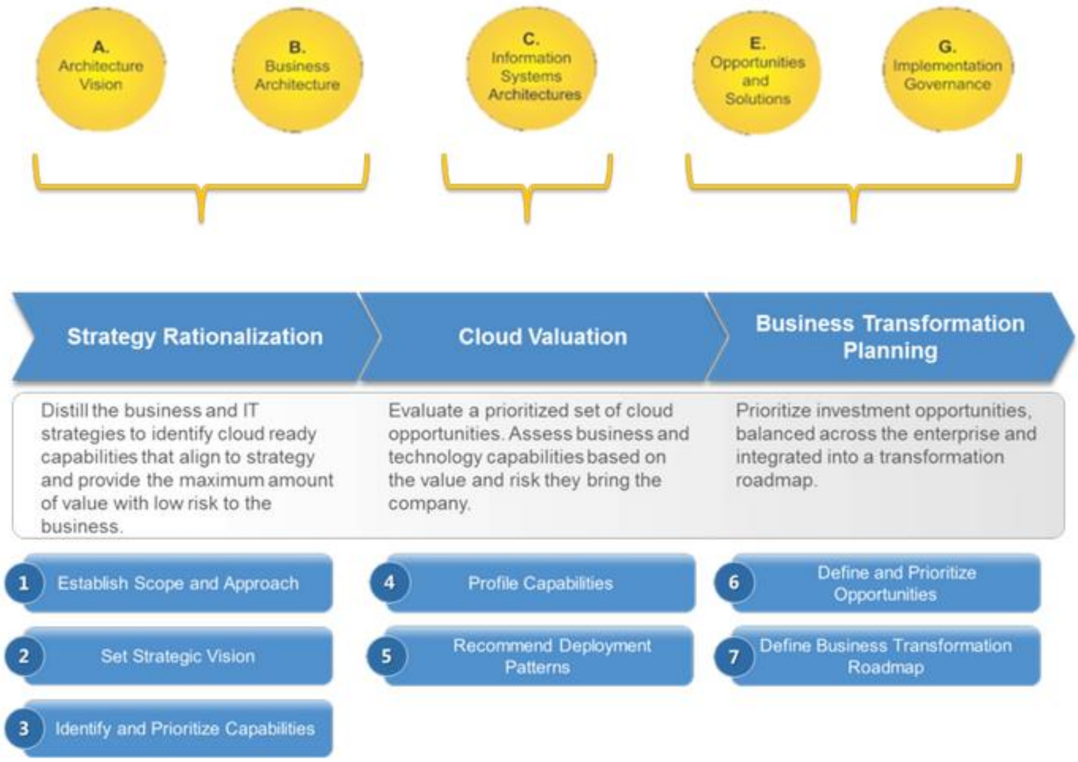


Figure 17: The Cloud Strategy and Planning framework (Walker 2012).

The first phase targets to prepare the organization and to create the strategy including Cloud Computing aspects. The next phase assesses the Cloud readiness of the organization by evaluating if it is rationale to adopt Cloud-based solutions or not. The final phase assesses investment alternatives (based on benefits, risks, technology impact and project plan). In this phase it is also developed a business transformation roadmap, and assessed the dependencies and implementation risks. It is suggested that the assessment of the dependencies and risks should be taken place in earlier phases. Also the lack of iteration in this approach is a big disadvantage as it does not allow the architects' team to correct or improve their deliverables and models. On the other hand this top-down approach can balance risks and value, and drives the projects based on the capability of the organization.

According to Thorn (2010), the Cloud Computing technology is another architectural style (like SOA, RFID, Client/Server etcetera) where the Enterprise Architecture should address. The fit between Enterprise Architecture and Cloud Computing depends on the maturity of the internal architecture. The more mature is the architecture, the better the fit and then the TOGAF ADM should be *"Cloud architecture aware"* (Thorn 2010).

Figure 18 summarizes the work of Thorn (2010), where he illustrates what should be added in every phase of the ADM to support Cloud migration modeling and analysis. It is suggested that this approach is not completely correct for two reasons. Although there are many aspects of the Enterprise Architecture that are simplified (e.g., views, models etcetera) from the Cloud Computing paradigm, they are not mentioned anywhere. Additionally, Thorn (2010) identifies candidate Cloud services during phase E, and considers a Cloud reference model in phase B. Both tasks should be done in earlier phases (i.e. preliminary phase), in order to have a clear landscape of the Target Architecture.

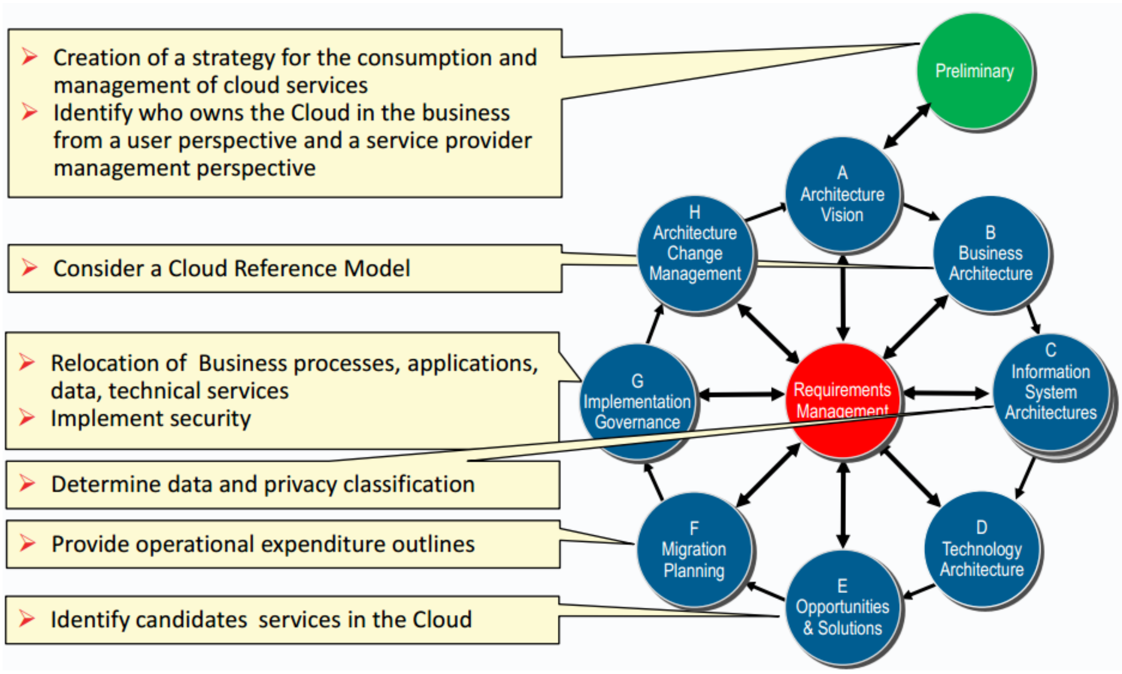


Figure 18: Cloud Computing requires EA with TOGAF (Thorn 2010).

4.6 Conclusion

Chapter 4 provides the preliminary information of the actual research which is described in the next chapters. First it is defined what is an architectural framework, together with the main characteristics of the most important Enterprise Architecture approaches (namely the Zachman framework, Federal Enterprise Architecture Framework, The Open Group Framework, the Gartner Enterprise Architecture Framework). This analysis provided useful insights on how an Enterprise Architecture approach for the Cloud should be. Consequently the requirements of a "Cloud aware" EA approach are set; and based on them it is identified that TOGAF is the most appropriate approach to facilitate Cloud migration analysis and modeling. Finally it is presented the related work in the field in order to prove that this research is actually worthwhile and also to gain important insights.

Chapter 5 – TOGAF for Cloud Ecosystems Approach

The outline of this chapter is the following: Section 5.1 introduces the TOGAF for Cloud Ecosystems approach and Section 5.2 gives an overview of it. Section 5.3 describes the ArchiSurance case study and Section 5.4 concludes Chapter 5.

5.1 Introduction and Objectives of the Approach

Nowadays, the demand for greater business agility pushes enterprises to deliver Cloud solutions rapidly and efficiently while reducing overall costs. Enterprise Architecture must enable rapid Cloud solutions development and enhancement opportunities in a way to realize the Cloud Ecosystem of an organization. Greater flexibility in delivering successful business solutions can be achieved by exploiting the essential capabilities of Cloud Ecosystem. To address any gap in the enterprise's capabilities, an enterprise often collaborates with the participants of a Cloud Ecosystem (e.g., Cloud Service Providers (CSPs), strategic vendors) and leverages participants' Cloud services. However, the extended enterprise environment (external entities and outsourced services) impacts the Enterprise Architecture and requires routine assessments of the Cloud solutions to ensure timely evolution and necessary alignment with the enterprise's strategic vision, goals and objectives.

The motivation of the present research is to use TOGAF in order to develop and maintain an Enterprise Architecture of the Cloud Ecosystem. In that way we can test the suitability of TOGAF to facilitate emerging technologies. The resulting approach provides guidelines and model-based support (with the use of ArchiMate) for making architectural design and implementation decisions to create and evolve Enterprise Architecture of the Cloud Ecosystem to ensure business agility. The proposed approach describes how to effectively manage interactions and relationships between the participants of the Cloud Ecosystem in order to minimize the impact of changes in Cloud services (either developed by the enterprise itself or by participating entities of the Cloud Ecosystem).

This thesis presents the chosen adaptation of TOGAF with rational to the approach. It is a practice-oriented approach that allows effective alignment of business and technical capabilities by structuring the architectural components (and their inter-relationships), and providing guidelines to adapt the governance process(-es) to take account of a Cloud Ecosystem over time. The goals and objectives of this research are to:

i. Explain how to use TOGAF to develop, manage and govern Enterprise Architecture for an enterprise Cloud Ecosystem.

ii. Use TOGAF to provide architectural information to drive decisions necessary to operate successfully within an enterprise Cloud Ecosystem.

The present research does not aim to create yet another methodology, because people tend to use techniques, tool, methods and methodologies which are known and feel comfortable to use them. So the target is to complement TOGAF with additional knowledge and also to tailor the existing knowledge base of TOGAF in order to create a new version of TOGAF which is applied in Cloud Ecosystems.

5.2 Overview of the TOGAF for Cloud Ecosystems Approach

It is important, before presenting the resulting approach, to delineate under which circumstances TOGAF for Cloud Ecosystems approach should be used. It is prominent that adopting this approach requires knowledge and on-hands experience with TOGAF (or other versions of TOGAF-based frameworks), either wise it is necessary to train accordingly the employees who are involved with EA activities. It does not matter whether the organization has an existing Enterprise Architecture (and governance structure to support the EA activities) because TOGAF for Cloud Ecosystems approach provides sufficient guidance to develop an enterprise Cloud Ecosystem from scratch.

In order to make effective and informed decisions for an enterprise Cloud Ecosystem, it is imperative to understand the overall enterprise context. Some things to consider include:

- Key requirements, issues, and concerns of the stakeholders.
- The cultural aspects, and business imperatives of an enterprise.
- The skills and capabilities of the enterprise in regards to adopting TOGAF.
- The Architecture Development Method (ADM) process can be adapted to support different usage scenarios with customized use of iteration.
- Describe how Cloud Ecosystem can be supported by TOGAF.

The main result of the research is specific guidelines together with model-based support that should be considered during the development of an enterprise Cloud Ecosystem. In order to illustrate and evaluate the approach with a running example, the approach is applied to the ArchiSurance case study (Jonkers et al. 2012) (described in Section 5.4). Besides having a strong IT function in the organization, ArchiSurance thinks to engage an external Cloud Service Provider for its software services to support its business needs. The organization intends to use TOGAF for Enterprise Architecture practices to manage its Cloud Services.

Specifically, the content of every Phase of ADM is combined, omitted, or added with new. This results in a set of guidelines concerning enterprise Cloud Ecosystem modeling and analysis. Based on these the corresponding deliverables (inputs/outputs) are created with the architectural modeling language ArchiMate. The resulting models can be used as reference models to develop enterprise Cloud Ecosystems for various insurance companies. In that way it allows the practitioners to effectively align business and technical capabilities in creating the structure of architectural components, their inter-relationships, and the guidelines in governing the architecture of a Cloud Ecosystem over time.

The thesis focuses on the Architecture Development Method (ADM) which is an iterative step-wise process for the development and implementation of Enterprise Architecture. It is comprised from ten Phases which can be grouped into four main parts. Apart from the main ADM iteration (from Phase A-H) internal iterations can take place in between the four subsequent parts of ADM (Preliminary – Phase A, Phase B – D, Phase E – F, Phase G – H). Every part of the ADM has a specific role (which is described in the list below) in the vision, development, delivery and governance of the Enterprise Architecture. Following Figure 19 illustrates the grouping of the ADM Phases we used in this work and the resulting parts are explained below:

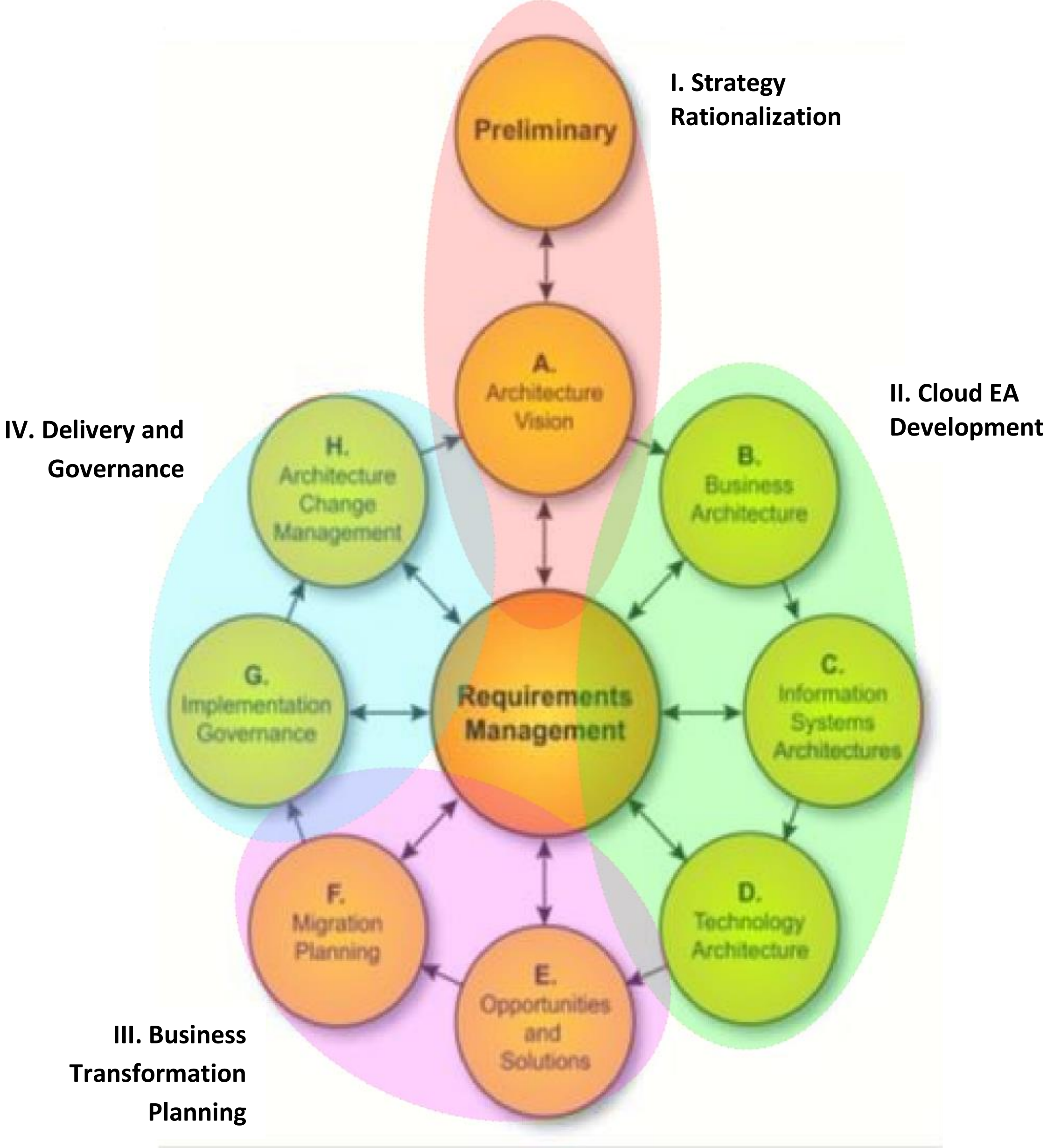


Figure 19: Grouping of TOGAF Architecture Development Method.

Part I: Strategy Rationalization

"Strategy Rationalization" groups the Preliminary and Architecture Vision Phases in order to get all the members of the organization involved and committed. The objective is to identify from the business and IT strategies Cloud-specific capabilities which are aligned with the enterprise-wide strategy in order to exploit maximum value from the Enterprise Architecture with low risk. The main activities of this group are to establish the scope of the architecture work, the creation of the strategic vision and the identification and prioritization of capabilities (Walker 2012).

Part II: Cloud Enterprise Architecture Development

"Cloud Enterprise Architecture Development" groups the Business Architecture, Information Systems Architecture and Technology Architecture Phases. The objective is to get the appropriate architecture by developing the Baseline and Target Architectures and analyzing the gaps between them. The main activity is the design of the appropriate architectural viewpoints to develop the respective architectures (Business, IS, and Technology Architectures) (Iacob et al. 2012).

Part III: Business Transformation Planning

"Business Transformation Planning" groups the Opportunities and Solutions and Migration Planning Phases in order to plan the implementation and migration of the architecture developed in Phases B-D. The objective is to identify and prioritize the investment opportunities and then to integrate them into a transformation roadmap. The main activities are the translation of the Gap Analysis results into work packages and the development of the implementation and migration plan (Iacob et al. 2012).

Part IV: Delivery and Governance

"Delivery and Governance" groups the Implementation and Governance and Architecture Change Management Phases in order to manage, prioritize and control the architectural requirements. The objective is to deliver and govern the Enterprise Architecture. The main activities are monitoring whether the implementation projects comply with the architecture, the identification of new requirements (if any) and based on that to decide whether it is necessary to start a new ADM cycle (Iacob et al. 2012).

Applicable to All Parts: Requirements Management Phase

As it is pre mentioned, every Phase has its own requirements (Requirements Management Process) which guide the ADM process and its subsequent Phases. Consequently, during every Phase and iteration the architecture team should check whether the architecture work is in accordance with the requirements which are set in the Requirements Management Phase.

The Requirements Management is a process that is triggered by some organizational change that needs to be addressed (Iacob et al. 2012). It is a dynamic process whereby the Enterprise Architecture requirements together with the subsequent changes are identified, stored and used by the relevant ADM phases and also between iteration of the ADM. The focus of the Requirements Management process is to manage the requirements across the ADM rather than addressing and prioritizing the requirements (this is done within the relevant phase of ADM) (The Open Group 2011).

When a new architectural problem is assigned to the architecture team the first task is to analyze the problem based on goals and requirements. This can be done with the Motivation Extension of ArchiMate. The goals and requirements help to identify which combination of products, services, processes and applications are needed to solve the problem and translate them into Enterprise Architecture models. If there are still unclear issues the architecture team must repeat this process in order to refine and realize the elements of the architecture (Iacob et al. 2012).

The first step in the process of developing Enterprise Architectures for Cloud Ecosystem is to identify the architectural requirements. In order to identify and understand the requirements, the organization has to conduct need assessment and requirement analysis. The information can be gathered from the related stakeholders, Cloud vendors and Cloud Computing experts. A workshop (whereby the business scenario is identified) will be useful to identify the services that the organization needs and also the details of each service (Wang et al 2012). Esteves (2011), states that useful sources to elicit Cloud-specific requirements are the Cloud Computing building blocks, service delivery models, deployment models, enabling technologies and the essential characteristics of Cloud Computing. According to Narman et al. (2011), advocate interviews can be the primary source of data collection to do requirement analysis. Below it is given a list of the most cited Cloud-specific requirements in the scientific literature (Wang et al. 2012, Rimal et al. 2011, Esteves 2011, Guo et al. 2008, Li et al. 2009, Mysore et al. 2009, Zhang et al. 2010):

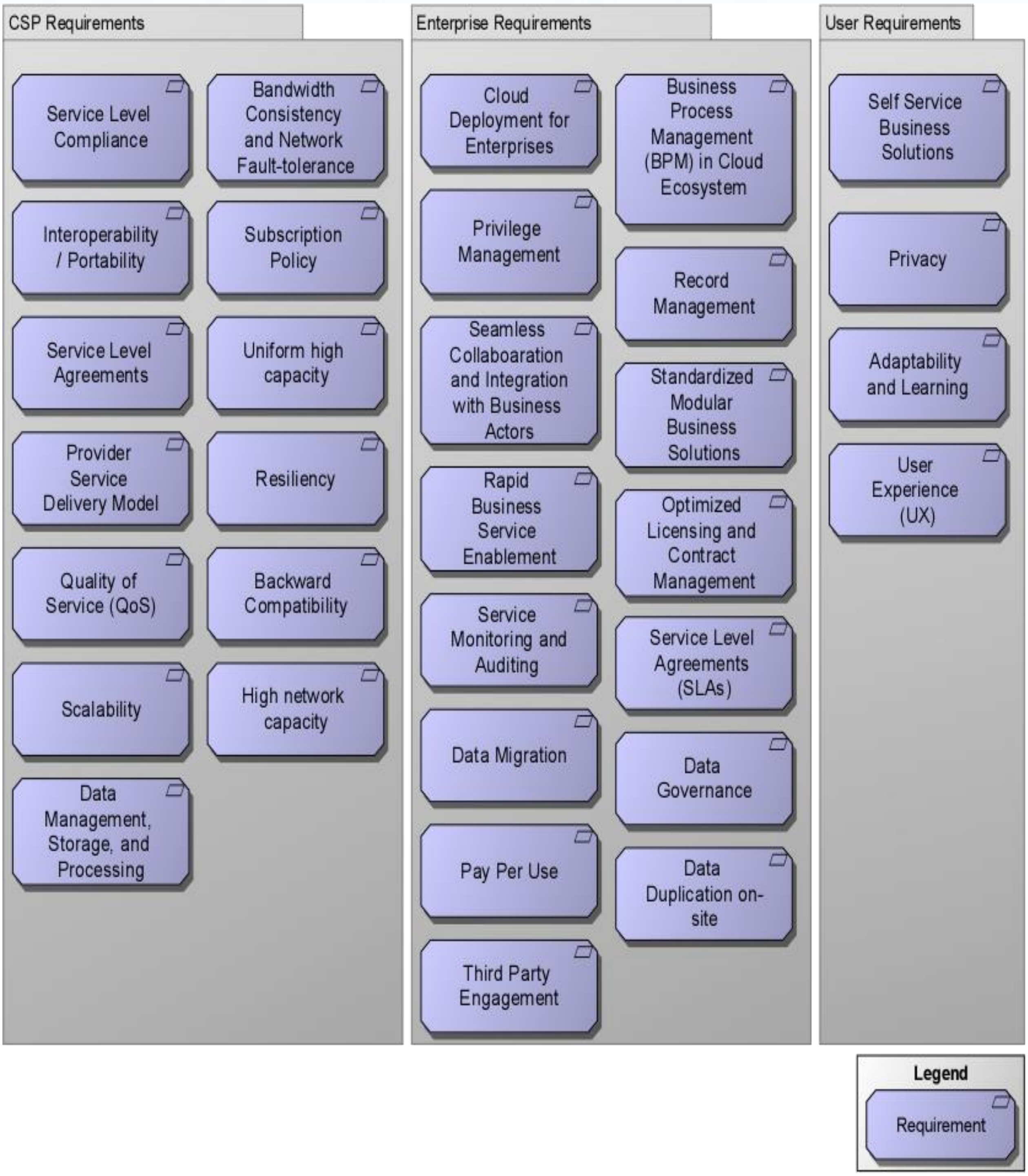


Figure 20: Cloud-specific Requirements List.

Based on this grouping, for every Phase of the ADM is assigned a specific set of guidelines and deliverables that should be produced in order to realize the enterprise Cloud Ecosystem. Tables 8-12 summarize the activities and deliverables that should be followed when developing the enterprise Cloud Ecosystem. TOGAF for Cloud Ecosystems prescribes what guidelines should be followed and what deliverables should be produced but is not restricted to them.

Table 8: Summary of Part I – Strategy Rationalization of the TOGAF for Cloud Ecosystems.

Phase	Approach/Objective	Main Activities	Deliverables
Preliminary	Prepare the organization for the new Enterprise Architecture with the definition of Cloud Ecosystem principles and organizational change principles for common understanding across the enterprise and also to govern the architecture process.	1. Define Cloud principles, requirements and constraints. 2. Align them with the business mission, goals, and objectives. 3. Align the Cloud business goals and objectives with the organization model. 4. Support the Cloud Ecosystem with the appropriate governance structure. 5. Ensure that the impact of the new architecture is communicated, understood and agreed by all stakeholders. 6. Prepare a request for Cloud Ecosystem architectural work. 7. Create a strategy for the consumption and management of Cloud services.	-Roles & responsibilities for architecture team(s) -Architecture principles
Architecture Vision	Identify from the business and IT strategies Cloud capabilities which are aligned with the enterprise-wide strategy in order to exploit maximum value from the EA with low risk.	1. Ensure top management support. 2. Create a Business Scenario, referring only to business solutions and not to architectural styles in order to solidify the set of requirements. 3. Define Cloud-specific KPIs to validate the Enterprise Architecture. 4. Align the potential solution with the Strategic Enterprise Architecture to achieve maximum value exploitation. 5. Obtain formal approval for Cloud Ecosystem architecture work.	-Architecture Vision, including: (i)Summary view, (ii) Plan the architecture work -Refined Statements of Business Principles, Goals and Drivers -Capability Assessment -Stakeholder Map matrix -Value Chain diagram

Table 9: Summary of Part II - Cloud EA Development of TOGAF for Cloud Ecosystems.

Phase	Approach/Objective	Main Activities	Deliverables
Business Architecture	Verify and update the business strategy and plans by including Cloud Ecosystem concerns in order to identify how to deliver business value to its customers with Cloud-enabled business capabilities. Then business services are realized by different Cloud service models, which must be consistent with the Cloud business capabilities.	1. Transform business and IT functions by adopting Cloud services as part of the enterprise strategy. 2. Establish effective Cloud services management to assess the impact on existing business processes. 3. Transform the existing business processes by enabling business process redesign. 4. Manage the extended Cloud environment by assessing business capabilities and realizing new organizational roles. 5. Illustrate the relationships between the Cloud services with the respective deployment models.	-Refined and updated version of the Statement of Architecture work -Draft Architecture Definition Document, including: (i) Target Business Architecture
Information Systems Architecture	Develop the Target IS Architectures by assessing comprehensively organization's data for effective use which will enable the organization to capitalize on its competitive advantage.	1. Establish a structured and comprehensive data management approach for enterprise-wide data definition. 2. Utilize data caching techniques for the Cloud Data Architecture to improve data availability, performance and scalability. 3. Ensure that the Cloud solutions are fault tolerant and data consistent. 4. A Cloud Ecosystem that utilizes different Cloud instances requires data partitioning to expose consistent data via Cloud solutions. 5. Provide flexible data integration mechanism and ensure that data in the Cloud is appropriately shared and maintained. 6. Treat data as information assets associated with appropriate categorization, quality, and their potential use in Cloud Ecosystem. 7. Determine Data and privacy classification and prioritize the risk criteria of what goes in the Cloud and what stays on-premise.	-Draft Architecture Definition document, including: (i) Target Application Architecture (ii) Target Data Architecture

Technology Architecture	The Technology Architecture reveals the technology services strategy to address technical services requirements. It is also identified the logical and physical technical aspects of IaaS, PaaS, SaaS capabilities which support the business objectives. Then it is possible to realize Cloud-based SBBs in the later phases of ADM and to redefine the solution architecture. A comprehensive assessment of the Baseline Technology Architecture will identify the technology gaps.	1. Assess the interactions and relationships between the technology capabilities and the IS ABB. 2. Determine overall technology architecture approach and identify any Cloud specific technology resources required for Cloud Ecosystem. 3. Devise the appropriate technology views to capture the interactions and relationships of architectural capabilities to enable multi-tenant environments. 4. Realize a particular Cloud service model by identifying technology capabilities. 5. Consider Architectural capabilities to support essential Cloud characteristics and handle their impact on architecture. 6. Non-functional aspects of the Cloud Ecosystem that must be addressed.	-Draft Architecture Definition document, including: (i) Target Technology Architecture

Table 10: Summary of Part III – Business Transformation Planning of TOGAF for Cloud Ecosystems.

Phase	Approach/Objective	Main Activities	Deliverables
Opportunities & Solutions	Deliver the Target Architecture through projects, programs and portfolios. The project lifecycle in Cloud Ecosystem is reduced significantly due to the rapid provisioning of services through SaaS, PaaS and IaaS. As a result the gap analysis (between target ABB and baseline ABB) is not directly relevant since Cloud Computing mandates infrastructure replacement.	1. Identify potential sources for value generation in the Enterprise Cloud Ecosystem. 2. Handle the IT resources that need to be acquired, as shared assets and the business side must justify the initiative with operational expenditure (OpEx) outlines. 3. Identify candidate services in the Cloud. 4. Confirm the organizations capability for undergoing change in order to develop an Enterprise Cloud Ecosystem. 5. Derive Transition Architectures that deliver continuous business value through exploitation of opportunities to realize building blocks.	-Draft Architecture Requirements Specification, including: (i) Consolidated gaps, Solutions, and Dependencies Assessment -Architecture Roadmap, including: (i) Revised motivation, (ii) Identification of Transition Architectures, (iii) Implementation Factor Assessment and Deduction -Implementation and Migration Plan v0.1 -Benefits diagram -Project Context diagram
Migration Planning	Finalize the Architecture roadmap and the Implementation and Migration Plan. For each migration project assess the dependencies, costs, benefits and whether they remain conformant with the architecture design models. Then the projects can be prioritized by assigning business value to each project.	1. The prioritized list of projects is the basis for the Implementation and Migration Plan. 2. Follow the suggested process in order to reach a sound Implementation and Migration plan for Cloud Ecosystem.	- Implementation and Migration Plan v1.0, including: (i) Project and portfolio breakdown of the implementation

Table 11: Summary of Part IV – Delivery and Governance of the TOGAF for Cloud Ecosystems.

Phase	Approach/Objective	Main Activities	Deliverables
Implementation Governance	The implementation program is decomposed into individual implementation projects and deployment schedule. The Target Architecture must be deployed as a series of transitions whereby each transition represents incremental steps (each step delivers benefits and value on its own) towards the target situation.	1. Ensure that the implementation projects conform to the Cloud Ecosystem Target Architecture. 2. Perform the actual relocation (physical and logical relocation) of the business processes, applications, data and technical services. The security must be implemented during the relocation of these business and IT elements to ensure that the Target Architecture meets the non-functional requirements.	No deliverables specified with ArchiMate
Architecture Change Management	Evaluate whether the target business objectives and value are met by the architecture work. Also address, evaluate and evolve the external and internal factors which contribute to the overall business performance, and specify which governance process will steer the Enterprise Cloud Ecosystem from now on.	1. Define business requirements to address the new way of interaction. 2. Perform incremental improvements which are critical to business process transformation through automation. 3. Identify new performance improvement opportunities which enhance customers' experience. 4. Create service contracts with CSPs that allow the organization to change, exit or migrate to another solution safely. 5. Monitor the utilization of the Cloud services and perform routine risk assessments.	-New Request for Architecture Work -Cloud Compliance Assessments -Architecture Contract

Table 12: All Parts –Requirements Management Phase of the TOGAF for Cloud Ecosystems.

Phase	Approach/Objective	Main Activities	Deliverables
Requirements Management	Manage the Cloud-specific requirements across the ADM rather than addressing and prioritizing the requirements (this is done within the relevant phase of ADM).	1. Identify the Cloud requirements by conducting need assessment and requirement analysis. 2. Gather information from the related stakeholders, advocate interviews, Cloud vendors and Cloud Computing experts, Cloud Computing building blocks, service delivery models, deployment models, enabling technologies and the essential characteristics of Cloud Computing conducting a workshop (whereby the business scenario is identified).	-Cloud Requirements List

5.3 The ArchiSurance Case Study

The ArchiSurance is a fictitious case which is used from the Open Group to illustrate the use of ArchiMate in the context of TOGAF (Jonkers et al. 2012). ArchiSurance is an insurance company which resulted from the merger of three different companies which were specialized in different insurance products namely:

- Home and travel insurance (Home & Away)
- Auto insurance (PRO-FIT)
- Legal expense insurance (Legally Yours)

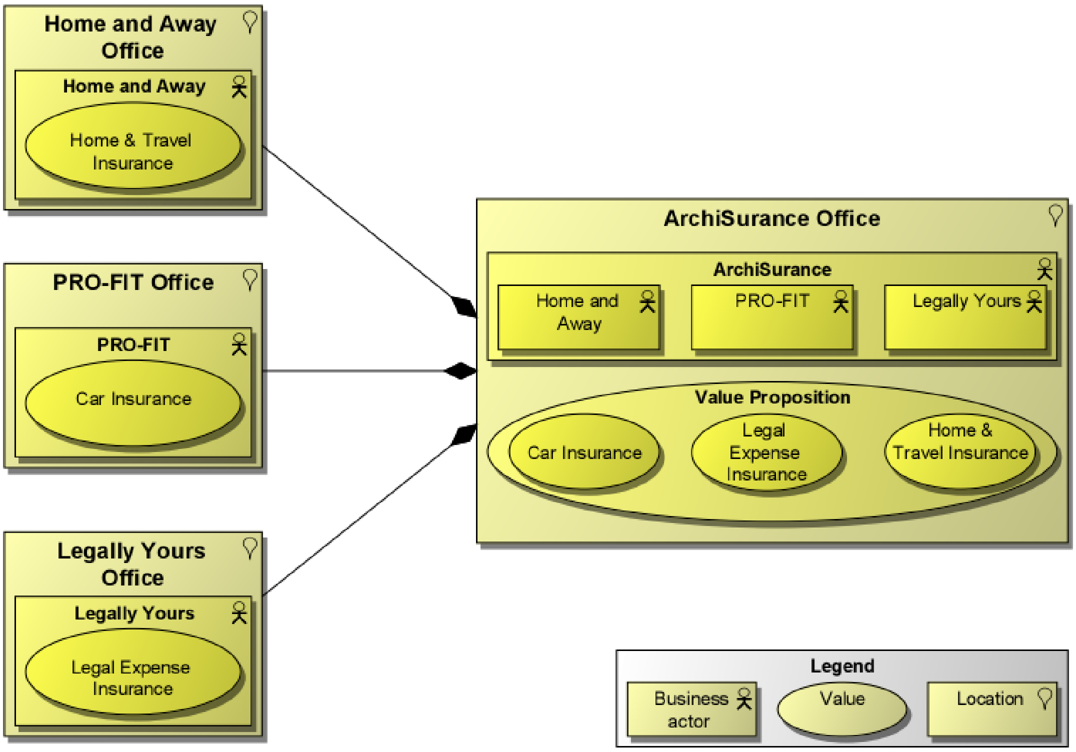


Figure 21: The ArchiSurance Merger – Illustrated in ArchiMate.

The owners of ArchiSurance observed convergence between the business models of the pre-merger organizations; consequently they wanted to benefit from the synergies between the three companies. They realized that only a larger, combined company could simultaneously control its costs, maintain its customer satisfaction, invest in new technology, and take advantage of emerging markets with high growth potential (Jonkers et al. 2012).

The previous ArchiSurance scenario was to develop the Enterprise Architecture of the new organization. The new Enterprise Architecture has an integrated back-office application suite and a new CRM system which resulted from the integration of the general CRM system and the legal expense CRM of the pre-merger companies. The result for ArchiSurance is increased profit and agility to changing market conditions. ArchiSurance sells directly to customers via print, web, and direct marketing.

The imperative of cost savings, business agility, and acquisition of new business and retention of the existing ones bring new changes for ArchiSurance. The decision support matrix below (Figure 22) supported the ArchiSurance board to decide what capability to migrate to the Cloud. The notion behind that is simple; capabilities with low risk and high gain (high standardization, low business importance) should stay on premise and vice versa. The other two squares of the matrix (high business importance and standardization; low business importance and standardization) include capabilities that can be migrated to the Cloud under certain circumstances (e.g., not mission critical applications, bring more benefits than the risks they hide, similar successful practices etcetera).

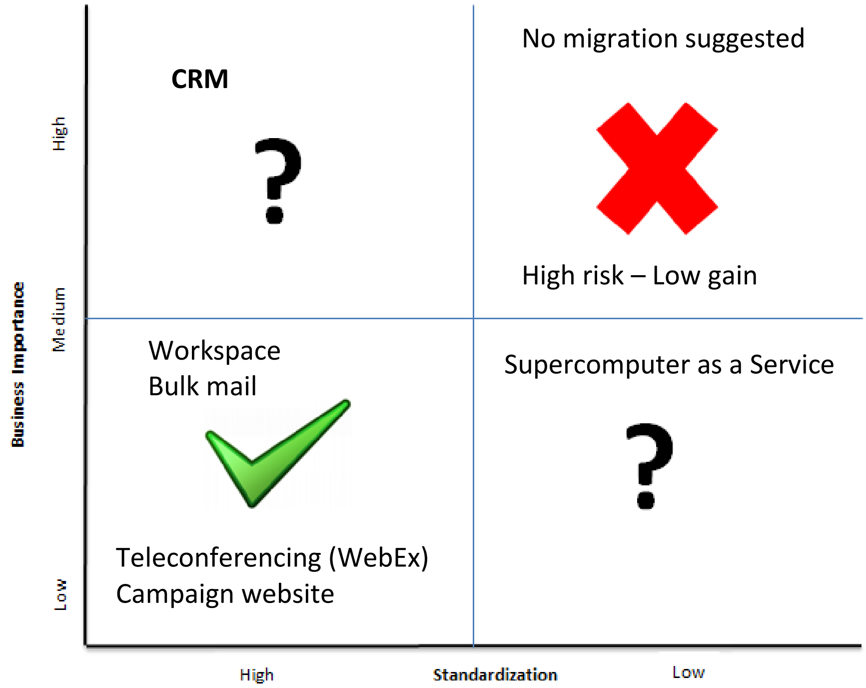


Figure 22: Decision support matrix of what applications to migrate to the Cloud.

Despite the high risk of the CRM migration to the Cloud, the ArchiSurance board decided to adopt a Cloud-based CRM solution because the benefits outnumber the risks. The reason is that ArchiSurance strives to extend its market share by retaining the existing customers at the same time. Customer satisfaction is an important motivator towards the new architecture. Also the high standardization of the Cloud-based CRM solutions is reducing the time and effort to integrate and deploy the new solution. Consequently a new Enterprise Architecture project is initiated from the executive board in order to address the impact of the CRM migration.

5.4 Conclusion

Chapter 5 provides the summary of the results which are described in detail in the next chapters. The resulting TOGAF for Cloud Ecosystems approach explains how to use TOGAF to develop an enterprise Cloud Ecosystem. The main activities, objectives, and deliverables of every part of the resulting approach, are summarized in the corresponding tables (Tables 8-12). The TOGAF for Cloud Ecosystems approach is adapted systematically to the ArchiSurance case study (The case study is described in Chapter 5 and the application of the TOGAF for Cloud Ecosystems approach is provided throughout Chapters 6-9) in order to demonstrate the approach and also to provide architectural information to drive decisions necessary to evolve an enterprise Cloud Ecosystem.

Chapter 6 – Strategy Rationalization

The outline of this chapter is the following: Section 6.1 and 6.2 explain TOGAF for Cloud Ecosystems approach to cope with the Preliminary Phase and the Architecture Vision Phase respectively. Both Phases are demonstrated in the context of ArchiSurance case with the use of ArchiMate modeling language. Lastly Section 6.3 gives the conclusions of this chapter.

6.1 Preliminary Phase

Section 6.1 suggests a Cloud-enabled approach for the Preliminary Phase of ADM, by suggesting guidelines and deliverables which are necessary to develop an enterprise Cloud Ecosystem. The TOGAF for Cloud Ecosystems approach adapts systematically the Architecture Development Method (ADM) of TOGAF in the ArchiSurance case study.

6.1.1 Approach

The Preliminary Phase includes all the activities which prepare the organization for the new Enterprise Architecture. The main activities of our approach are the definition of Cloud Ecosystem principles and the definition of an organization-specific architecture framework (The Open Group, 2011).

TOGAF ADM is a logical process model and each ADM cycle creates an increment to the Enterprise Architecture. Typically an ADM cycle goes through Phases A to H but in most (if not all) of the cases the cycles overlap, with Phases A to F of the N^{th} cycle carried out in parallel with Phase G of the N^{th}-1 cycle. In order to obtain a logically consistent architecture Phases A to E should start simultaneously.

The Cloud Ecosystem principles and organizational change principles are defined in this Phase as mentioned above. This impacts the governance and support strategy and the content of the initial Architecture Repository. The architecture principles are set in the Preliminary Phase for common understanding across the enterprise, and also to govern the architecture process. The architecture principles can be translated into rules and guidelines for the usage, structure and deployment of all IT resources and assets across the enterprise.

6.1.2Guidelines

Following the main focus is on the aspects which ensure that the organization's architectural model has the support for necessary business and IT capabilities for the use of Cloud solutions.

1. Define a process for documenting the architecture principles, business requirements and constraints which are related to the Cloud.
2. Align these architecture principles with the business mission, goals, and objectives.
3. Align the business goals and objectives of the Cloud Ecosystem with the organization model for the Enterprise Architecture.
4. Support the organization's Cloud Ecosystem with the appropriate governance structure by ensuring that the governance structure includes the processes, roles and responsibilities related to the Cloud Ecosystem (Thorn, 2010).
5. Communicate the impact of the new architecture initiative to all stakeholders by ensuring that this initiative is understood and agreed by all stakeholders.
6. Prepare a request for Cloud Ecosystem architectural work which must be approved in Phase A.
7. Add a step related to the creation of a strategy for the consumption and management of Cloud services (public/private Clouds, semantic management, security, transactions) (Thorn, 2010).

The definition of architecture principles is of utmost importance in the Preliminary Phase because they will guide the rest of the EA program. Below it is given a list of high level architecture principles (Explained in Appendix II) which are applicable in every Enterprise Architecture program for Cloud Ecosystems.

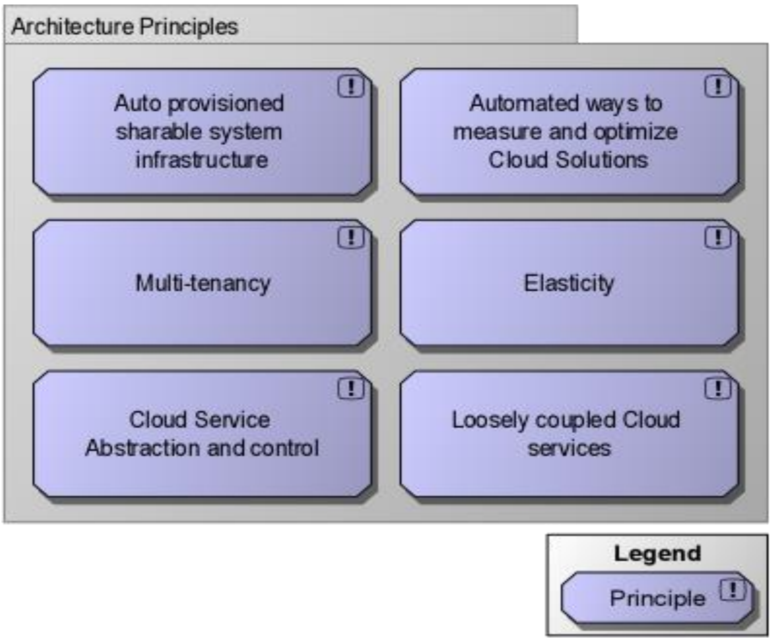


Figure 23: High-level Architecture Principles for Cloud Ecosystems.

Organizations in general will have an established set of architecture principles from previous architecture programs. These principles must be checked then for their applicability and completeness to the Cloud Ecosystem. Below they are given some guidelines on how to define and reuse Cloud-specific principles.

Table 13: Remedies on how to adapt existing principles for the Cloud Ecosystem.

Type of principle	Remedy
New	Must address the concerns of the Cloud Ecosystem.
Existing-Poor fit with Cloud	This can happen when a principle dates from an earlier period, when cloud in its current form did not exist. Should we keep the principle as-is and accept the consequences, even if it means little or no cloud? Can it be amended? In this case we need to look at the underlying Business Principle and evaluate whether the Architecture Principle can be phrased differently. It is possible that we may come to the conclusion that the principle is no longer valid.
Existing-Not particular for Cloud	These principles should be evaluated whether they address adequately the concerns of the Cloud Ecosystem.
Existing-Relevant to Cloud	Need to be given particular attention in the Cloud context.

6.1.3 Deliverables

The deliverables which are listed below are essential to capture the aforementioned aspects. The present research focuses only on the deliverables which can be modeled with the use of ArchiMate. Consequently, the deliverables which are created with other techniques or notations are not presented in the ArchiSurance case study. The Preliminary Phase outputs may include the following but are not restricted to:

Table 14: Suggested deliverables of the Preliminary Phase which can be modeled with ArchiMate.

Preliminary Phase Outputs (The Open Group 2011)	Supporting ArchiMate Viewpoints (Iacob et al. 2012)
-Organization Model for EA, including: Roles & responsibilities for architecture team(s)	Organization viewpoint (Figure 24)
-Tailored Architecture Framework, including: Architecture principles	Principles viewpoint (Figure 25)
-Governance and Support Strategy	N/A (in document form)
-Initial Architecture Repository	N/A (in document form)
-Request for Architecture Works	N/A (in document form)

6.1.4 Preliminary Phase in ArchiSurance

Step: Define and Establish Enterprise Architecture Team and Organization

The executive board of ArchiSurance consulted the EA governance board and they decided to start an architecture program for the development of the new architecture. The governance structure and the roles and responsibilities (Figure 24) of the project were defined by the EA Governance Board. After that the Cloud Architecture Team scoped the EA project. The biggest impact is expected in the customer-related information management as the goal of the project is to replace the old CRM system by a Cloud-based solution.

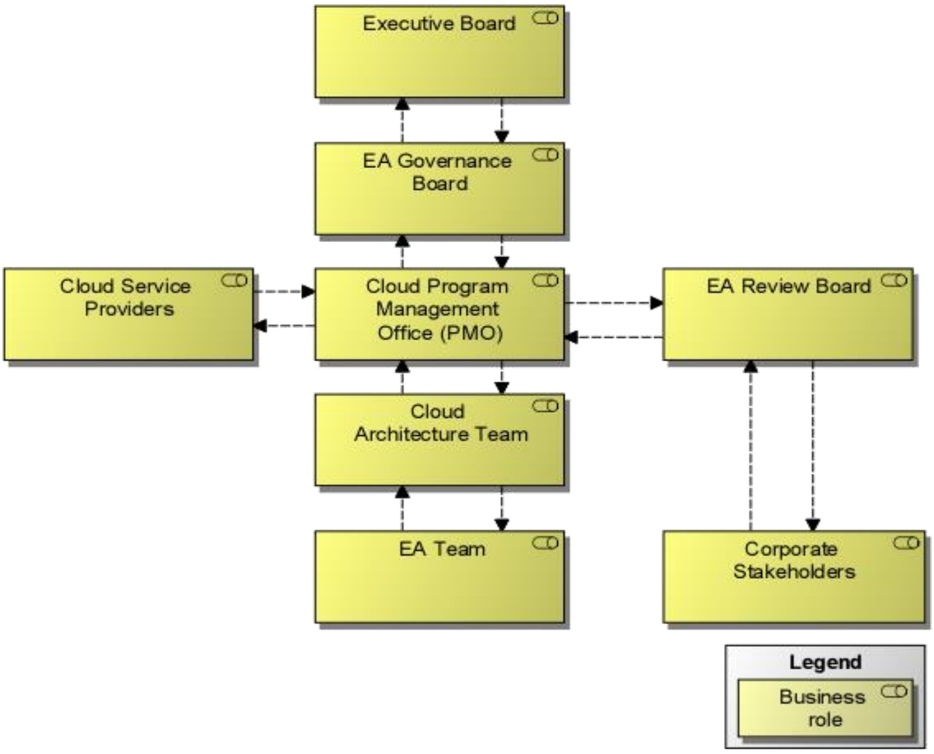


Figure 24: Roles & Responsibilities in ArchiSurance.

Step: Identify and Establish Architecture Principles

The architecture principles, sourcing from the business principles, are important for the architecture governance. Once the organizational context is in place, the Cloud Architecture Team defined a set of appropriate architecture principles.

The Cloud PMO reviewed the inventory with the high-level principles that will govern the new architecture project (Figure 25). This principles list is a combination of new and existing principles. The new principles are Cloud-specific principles, while the existing ones (from previous EA programs) have been rephrased to address the challenges of the Cloud Ecosystem. For a detailed description of the principles refer to Appendix II.

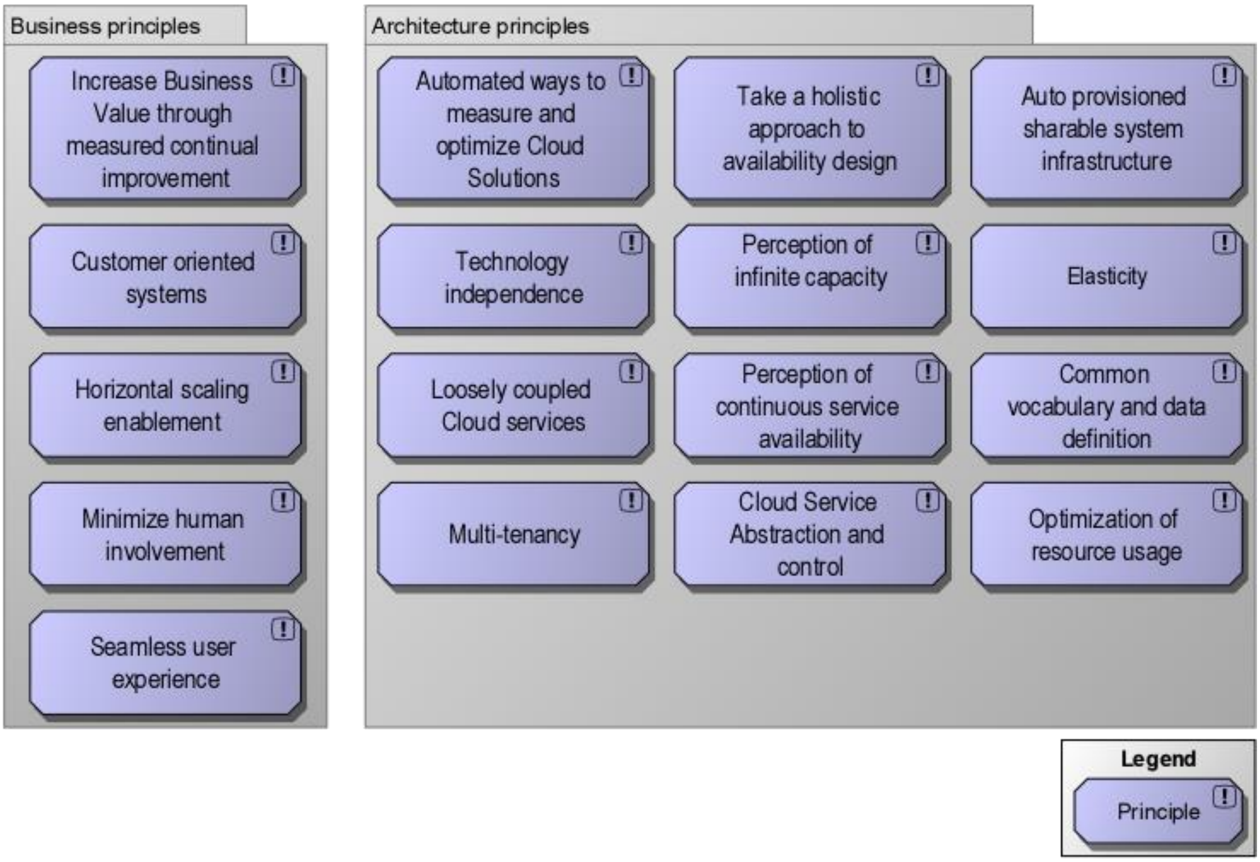


Figure 25: High-level Business & Architecture Principles of ArchiSurance.

6.2 Phase A – Architecture Vision

Section 6.2 suggests a Cloud-enabled approach for the Architecture Vision Phase of ADM, by suggesting guidelines and deliverables which are necessary to develop an enterprise Cloud Ecosystem. The TOGAF for Cloud Ecosystems approach adapts systematically the Architecture Development Method (ADM) of TOGAF in the ArchiSurance case study.

6.2.1 Approach

The principles which are set during the Preliminary Phase must be unambiguously defined. These principles can be translated as constraints on the architecture because they indicate implicitly what is in and what is outside the scope of the architecture. In most of the cases, the business principles, business goals and strategic drivers are already defined before the EA program starts. If so, in Phase A, the existing definitions must be checked for relevance to the Cloud Ecosystem. If these items (business principles, business goals and strategic drivers) are not defined yet, then they must be defined in Phase A (The Open Group, 2011).

Next the principles can be decomposed into requirements. Phase A addresses the changing business requirements of all stakeholders (both internal and external), and sets a mechanism to meet these requirements in an optimal way.

6.2.2 Guidelines

These requirements can be met by adjusting the current business and IT capabilities in a way to enable the use of Cloud resources. This can be done by focusing in the following aspects:

1. Ensure the organization's top management support and the commitment of all stakeholders.
2. Align the architecture principles with the business mission, goals, and objectives.
3. Create a Business Scenario (including the business problems, business requirements and a potential solution) by referring only to business solutions and not IT aspects. In that way the set of requirements is consolidated (Thorn, 2010).
4. Define a process for documenting the business requirements and constraints which are related to the Cloud.
5. Define Cloud-specific KPIs (Key Performance Indicators) to validate the Enterprise Architecture of the organization.
6. Establish architecture governance to manage the Cloud Ecosystem.
7. Align the potential solution with the Strategic Enterprise Architecture to achieve maximum value exploitation (Thorn, 2010).
8. Obtain a formal approval for Cloud Ecosystem architecture work.

Apart from these the organization should perform a Cloud Readiness Assessment workshop with the involved stakeholders. The purpose is twofold: First the organization should identify the desired functionality which can be deployed through a Cloud Ecosystem (Cloud Discovery workshop) and then to identify its readiness state to adopt and use Cloud services (Cloud Readiness Assessment workshop). Examples of assessment summary dashboards for reporting on Cloud readiness performance are listed below:

- Business benefits dashboard.
- Risks dashboard.
- Business and technical performance dashboard.
- Legal security and operational compliance dashboard.

In that way the Cloud Roadmap Planning is created by developing the plan for effective Cloud adoption and involves a number of key planning activities (Table 14). Following these guidelines (including the guidelines of the Preliminary Phase) the organization can identify from the business and IT strategies Cloud capabilities which are aligned with the enterprise-wide strategy in order to exploit maximum value from the EA with low risk.

Table 15: Activities and tasks overview for planning the Cloud Roadmap.

Key Roadmap Plans	Key Tasks in Plan	Aim
Business goals plan	Cost, growth, compliance, consistency	The business plan is aligned with the budget plan
Business plan	Mission and objectives	
Budget plan	Investments planning	
Capability plan	Resources and skills planning	Strategic capabilities identification
Cloud services plan	Responses and networks	
Foundations-Cloud governance	Security, platforms, tools	

6.2.3 Deliverables

The deliverables which are listed below are essential to capture the aforementioned aspects. The present research focuses only on the deliverables which can be modeled with ArchiMate. Consequently, the deliverables which are created with other techniques or notations are not presented in the ArchiSurance case study. The Architecture Vision Phase outputs may include the following but are not restricted to:

Table 16: Suggested deliverables of the Architecture Vision Phase.

Architecture Vision Outputs (The Open Group 2011)	Supporting ArchiMate Viewpoints (Iacob et al. 2012)
-Architecture Vision, including: (i)Summary view, (ii) Business scenario, (iii) Plan the architecture work	(i)Landscape map viewpoint, (ii) N/A, (iii) Total viewpoint
- Refined Statements of Business Principles, Goals and Drivers	Motivation viewpoint, Requirements Realization viewpoint, Goal refinement viewpoint
- Capability Assessment	Motivation viewpoint
- Stakeholder Map matrix	Stakeholder viewpoint
-Value Chain diagram	Architecture Vision viewpoint

6.2.4 Phase A in ArchiSurance

Step: Establish the Architecture Project

ArchiSurance conducted the necessary procedures to ensure that the Cloud initiative have been recognised and endorsed by the corporate and line management. The Cloud Program Management Office (CPMO) is responsible for the Cloud architectural activity which will be managed by combining existing project and program management frameworks. The project will be governed by the existing governance structure of ArchiSurance which is illustrated below.

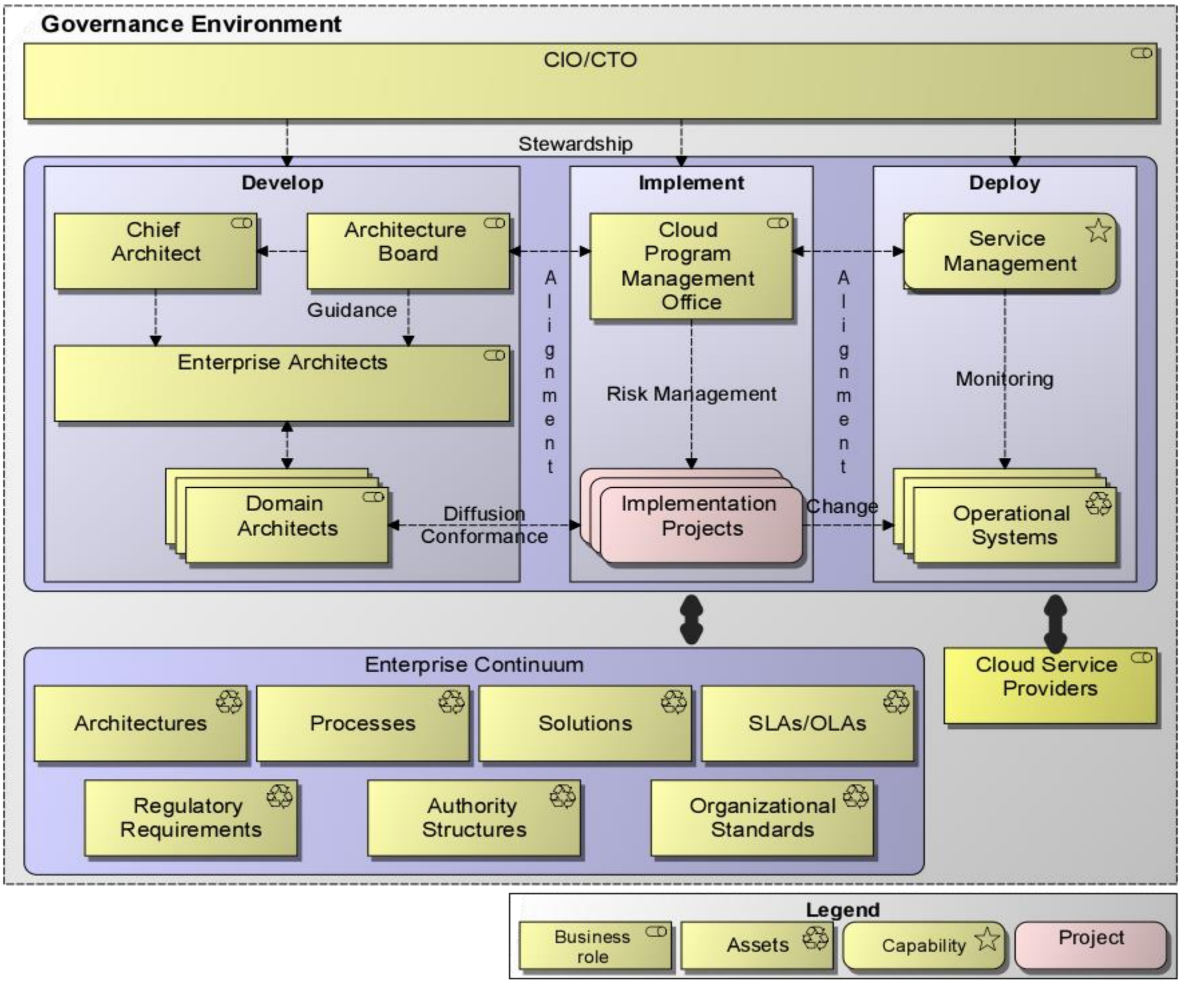


Figure 26: Established architecture governance structure of ArchiSurance (The Open Group 2013).

Step: Identify Stakeholder Concerns and Business Requirements

In this step it is important to identify the key stakeholders in order to finalize the business requirements, scope and expectations of the new EA program. Every stakeholder has different concerns, which are the key drivers for the acceptance of the architecture program. In the Architecture Vision Phase an inventory of all stakeholders and their concerns (modeled as drivers in ArchiMate) should be created.

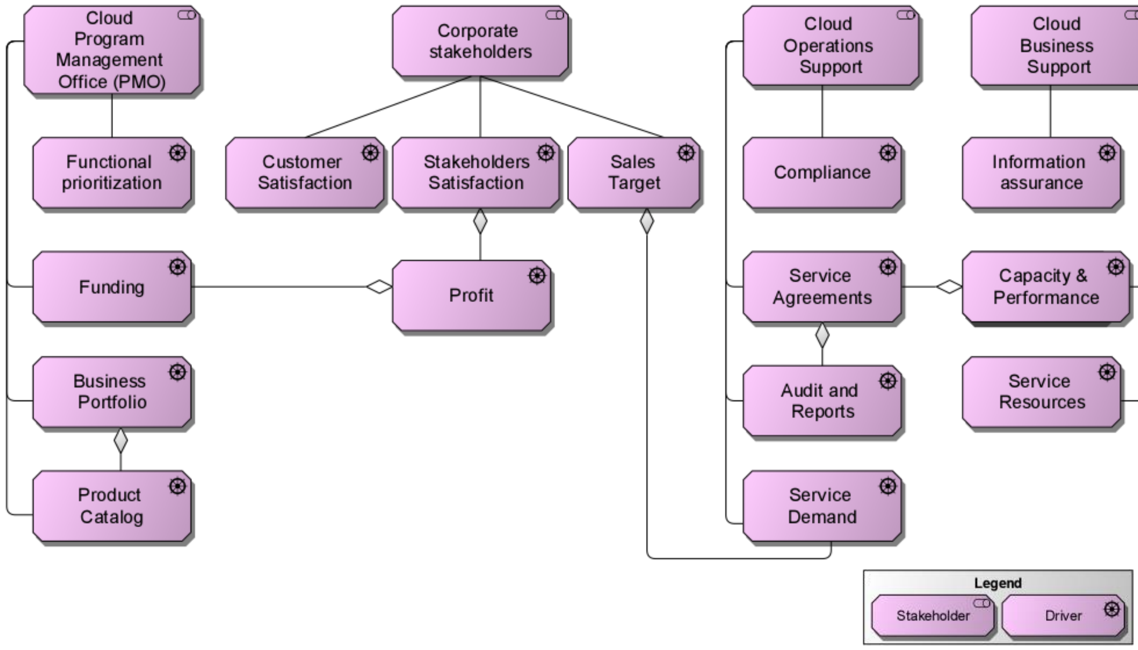


Figure 27: Stakeholder Concerns of ArchiSurance (The Open Group 2013).

After that, these drivers can be decomposed into business goals of the Target Architecture. Figure 28 illustrates the decomposition of the driver Profit into business goals. The driver profit is shown because it is the most important driver for this EA program.

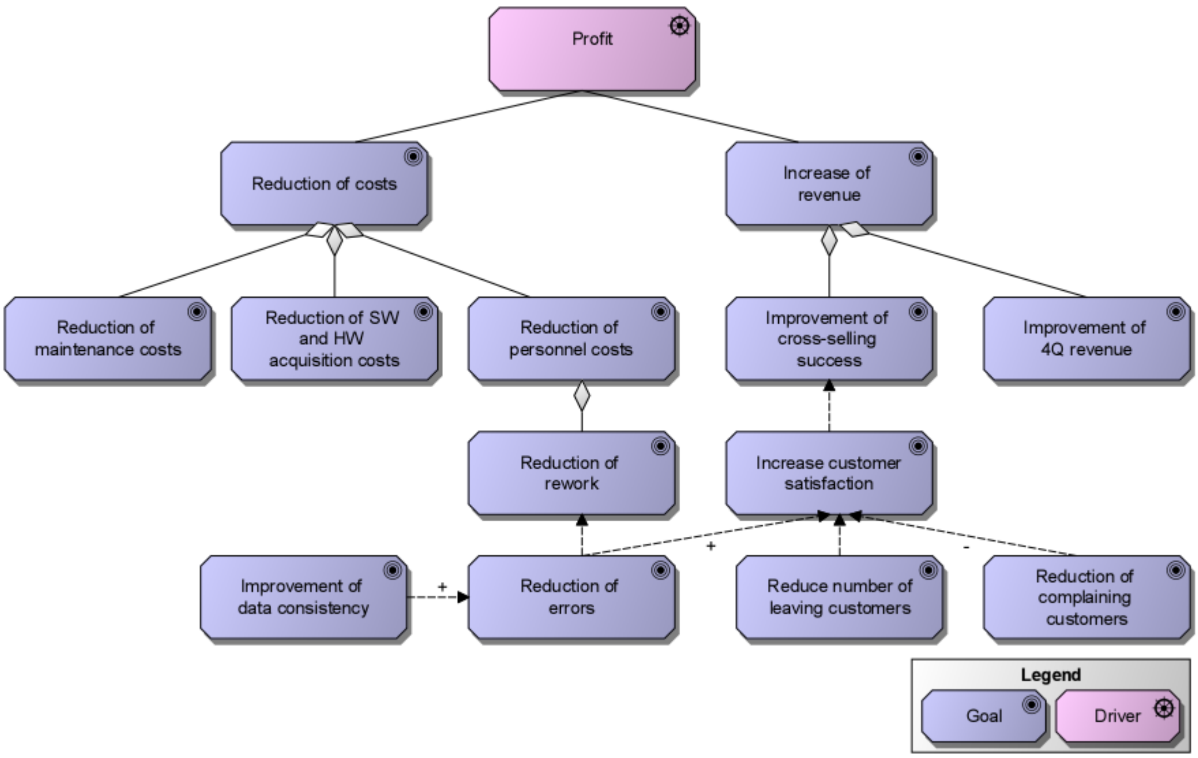


Figure 28: Business goals associated with the driver profit (Based on Jonkers et al. 2012).

These goals can be refined into high level requirements of the future architecture (Iacob et al. 2012). In order to visualize this, the motivation viewpoint is used in Figure 29 for the CxO level stakeholders of ArchiSurance**.**

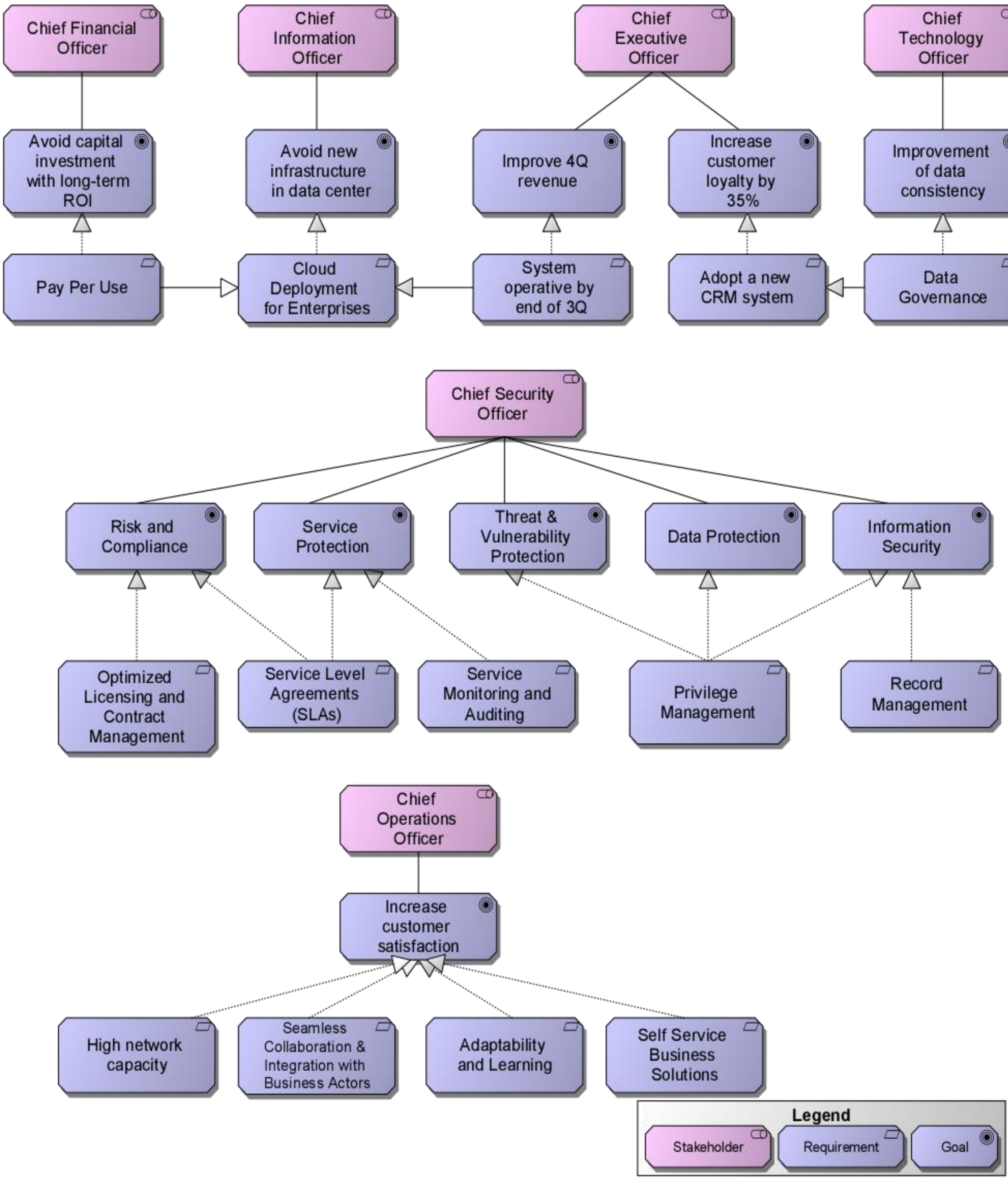


Figure 29: Motivation view for the new Cloud-based CRM of ArchiSurance.

Step: Confirm and Elaborate Business Goals, Business Drivers, and Constraints

The major business goals and drivers have already been defined from previous architecture programs of ArchiSurance. In this architecture program, the business goals and drivers are adapted to the specific Cloud initiative in order to clarify any area of ambiguity. This captures the various business, operational and technical constraints of ArchiSurance, and consequently ensures the endorsement of the corporate management.

Step: Evaluate Capabilities

Figure 30 illustrates the target business capabilities of ArchiSurance. The target capabilities support the value chain targeted to achieve business agility. If there are gaps in the Architecture Capability, iteration is required between Architecture Vision and Preliminary Phase (The Open Group, 2011).

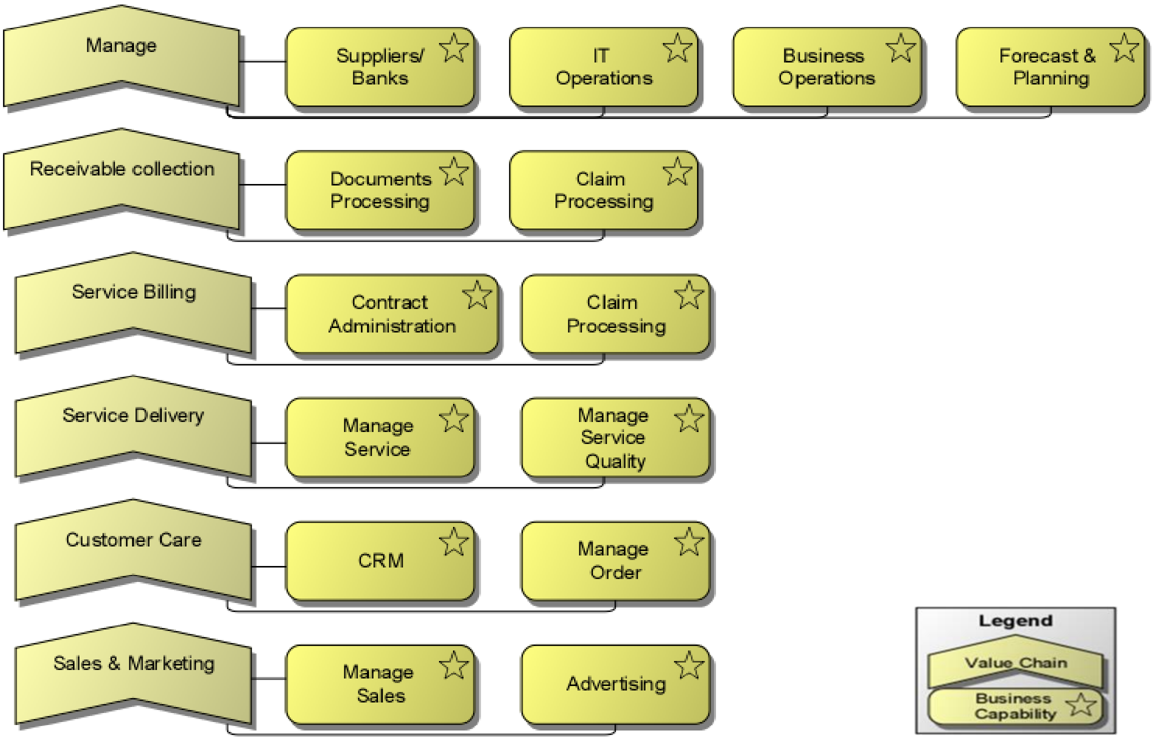


Figure 30: Target business capabilities of ArchiSurance.

Once the capabilities are defined, the possible implications for the Customer Relations Management (CRM) capability can be assessed and visualized with the stakeholder view. The CRM capability is required to support the Target Architecture Vision (Iacob et al. 2012).

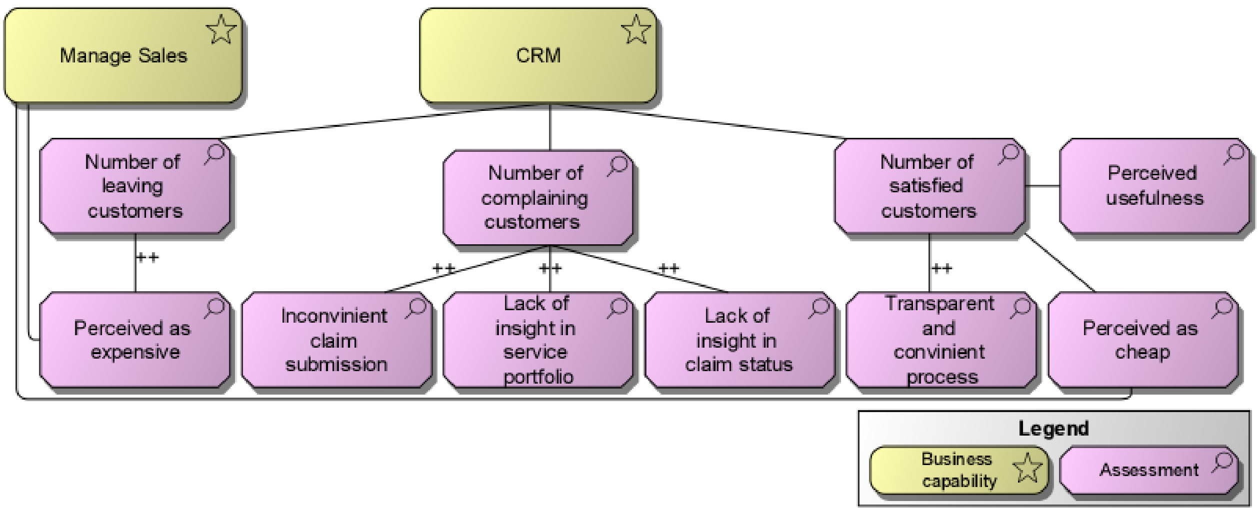


Figure 31: Capability Assessment in ArchiMate (The Open Group 2013).

The results of the assessment are documented in a Capability Assessment (see Part IV, Section 36.2.10 in TOGAF 9.1) (The Open Group, 2011).

Step: Assess Cloud Readiness Assessment for Business Transformation

Table 17 summarizes the result of the Cloud Readiness Assessment workshop to perform architecture work in Cloud Ecosystem. This table can be illustrated also with ArchiMate by highlighting the most important aspects.

Table 17: Readiness Assessment for Business Transformation (The Open Group 2013).

Assessment ID	Readiness factor	Priority (Low/Med/High)	Readiness Status (Yes/NO)	Transformation assessment (Difficulty Level: Low/Med/High)
1	Business needs	High	Yes	Low
2	Financial support	High	Yes	Low
3	Sponsorship support	High	Yes	Low
4	Business readiness	High	No	High
5	IT readiness	High	No	High
6	Operational Readiness	High	No	Med
8	Governance readiness	Med	No	High

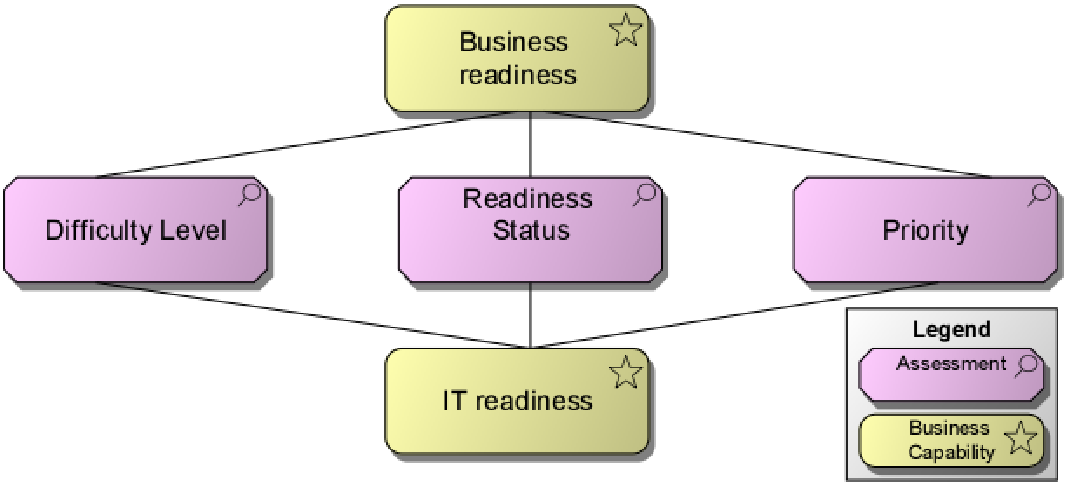


Figure 32: Readiness Factors Assessment-Illustrated with ArchiMate (The Open Group 2013).

Step: Define Scope

In this step the core architecture team of ArchiSurance decided what is inside and what is outside the scope of the Baseline and Target Architectures. The SaaS solution impacts all the architecture domains (Business, Information Systems and Technology Architectures) so the scope covers the business, information systems and technical domains. The combination of these domains will provide the strategic architecture and the way it will support the business objectives. The Cloud PMO must manage the Cloud Services Portfolio to ensure effective execution of architectural activities. The ArchiMate models resulted from previous ArchiSurance EA programs are being used to describe the Baseline Architecture of ArchiSurance and also to guide the architecture activities of this program.

Step: Confirm and Elaborate Architecture Principles, including Business Principles

The Cloud PMO of ArchiSurance confirmed the architecture principles (defined in the Preliminary Phase, Section 6.1.4) and validated that they are aligned with enterprise principles.

Step: Develop Architecture Vision

We assume that this is the first attempt of ArchiSurance to adopt Cloud-based applications. Therefore in this experimental initiative the ArchiSurance Cloud Ecosystem will include only one CSP to meet the objectives of the stakeholders. The Architecture Vision, which is one of the outputs of this phase, must respond to the requirements which are illustrated in Figure 29 (The Open Group, 2011). ArchiSurance seeks to achieve cost savings and business agility by enabling the SaaS CRM system in the architecture. Figure 33 depicts the Target Architecture vision of ArchiSurance. The Target Architecture is developed, based on the stakeholder concerns, business capability requirements, scope, constraints, and principles for the Cloud Ecosystem of ArchiSurance.

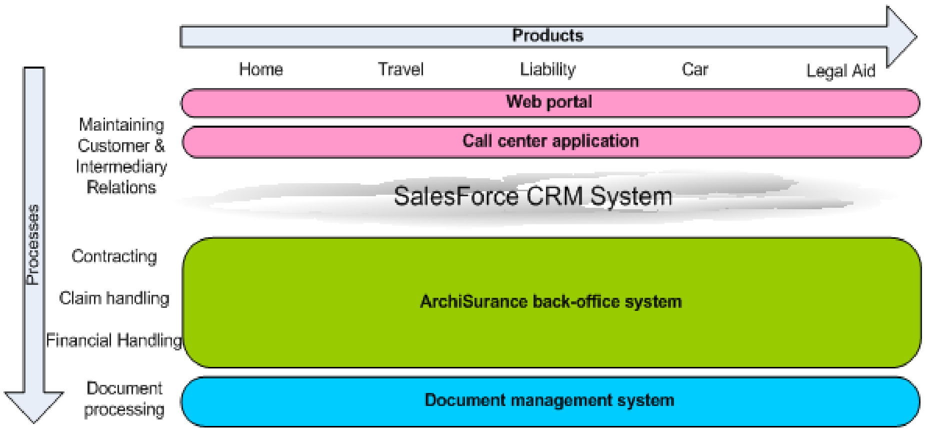


Figure 33: ArchiSurance Target Architecture Vision.

Step: Define the Target Architecture Value Propositions and KPIs

In this step important activities are taken place in order to ensure the commitment of the top management and to delineate concerns and risks about the Cloud. First the Business Case is developed to address the changes which are required due to the Cloud initiative. For a detailed description of how to develop the Business Case for using the Cloud refer to the white paper published by the Open Group "Strengthening your Business Case for using the Cloud" (Isom & Hawley, 2010). It is also necessary to assess the business risks of the architecture initiative. This can be done in the Business Case or separately.

Lastly, the KPIs are defined to measure the performance of the new solution and to meet the business needs. The Cloud-specific KPIs we defined in the context of ArchiSurance are listed below:

- ROI of the Cloud-based initiative.
- The customer fidelization will be at least 30% more than the current.
- The system must respond within 3 seconds.
- Procurement of Cloud Services will be at least 40% cheaper than the development cost.
- The operational cost of Cloud Services will be at least 35% of the current operational cost.

All the outputs of this step are incorporated in the statement of Architecture work (The Open Group, 2011).

Step: Develop Statement of Architecture Work; Secure Approval

We assume that the architects and the management of ArchiSurance have agreed on a Statement of Architecture Work for the introduction of the new Cloud-based CRM system. In this step, the deliverables which are produced in Phase A are assessed. They provide a roadmap and a communications plan for all the stakeholders (The Open Group, 2011). All the identified risks are classified and a risk mitigation strategy has been assigned to them.

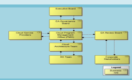
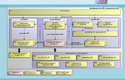
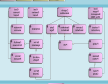
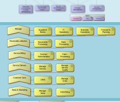
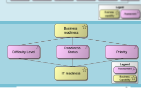
6.3 Conclusion

"Strategy Rationalization" includes all the activities and the steps from the Preliminary and the Architecture Vision Phases, in order to distil Cloud-specific capabilities from the business and IT strategies.

Preparing the organization for the new Enterprise Architecture means that the organization's model is aligned with the business goals and objectives, all stakeholders are aware and involved, and an appropriate governance structure (including roles, responsibilities and business processes) is in place. Apart from that, there must be a process to identify and document the architecture principles, constraints and requirements related to the Cloud, which must be aligned with the business mission, goals and objectives. The principles should be checked for relevance in the Cloud Ecosystem.

The principles scope the architecture effort and must be decomposed into requirements. These requirements can be met by adjusting the current business and IT capabilities in a way to enable the use of Cloud resources. In order to identify and consolidate the requirements list, a business scenario has to be created (referring only to business solution and not to architectural styles). This can help align the potential solution with the Strategic Enterprise Architecture to achieve maximum value exploitation. Lastly, management support and commitment of all stakeholders is vital for obtaining formal approval for the architecture work. Table 18 summarizes all the diagrams/viewpoints that are used for communicating, deciding and designing the Enterprise Architecture of ArchiSurance in Cloud Ecosystems. The "Impact" column indicates which diagrams have to be modified to include Cloud concerns. The impact level is measured based on the differences and required modifications between the Baseline ArchiSurance models (Jonkers et al. 2012, Iacob et al. 2012) and the Cloud Ecosystem (Target) ArchiSurance models.

Table 18: Summary of the Architecture Diagrams of the Strategy Rationalization.

Phase	Viewpoint	Diagram Name	Thumbnail	Impact (High/Medium/Low)
Preliminary	Organization Viewpoint	Roles & Responsibilities		Medium
	Principles Viewpoint	High-level Business & Architecture Principles		High
Architecture Vision	Organization Viewpoint	Established architecture governance structure		Low
	Stakeholder Viewpoint	Stakeholder Concerns		High
	Motivation Viewpoint	Business Goals Associated with Driver Profit		Medium
	Requirements Realization Viewpoint	Motivation view for the new Cloud-based CRM		High
	Architecture Vision Viewpoint	Target Business Capabilities		Medium
	Motivation Viewpoint	Capability Assessment		Low
	Motivation Viewpoint	Readiness Factor Assement		Low
	Landscape Map Viewpoint	Target Architecture Vision		Low

Chapter 7 – Cloud Enterprise Architecture Development

The outline of this chapter is the following: Section 7.1, 7.2 and 7.3 explain TOGAF for Cloud Ecosystems approach to cope with the Business Architecture Phase, Information Systems Architecture Phase and the Technology Architecture Phase respectively. All Phases are demonstrated in the context of ArchiSurance case with the use of ArchiMate modeling language. Lastly Section 7.4 gives the conclusions of this chapter.

7.1 Phase B – Business Architecture

Section 7.1 suggests a Cloud-enabled approach for the Business Architecture Phase of ADM, by suggesting guidelines and deliverables which are necessary to develop an enterprise Cloud Ecosystem. The TOGAF for Cloud Ecosystems approach adapts systematically the Architecture Development Method (ADM) of TOGAF in the ArchiSurance case study.

7.1.1 Approach

TOGAF ADM is a business driven approach, where the actual design process begins with the Business Architecture. The Target Business Architecture guides the architecture work in any other domain (Information Systems, Technology) by defining the business strategy, functions, processes, information, organization's structure, governance as well as the interactions and relationships between these concepts (Iacob et al. 2012). In that way, the organization identifies how to deliver business value to its customers. This architectural layer describes also the business value of the Cloud Ecosystem and the Return On Investment (ROI) to key stakeholders (The Open Group, 2011).

These concepts (business strategy, functions, processes, information, organization's structure, governance as well as the interactions and relationships between them) might have been defined in a wider business strategy or enterprise planning activity that has its own lifecycle within the enterprise. In such a case the business strategy and plans need to be verified and updated to include the Cloud Ecosystem concerns. Otherwise the architecture team must define these concepts in Phase A or in a free-standing exercise. In both cases the business scenario (TOGAF v9.1, Part III, Chapter 26) is a suitable technique to identify key business and technical requirements for the Enterprise Architecture (The Open Group, 2011).

In Cloud Ecosystems the business services are provided from both internal and external organizational units and that extends the established business structures. These business services are realized by different Cloud service models, which must be consistent with the Cloud-enabled business capabilities. The external Cloud services impact the business processes and that requires efficient IT management. Lifecycle management of Cloud services requires constant check to ensure business objectives are met with efficient business risk management.

7.1.2 Guidelines

The Cloud services should be related with the business objectives (which are included in the business strategy) to enable efficient IT management and achieve business agility. This can be done by focusing in the following aspects:

1. Transform business and IT functions by adopting Cloud services as part of the enterprise strategy.
2. Establish effective Cloud services management to assess the impact on existing business processes.

3. Transform the existing business processes by enabling business process redesign which utilizes new capabilities to create optimal business solutions to achieve target objectives.
4. Manage the extended Cloud environment (external CSPs) by assessing business capabilities and realizing new organizational roles (e.g., Cloud Service Broker, Cloud Strategist) that the Cloud Ecosystem requires.
5. Ensure that business requirements are effectively addressed into the Target Business Architecture.

Apart from the description of the business processes, roles, actors and collaborations the Business Architecture must illustrate the relationships between the Cloud services with the respective deployment models. The business-focused approach of the TOGAF ADM will be used to ensure that the organization's business objectives of the Cloud Ecosystem support all stakeholders.

In order to develop relevant architectural viewpoints to describe how stakeholder concerns are addressed, we will use value stream mapping and describe the relationships between the key business participants. In addition, we should identify key business metrics to ensure the viability of cloud solutions. Once key participants for the Cloud Ecosystem are identified, a Functional Decomposition diagram and a Business Footprint diagram will be used to describe and capture their inter-relationships.

7.1.3 Deliverables

Fully fledged Business Architecture provides the recommended deliverables as well as the extended business boundaries, roles, products and services of the Cloud. The following deliverables are essential to capture the aforementioned concepts:

Table 19: Suggested deliverables of the Business Architecture Phase.

Business Architecture Outputs (The Open Group 2011)	**Supporting ArchiMate Viewpoints (Iacob et al. 2012)**
-Refined and updated version of the Statement of Architecture work	Actor collaboration viewpoint
-Draft Architecture Definition Document, including: Target Business Architecture	Business function viewpoint, Business product viewpoint, Functional decomposition diagram, Function support map, Business process viewpoint, Business Architecture viewpoint, Business footprint diagram

7.1.4 Phase B in ArchiSurance

Step: Select Reference Models, Viewpoints and Develop Target Business Architecture Description

In this subsection the main reference models and viewpoints are identified and used to develop the Target Business Architecture. The Baseline Architecture is already developed in the previous ArchiSurance case (Jonkers et al. 2012, Iacob et al. 2012). It is expected that some deliverables of the Target Business Architecture will remain the same while others will be significantly impacted.

Figure 6 is used as a reference model to determine viewpoints and functional activities, within ArchiSurance. First of all, the actor collaboration viewpoint shows the environment of ArchiSurance consisting of various external parties such as Cloud Service Broker, Cloud Service Provider, end-users (i.e.

business users, operations users, customers) and others. With this viewpoint it is determined the external dependencies and collaborations between the business actors of ArchiSurance (Iacob et al. 2012).

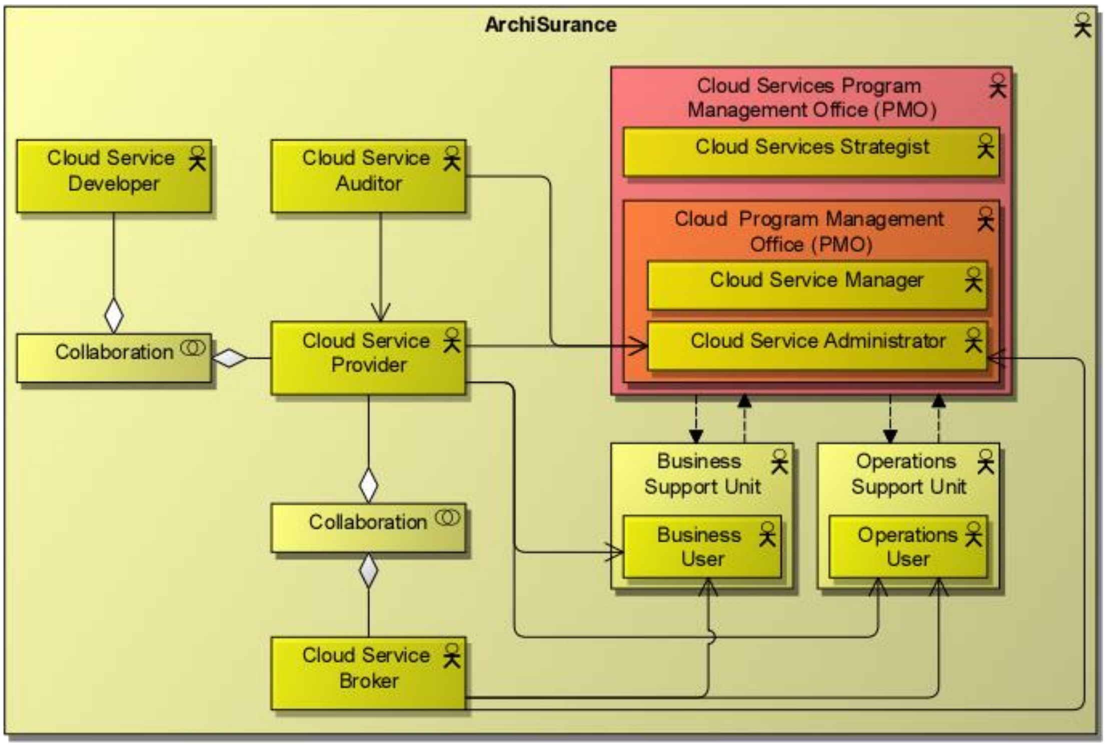


Figure 34: Actor Collaboration Viewpoint (Based on the Open Group 2013).

The business communication viewpoint illustrates the main business functions and the flow of information between them. The Inter-Cloud connection service bridges the Cloud services consumers and providers with the core functions of ArchiSurance.

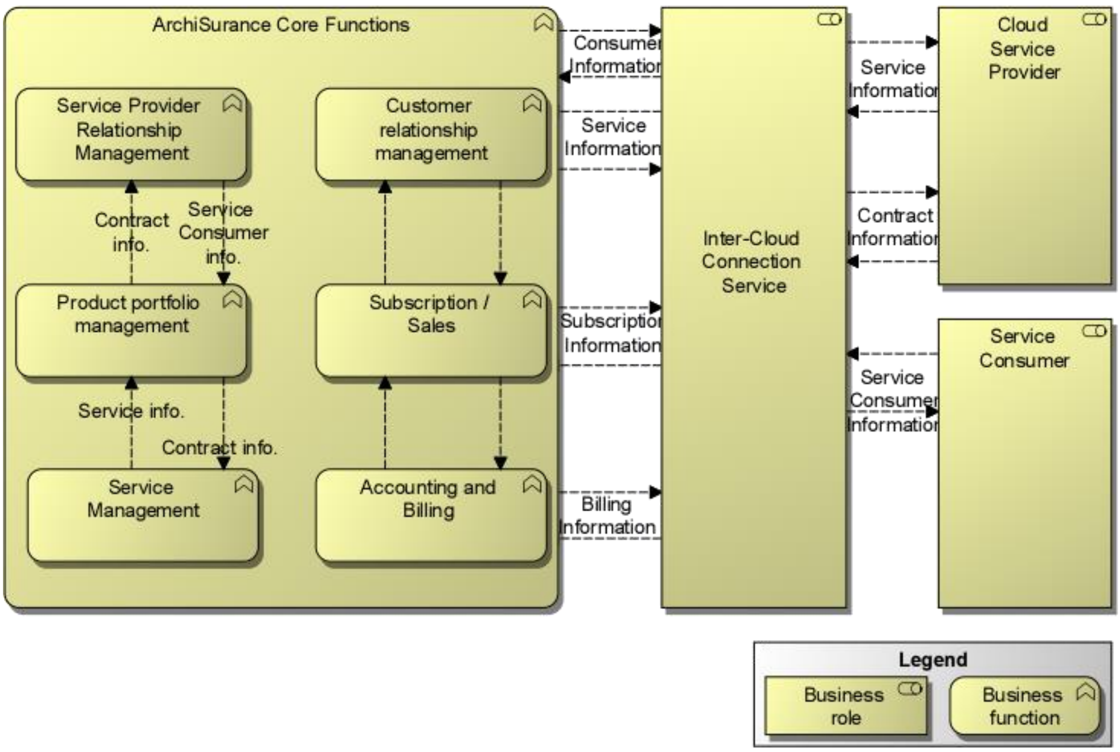


Figure 35: Business Communication Viewpoint of ArchiSurance.

Overall, these two viewpoints demonstrate the interconnection between the different entities and the information flow within ArchiSurance. They also provide a high-level description of the structure of ArchiSurance based on the main operations and activities of the organization. After that, the business support services are captured from the business product view which shows the characteristics of the product that ArchiSurance offers to its customers.

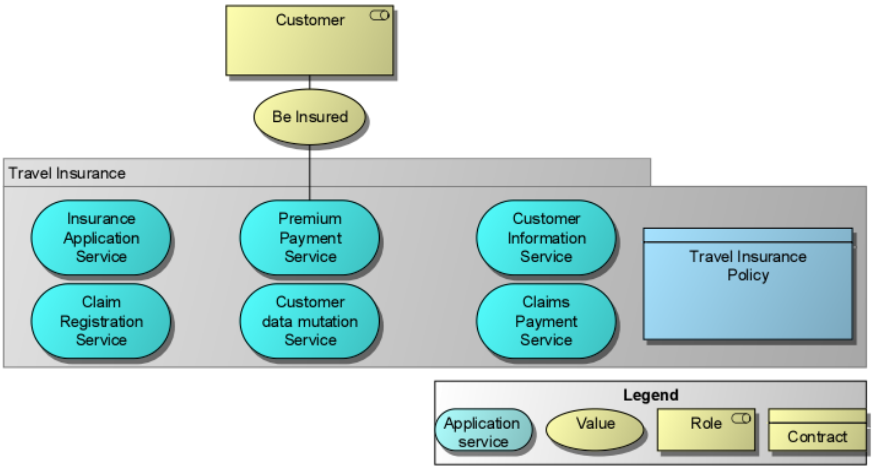


Figure 36: Business Product Viewpoint (Iacob et al. 2012).

The business functions will be associated with KPIs in order to measure the achievement of strategic objectives from the business support services. Various business functional capabilities are captured from the functional decomposition diagram.

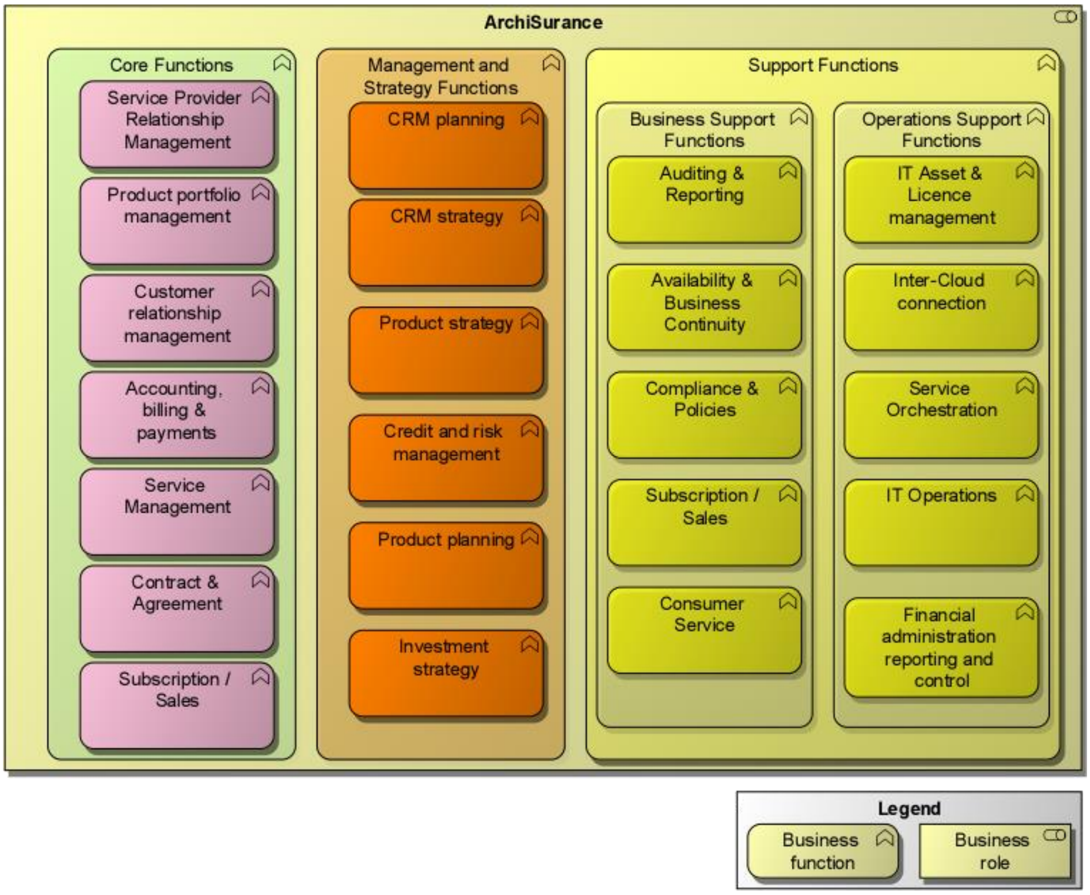


Figure 37: Functional Decomposition Diagram.

Following the business functions are mapped with the business processes to translate business objectives into operations. The function support map, maps business processes with the respective business functions.

Figure 38: Function Support Map (Iacob et al. 2012).

These high level business processes can be decomposed into lower level processes and also they can be associated with the corresponding business functions. Below it is depicted which business processes, functions and objects are necessary in order to realize the business service *"Customer information service".*

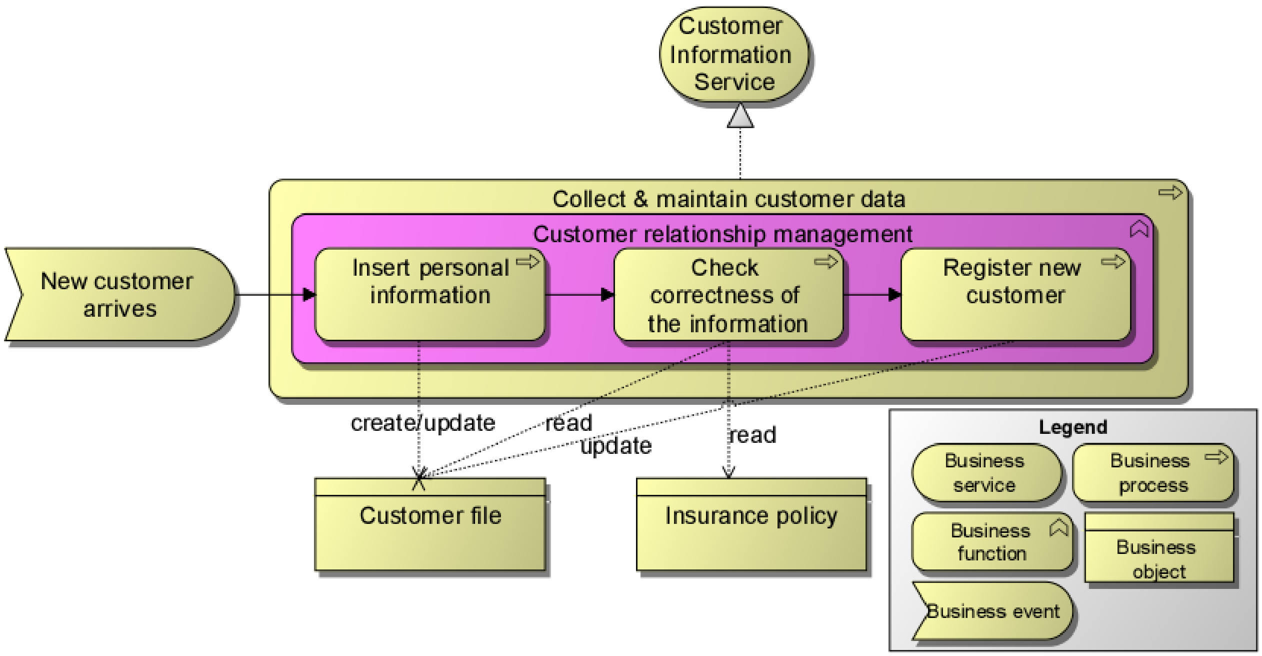


Figure 39: Business Functions Related with Processes.

An important principle of the Target Architecture is to minimize human involvement in order to reduce costs. Figure 40, illustrates the relation of the Business Architecture with business goals, principles and requirements.

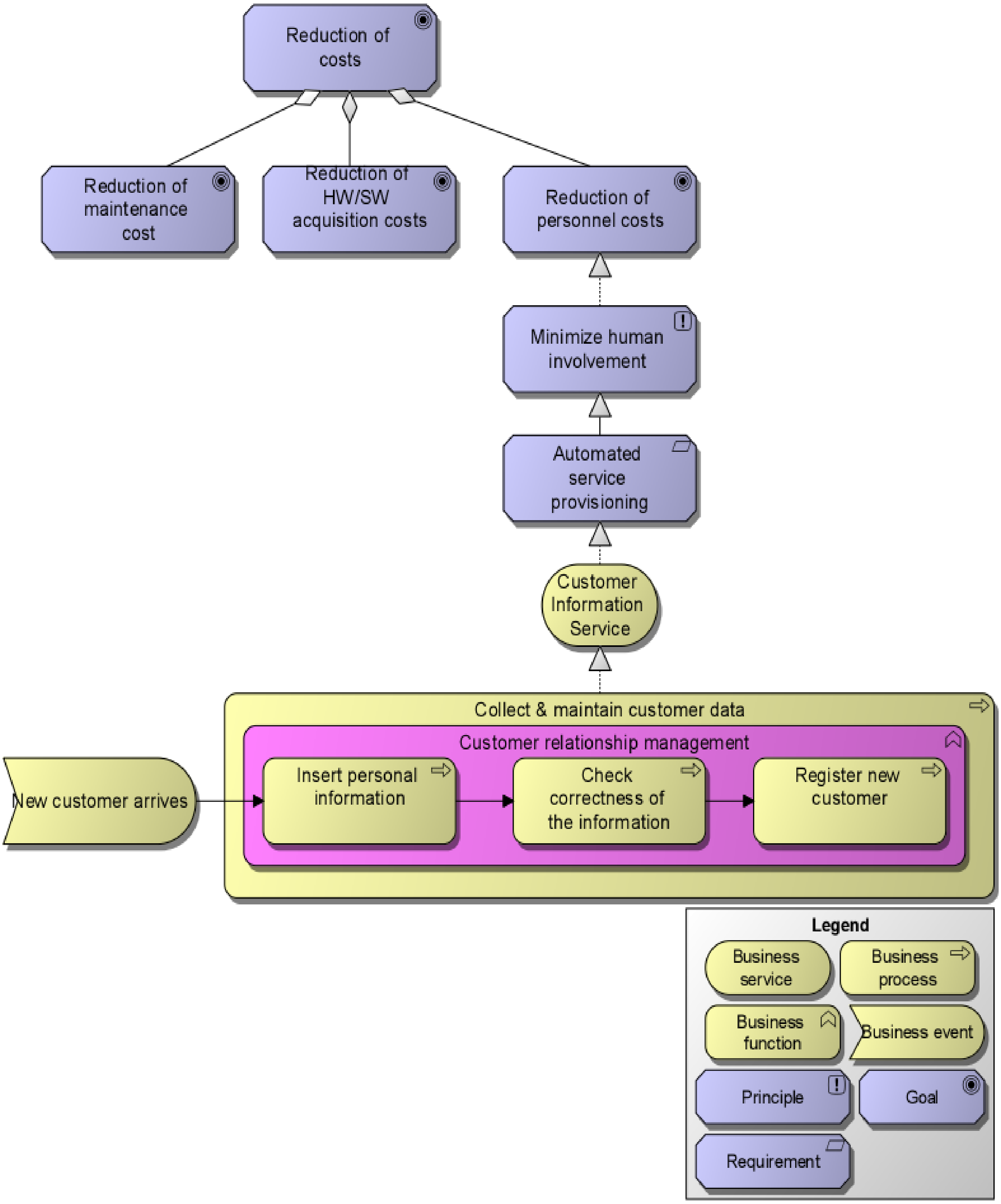


Figure 40: Relating Business Goals and Requirements to Business Architecture.

A similar diagram with Figure 40 is the business footprint diagram which explicates the relationships between the business goals, principles and requirements and how these functions are mapped to services provided by the CSP.

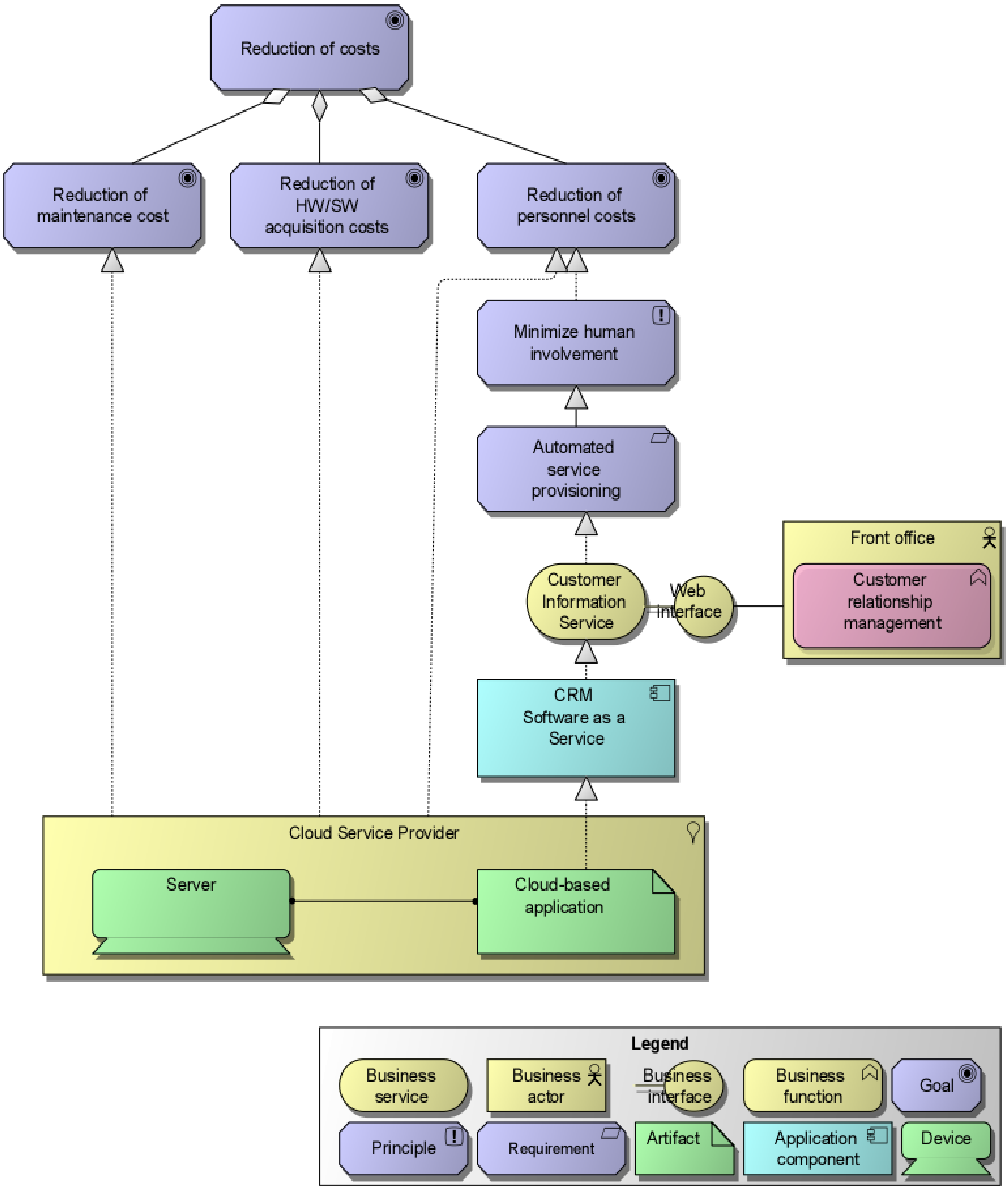


Figure 41: Business Footprint Diagram.

Step: Performa Gap Analysis

In the scenario of CRM system migration to the Cloud the biggest part of the Business Architecture will remain unchanged. The product of ArchiSurance is the same as before together with the business services and processes which are necessary to realize the insurance product. However it is needed to add business and operational support functions to manage the extended Cloud Ecosystem. The biggest difference between the Baseline and the Target Business Architecture is that the CRM capability would be realized by Cloud-based solution. Below they are given some general points that should be taken into account for the gap analysis in all architecture domains (Business, Information Systems and Technology Architectures):

- Verify the architecture models of the organization and its CSPs to ensure consistency and accuracy.
- Perform trade-off analysis to resolve conflicts among the different views.
- Validate that the architecture and models support the principles, objectives, and constraints of the enterprise.
- Test architecture models for completeness.
- Identify gaps between the Baseline and Target Architecture.

Step: Resolve Impacts across the Architecture Landscape
It is necessary to understand the wider impacts and implications from existing internal architecture work and services provided by external CSPs (The Open Group, 2011). Identify any services that could be leveraged from CSPs in Cloud Ecosystem of ArchiSurance. Envision the impact of Cloud Services provided by CSPs and developed internally on the Cloud Ecosystem.

Also, in order to effectively engage external CSPs, ArchiSurance must negotiate SLAs (e.g., price, liability, and service support and termination agreements) to ensure that its business and technical requirements and risks are fairly balanced with CSPs.

Step: Conduct Formal Stakeholder Review
Check the original motivation for the enterprise Cloud Ecosystem and the Statement of Architecture Work against the proposed Business Architecture, asking if it is fit for the purpose of supporting subsequent work in the other architecture domains. Adjustments should be made in order to ensure that the proposed Business Architecture support all stakeholders concerns (The Open Group, 2011).

Step: Create Architecture Definition Document
Finally, the Architecture Definition Document is created in order to get a buy-in from all stakeholders. The Architecture Definition Document describes the relation with people, locations and key business functions. It also captures the ArchiSurance Cloud Ecosystem rules, standards and guidelines which are enforced from the management of the organization (The Open Group, 2011).

7.2 Phase C – Information Systems Architecture
Section 7.2 suggests a Cloud-enabled approach for the Information Systems Architecture Phase of ADM, by suggesting guidelines and deliverables which are necessary to develop an enterprise Cloud Ecosystem. The TOGAF for Cloud Ecosystems approach adapts systematically the Architecture Development Method (ADM) of TOGAF in the ArchiSurance case study.

7.2.1 Approach
The objective of Phase C is to develop the Target Architectures for the Application and Data Architectures. The Information Systems Architecture specifies the relationships and dependencies between the Data and Application domains (and between these domains with the Business and Technology domains). The EA Architecture Team, based on the principles, will define the approach (application-driven or data-driven approach) which will guide the architecture work and also which architecture (Application or Data) to develop first (Iacob et al. 2012). However, in most of the cases, the Application and Data Architectures start the same day and evolve in parallel.

Table 20: Application Architecture or Data Architecture first.

Approach	Principle	Develop first
Application-driven approach	Key applications form the core underpinning of mission-critical business processes	Application Architecture
Data-driven approach	Data represents the corporate assets	Data Architecture

Adopting major Cloud-based applications (e.g., CRM system), provides to the host organization a combination of business application logic and technology infrastructure replacement. In that case the organizations should follow an application-driven approach whereby the key application(s) to support the mission-critical business processes are identified. As you can imagine the biggest emphasis is given to the implementation and integration of these applications and data (The Open Group 2011).

The Enterprise Information Model[1] (EIM) facilitates unified access across all types of enterprise data, consistently applies applicable business rules, and accelerates Cloud Services development. The EIM for a Cloud Ecosystem will facilitate a common understanding of the corporate structured and unstructured data and will serve as a basis for the Target Data Architecture. Data quality should be well defined and captured in the metadata for all data assets of an enterprise. These metadata attributes will dictate what technology constraints (e.g., caching, partitioning, and failover), service qualities (e.g., availability, performance, scalability), and service delivery concepts (e.g., DaaS) will be used within an enterprise Cloud Ecosystem. Data quality also drives the service levels requirements of Cloud Services (The Open Group 2013).

The information security service ABB (From Cloud Security Services in Figure 6) defines and manages the requisite security classifications, compartments, and legislative constraints on the use of the information within an enterprise Cloud Ecosystem. It is also critical to use the metadata to define access policies to support granular data access for individual, role-based, and governance-based security access controls.

7.2.2 Guidelines

Fully-fledged Information Systems Architecture requires a comprehensive assessment to organization's information. Effective use of data will enable the organization to capitalize on its competitive advantage. This can be achieved by following the guidelines below:

1. Establish a structured and comprehensive data management approach. The enterprise's Cloud requirements will guide the data migration process. Data governance ensures data quality by utilizing system of record for enterprise data. In that way enterprise-wide data definition is established.
2. Utilize data caching techniques for the Cloud Ecosystem Data Architecture to improve data availability, performance and scalability.
3. Ensure that the Cloud-based solutions are fault tolerant and data consistent. In case of failure the Data Architecture might need to accommodate new assumptions that data consistency is generally sacrificed over data availability and requires an enabling mechanism (e.g., data partitioning) to relay/expose consistent data via cloud solutions.

[1] Enterprise Information Model is a representation of concepts and the relationships, constraints, rules, and operations to specify data semantics for a chosen domain of discourse. It can provide sharable, stable, and organized structure of information requirements or knowledge for the domain context.

4. A Cloud Ecosystem that utilizes different Cloud instances requires data partitioning to expose consistent data via Cloud solutions.
5. Provide flexible data integration mechanism and ensure that data in the Cloud is appropriately shared and maintained.
6. Address big data and social networking data by utilizing semantic techniques to convey the intent of data during information exchange. Treat data as information assets associated with appropriate categorization, quality, and their potential use in Cloud Ecosystem. Data categorization shall integrate disparate data across extended enterprise boundaries of the organization to serve as common business objectives and make them securely available as information assets rapidly and efficiently.

Even though the core Entity Relationship model of the Cloud application matches its original on-premise enterprise application counterpart, multi tenancy aspect will impact the Logical Data Model and Data Security View. Determine Data and privacy classification and prioritize the risk criteria of what goes in the Cloud and what stays on-premise (Thorn 2010).

The Application Architecture provides an overview of the organization's applications, the relationships between them and the business goals and processes that they support (Iacob et al. 2012). In order to assess the impact of the new application portfolio to the business processes and technical infrastructure, utilize the appropriate views. If the business processes are impacted the corresponding views must be redesigned and the workflow must be adjusted to adhere to the new situation. The supported services will be the base to identify functional and non-functional requirements for the new SaaS solution. Address also the impact of the Cloud-based solution to the applications' interfaces.

7.2.3 Deliverables

The deliverables which are listed below are essential to capture the aforementioned aspects. The present research focuses only on the deliverables which can be modeled with the use of ArchiMate. Consequently, the deliverables which are created with other techniques or notations are not presented in the ArchiSurance case study. The Information Systems Architecture Phase outputs may include the following but are not restricted to:

Table 21: Suggested deliverables of the Information Systems Architecture Phase.

Application Architecture Outputs (The Open Group 2011)	**Supporting ArchiMate Viewpoints (Iacob et al. 2012)**
-Draft Architecture Definition document, including: Target Application Architecture	System use case diagram, Application usage viewpoint, Application cooperation viewpoint, Application and user location diagram, Total views (Application Architecture viewpoint, Layered viewpoint)
Data Architecture Outputs (The Open Group 2011)	
- Draft Architecture Definition document, including: Target Data Architecture	Data dissemination diagram, Total view (Non-Functional requirements viewpoint)

7.2.4 Phase C in ArchiSurance – Application Architecture

Step: Develop Baseline and Target Application Architecture, Perform Gap Analysis and Define Candidate Roadmap Components

The System Use Case diagram (based on UML Use Case Diagram) provides a detailed functional design of the CRM application by identifying the use cases of the new system.

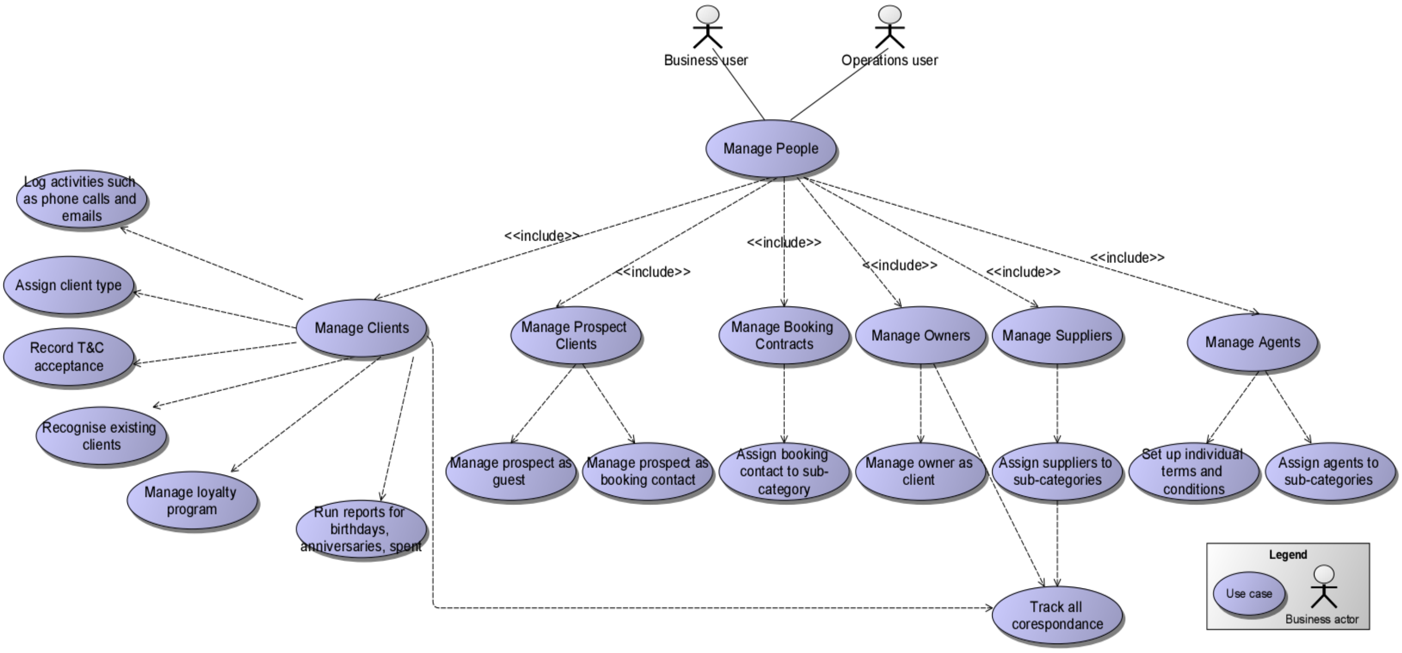


Figure 42: CRM System Use Case Diagram.

In the CRM migration scenario the business model and processes remain the same with the previous EA program (Jonkers et al 2012). For example the old CRM supports the Handle Claim process by providing Customer Administration Service and Printing Service. The supported services form the base to identify functional and non-functional requirements for the new SaaS solution. The application usage view provides an overview of the relationships between the Business and Application Architectures. The services, relations and applications which are impacted from the Cloud migration are marked with red.

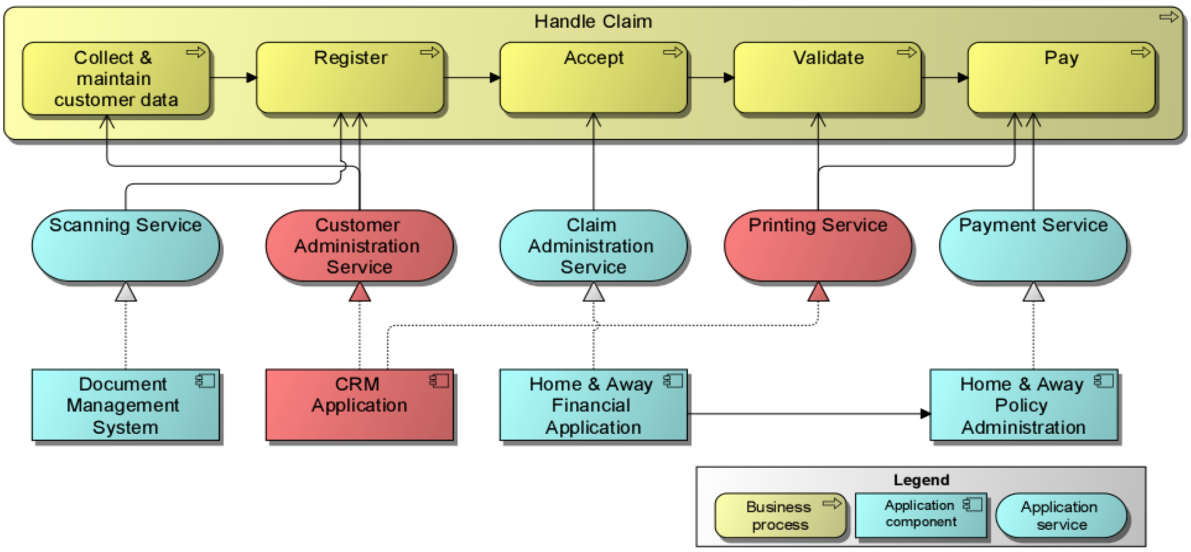


Figure 43: Application/Process Support – Impacted Applications and Services.

The new SaaS solution must meet all functional requirements and also the interface requirements with other applications. The application cooperation view (Figure 44) shows the Baseline and Target application portfolio of ArchiSurance. The role of the CRM system remains the same, but changes are expected in the interfaces (the data exchanged and the protocol which enables the exchange) with other applications (i.e. Customer Data Access and Policy Data Management). The application cooperation view is a useful model to identify the applications and interfaces that need to be redesigned and/or recoded. The application and user location diagram (Figure 45) is modeled to define the physical distribution of users and applications of ArchiSurance.

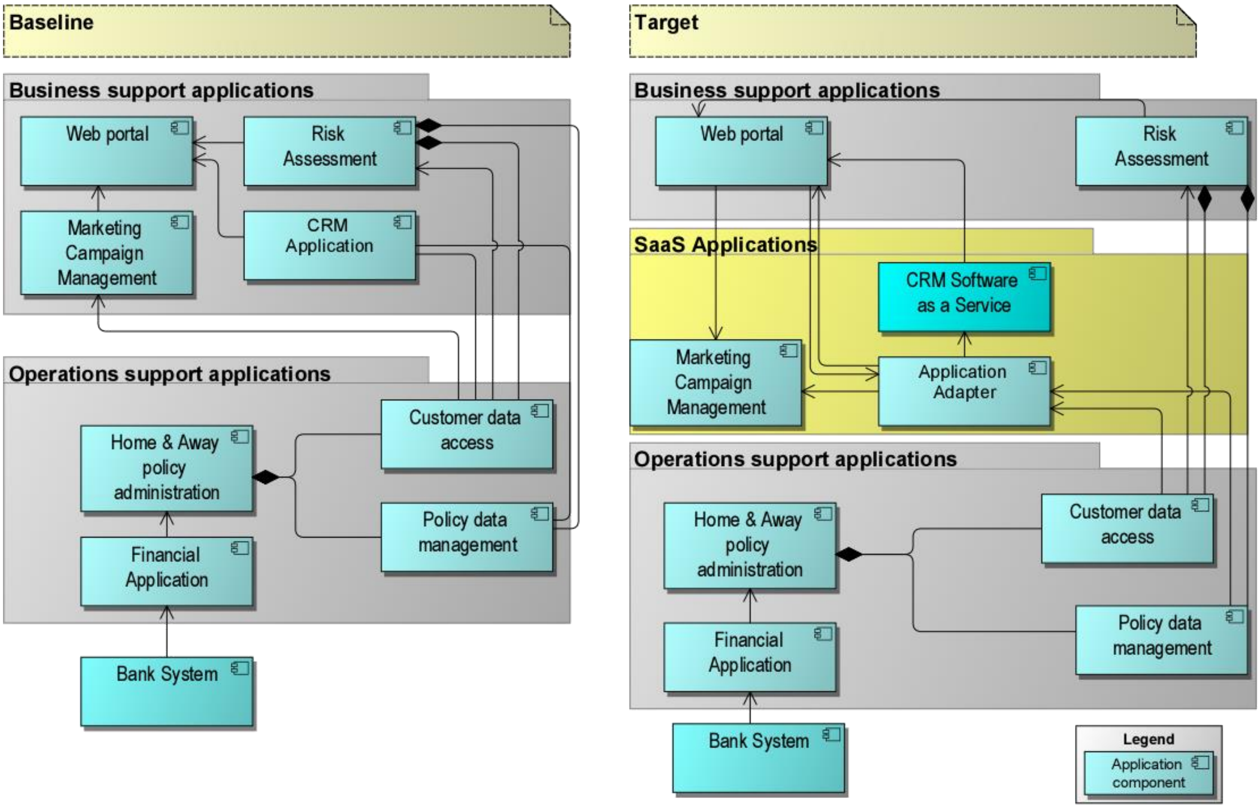


Figure 44: Application Cooperation View (Baseline & Target).

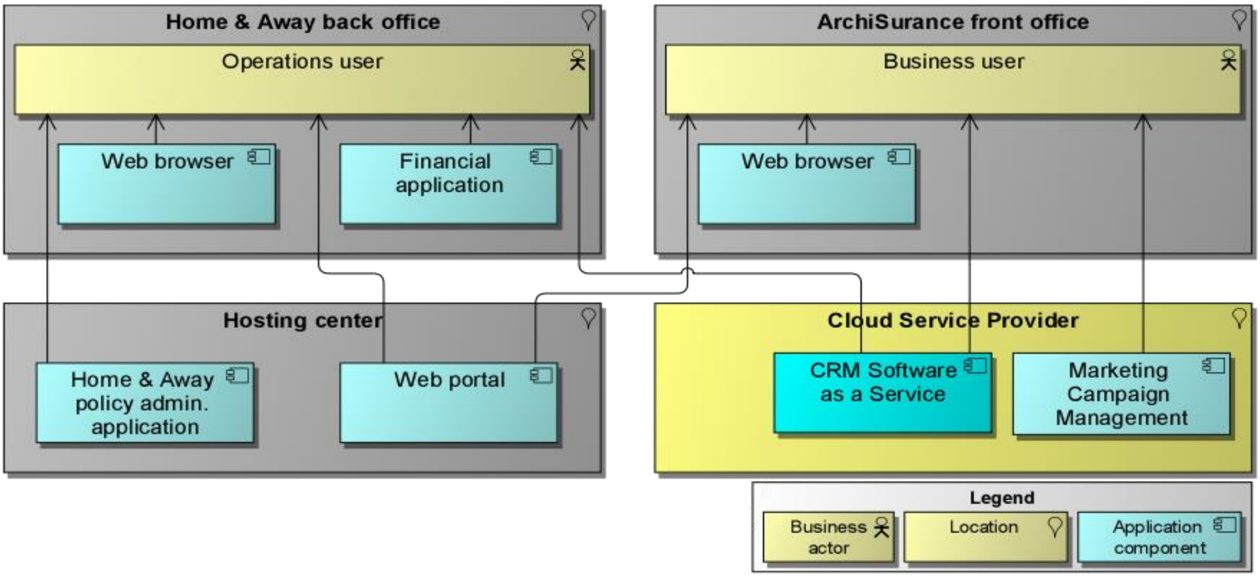


Figure 45: Application and User Location Diagram (Target).

Based on Figures 43-45, we can redesign the application model by making explicit the application interfaces and technical components which enable them. The SaaS solution requires an Enterprise Service Bus (ESB) technical component which enables Web Services interfaces to the company data. Non-functional requirements such as security are addressed by using a secure ESB and a secure FTP service toward the enterprise data warehouse.

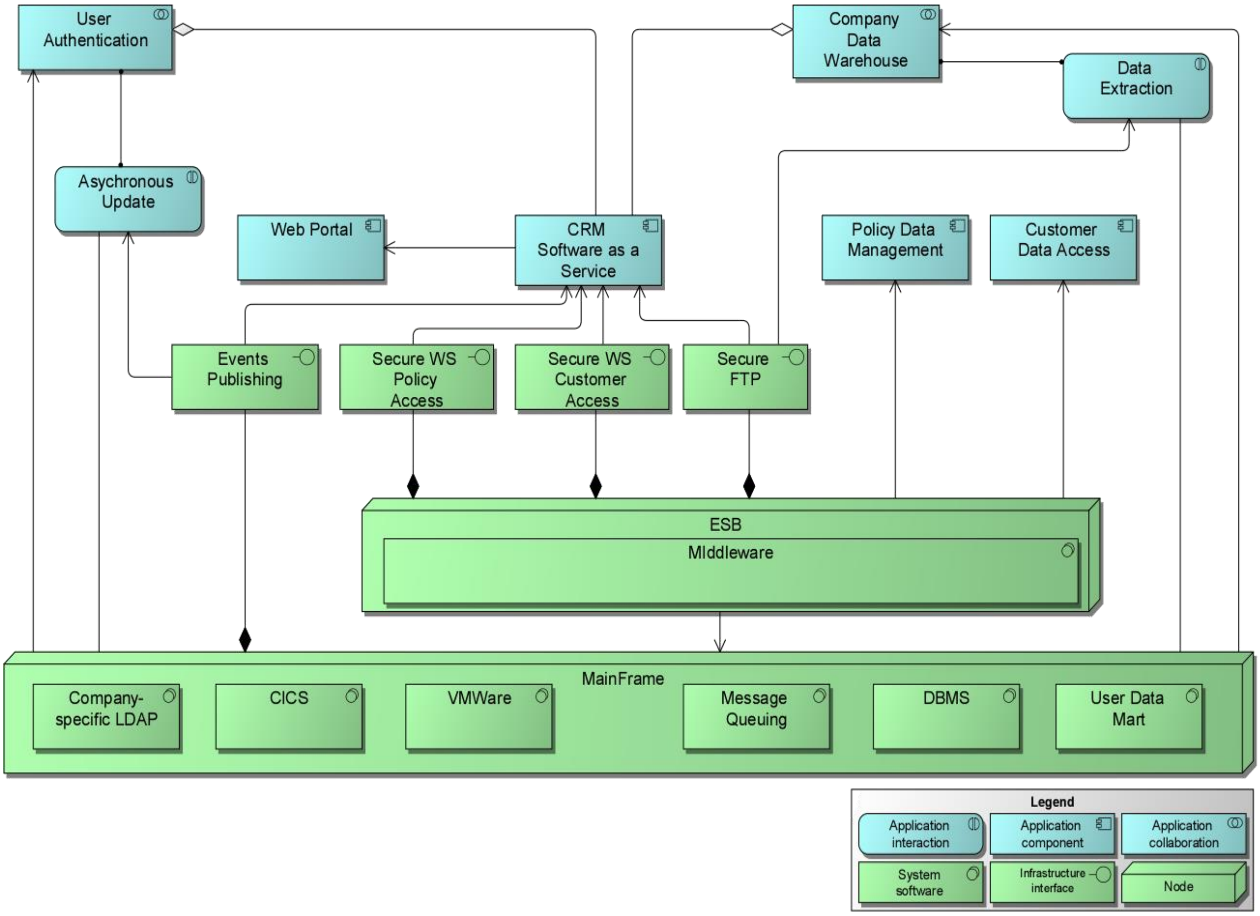


Figure 46: Application Model (Target).

The interface of the web portal requires a simple HTTP redirect and the user can logon to the system with a single username and password schema. Consequently the back-office and front office employees can access the internal systems and the Cloud-based CRM with a single pair of username and password.

The other important interface is between the LDAP (ArchiMate system software component) and the authentication mechanism (ArchiMate application collaboration component) which are used by the new CRM application. The CRM system cooperates (push LDAP updates, as CRM events) with the LDAP authentication and provides the new user authentication. The same goes for the CRM and the data mart cooperation to provide the new data warehouse function. The new application model will guide the design of the changes, needed to accommodate the new SaaS service with the existing on-premises infrastructure.

The Cloud-based CRM makes use of the Infrastructure Services of ArchiSurance (a platform for the thin client and an internet connection). The layered view below shows how the application service is deployed in ArchiSurance. The Business Objects that are accessed from the business process are not represented at the application layer because they exist in the Cloud and not in the ArchiSurance premises (Wierda, 2012).

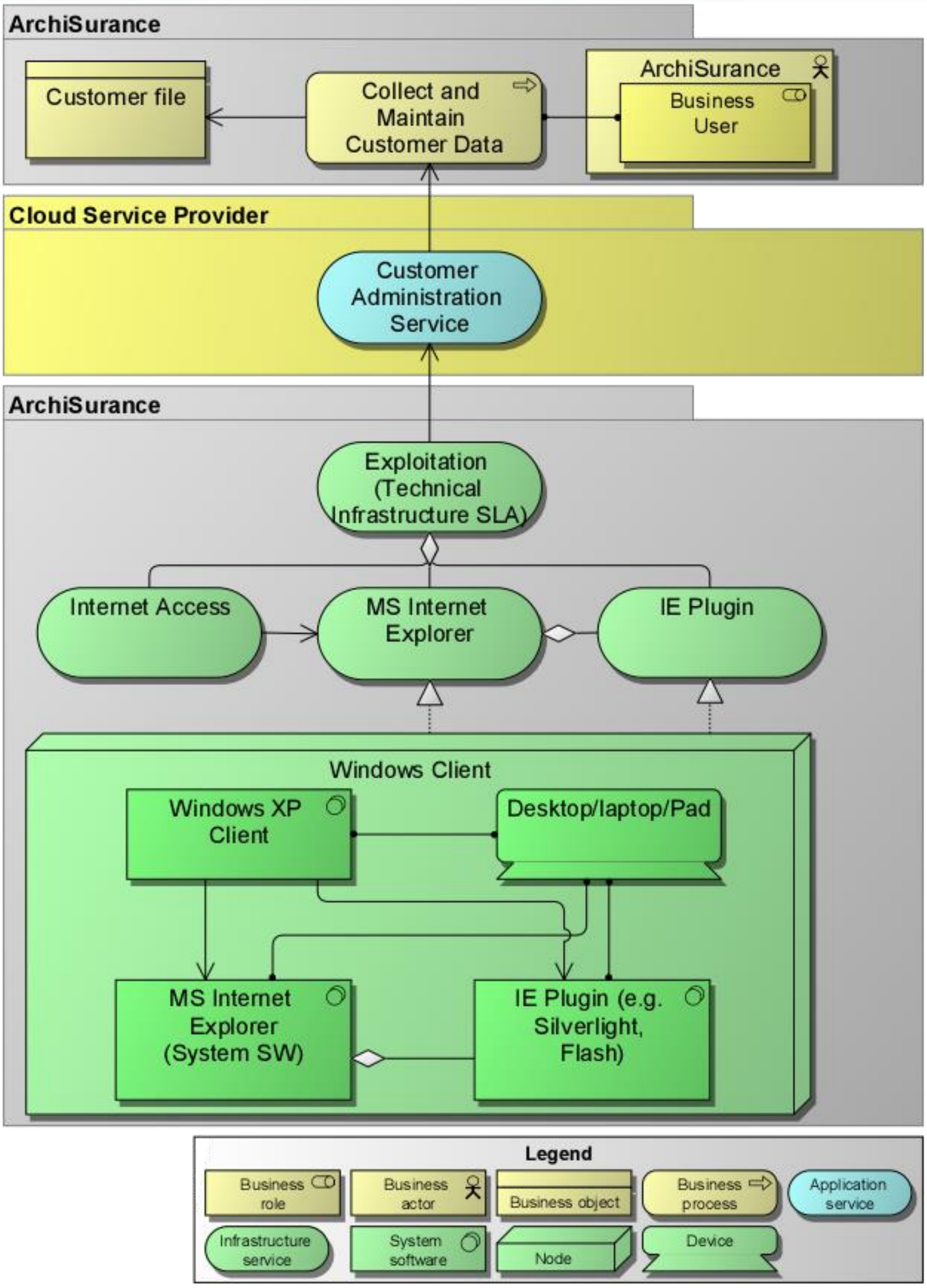


Figure 47: Layered View of ArchiSurance – Version 1.

7.2.5 Phase C in ArchiSurance - Data Architecture

The Data Architecture describes the Cloud services strategy to address the distributed nature of ArchiSurance data resources. The Cloud-based CRM handles social networking data and real time data with semantic techniques to convey the intent of data during information exchange. The Data Architecture of ArchiSurance provides a flexible data integration mechanism to enable effective sharing and maintenance of data. Then the enterprise data are treated as information assets associated with quality potential use and categorization. The data categorization will help to integrate disparate data across organization’s boundaries by making them securely available as information assets.

Step: Select Reference Models and Viewpoints

The Cloud Ecosystem Reference Model (Figure 6) can be used to determine the appropriate viewpoints for the stakeholders' concerns and functional activities of ArchiSurance. The Data Architecture requires a consolidated view of semantically consistent data inventory to resolve any possible overlaps and gaps in data relationships. The data used within and across business processes of ArchiSurance must be cataloged as the basis for further documentation. Conceptual data models are used to document data taxonomies in order to create consistent views and describe how data is created, distributed, migrated, secured, and archived in the enterprise Cloud Ecosystem of ArchiSurance.

Step: Develop Baseline and Target Data Architecture by Addressing Non-Function Requirements

The Baseline Data Architecture comes from the previous ArchiSurance cases (Jonkers et al. 2012). The Baseline Data Architecture includes cross-reference information entities to promote consistency, reuse and avoid redundancy. The Target Data Architecture must address the structural and operational changes for the Cloud Ecosystem. It is also necessary to incorporate the non-functional data requirements (e.g., volume of data, data availability, tolerance threshold on data loss, data security measuring criteria) in the target state and translate them in SLAs.

The data dissemination diagram shows the relationships between data entities, business services, and application components by depicting how the logical entities are to be physically realized by application components. By assigning business value to data the business-critical application components can be estimated. The customer file data and the customer file in the target state reside in the premises of the CSP.

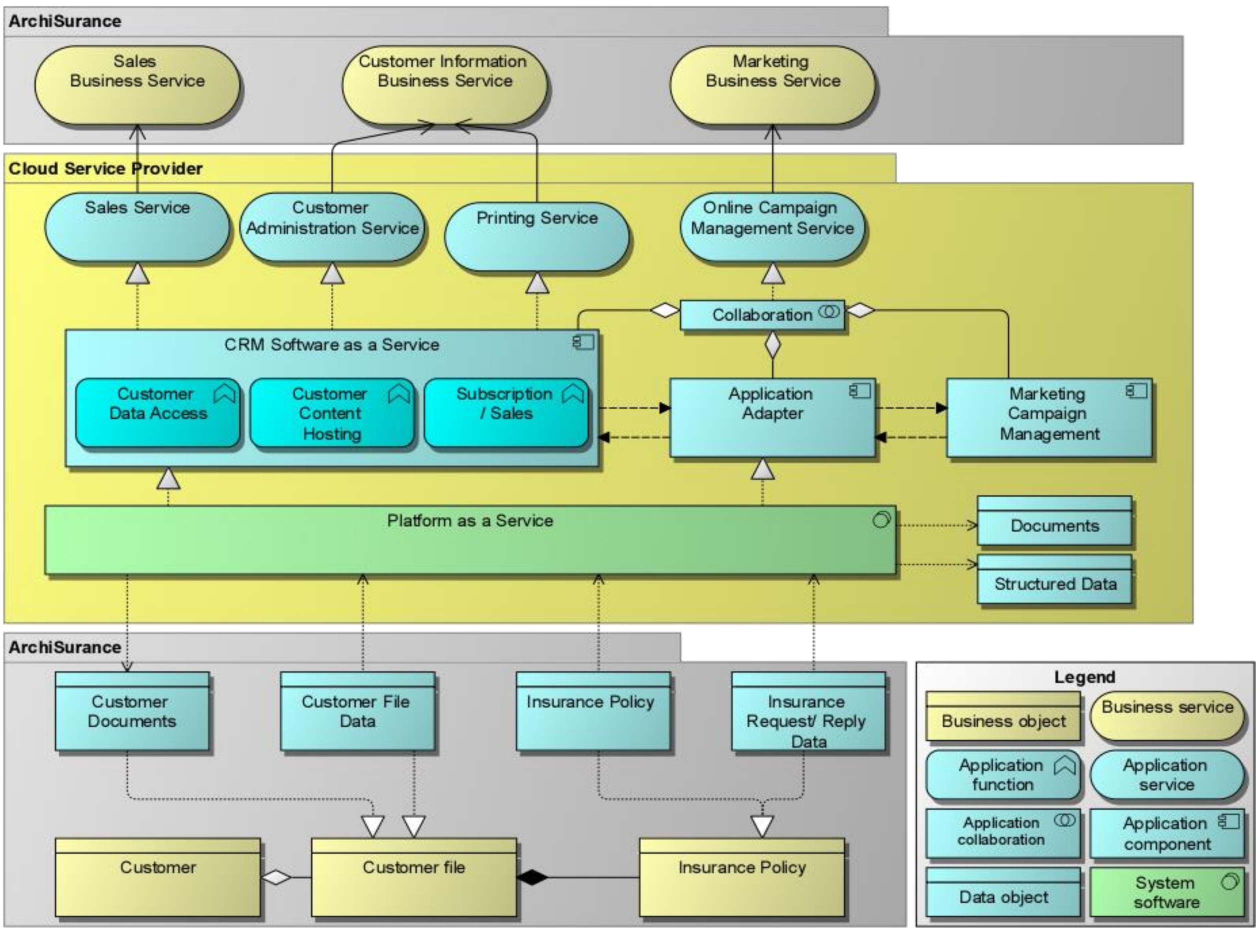


Figure 48: Data Dissemination Diagram.

The Data Architecture must assume failures of any component (infrastructure, platform, software components) in order to provide effective Cloud-based business solutions. The important data requirements of the Cloud solution are listed in Figure 49.

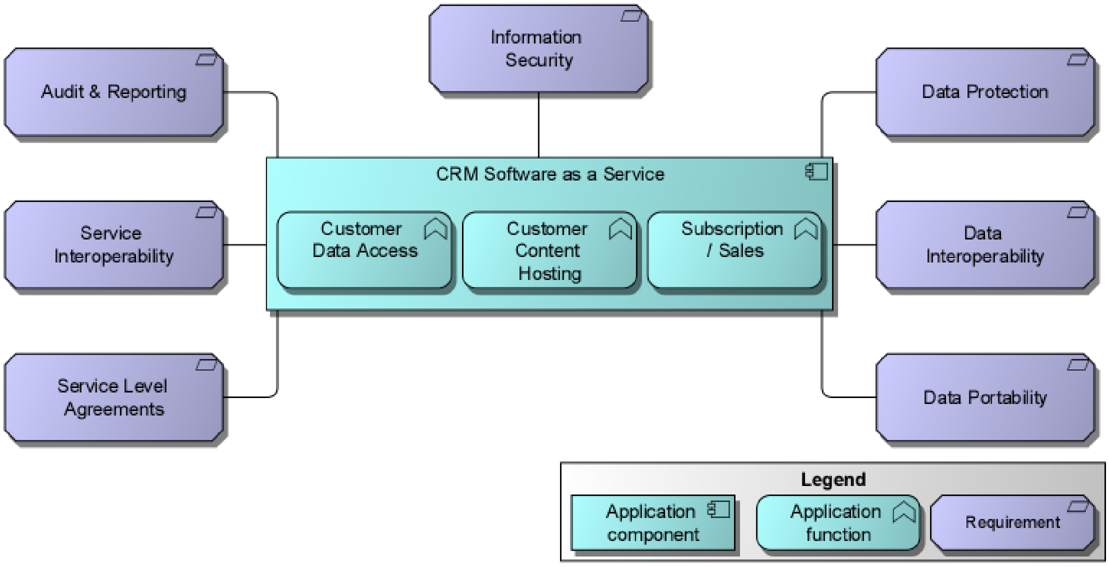


Figure 49: CRM SaaS and Data Requirements of ArchiSurance.

7.3 Phase D – Technology Architecture

Section 7.3 suggests a Cloud-enabled approach for the Technology Architecture Phase of ADM, by suggesting guidelines and deliverables which are necessary to develop an enterprise Cloud Ecosystem. The TOGAF for Cloud Ecosystems approach adapts systematically the Architecture Development Method (ADM) of TOGAF in the ArchiSurance case study.

7.3.1 Approach

The goal of Phase D is to develop the Target Technology Architecture which is vital to realize the data components, the logical and physical applications and the Architecture Vision. The Architecture Roadmap is identified based upon the gaps between the Baseline and Target Technology Architecture (The Open Group, 2011).

A Cloud Ecosystem provides modular sets of technology services that enable the Information Systems services. An organization which desires flexible and adaptable Technology Architecture will have to align the short and long term business objectives with a modular set of Cloud-based services. After considering the stakeholders' concerns this modular set of services will enable functionality of explicit capabilities which aim to address the gaps between the Baseline and Target Architecture. The stakeholders' requirements may be translated to demand for new technical services. In such a case the underlying technology building blocks and the relevant technical considerations are incorporated in the Technology Architecture. The stakeholders' concerns related to the technology layer can be illustrated with architectural viewpoints for non-functional requirements.

The next step is to perform trade-off analyses to determine whether these capabilities are to be built within the enterprise or utilize CSPs services. The analyses identify, evaluate and address the impact on the Enterprise Architecture from technology services which are modified, eliminated or introduced.

7.3.2 Guidelines

The following guidelines should be consulted during the development of the Baseline and Target Technology Architecture:

1. Assess the interactions and relationships between the technology capabilities and the Information Systems ABB.
2. Determine overall technology architecture approach and identify any Cloud specific technology resources required for Cloud Ecosystem (i.e. Cloud Product/Technology' Metrics to highlight relationships to be used for technology assessment).
3. Devise the appropriate technology views to capture the interactions and relationships of architectural capabilities in order to enable multi-tenant environments. The applicable views of environments (e.g., deployment, test, production) outline physical deployment locations (i.e. public, private, virtual private, hybrid, and community) in the context of the Cloud Ecosystem.
4. The technology capabilities reveal the technology need of the organization in order to realize a particular Cloud service model. However there are implications regarding the utilization of inter-service communications over various network boundaries. In addition the technology deployment model inadequately supports the non-functional requirements of the Cloud Ecosystem. In general the non-functional requirements are described and measured by Service Level Agreements (SLAs) which define measurements for services performance, availability, maintainability, and supportability aspects of Cloud services. In subsection 7.3.4, the appropriate viewpoints are devised to depict the non-functional requirements related with the technology layer.
5. Consider Architectural capabilities to support essential Cloud characteristics (e.g., resource pooling, rapid elasticity, measured services etcetera) and handle their impact on architecture by providing technology management capabilities that allow self-service administration within a context of participants of the enterprise Cloud Ecosystem.
6. Non-functional aspects of the Cloud Ecosystem that must be addressed:
    a. Security: The security implications result from the utilization of Cloud-based solutions, which must be captured from the Technology Architecture. Different levels of security controls are required to support variations of Cloud deployment models and impact on the workload processing and network/communication capabilities of enterprise Cloud Ecosystem.
    b. Interoperability & Portability: Data portability and service interoperability are recurring issues in Cloud Ecosystems. The Technology Architecture addresses these issues in order to achieve highly available services and effective communication between multiple Cloud instances. Standardized information exchange mechanisms will effectively allow Cloud service consumers to utilize multiple CSPs and efficient migration of data and services of Cloud Ecosystem when required.

The Technology Architecture reveals the technology services strategy to address technical services requirements. It is also identified the logical and physical technical aspects of IaaS, PaaS, SaaS capabilities which support the business objectives. Then it is possible to realize Cloud-based SBBs in the later phases of ADM and to redefine the solution architecture. A comprehensive assessment of the Baseline Technology Architecture will identify the technology gaps.

7.3.3 Deliverables

The deliverables which are listed below are essential to capture the aforementioned aspects. The present research focuses only on the deliverables which can be modeled with the use of ArchiMate. Consequently, the deliverables which are created with other techniques or notations are not presented in the ArchiSurance case study. The Technology Architecture Phase outputs may include the following but are not restricted to:

Table 22: Suggested deliverables of the Technology Architecture Phase.

Technology Architecture Outputs (The Open Group 2011)	Supporting ArchiMate Viewpoints (Iacob et al. 2012)
-Draft Architecture Definition document, including: Target Technology Architecture	Infrastructure viewpoint, Environments and locations diagram, Platform decomposition diagram, Total views (Application usage viewpoint, Layered viewpoint, Strategic technical architecture)

7.3.4 Phase D in ArchiSurance

Step: Select Reference Models, Viewpoints

In this Phase it is necessary to review and validate the technology principles. The technology principles form a part of the architecture principles with alignment to enterprise principles that include Cloud-specific principles. Ubiquitous access and self-service administration are the main guidelines to define and apply the technology principles. In that way the characteristics of the Cloud Ecosystem are included in the technology services.

Following the principles can be decomposed into requirements for tools and techniques that support IaaS, PaaS and SaaS instances. These technical requirements are used to define what viewpoints will be used to depict the stakeholder concerns in the Technology Architecture.

Step: Develop Baseline and Target Architecture by Addressing Non-Functional Requirements

In the previous ArchiSurance cases (Jonkers et al. 2012, Iacob et al. 2012) the activities concerned application portfolio rationalization, CRM systems and back office integration. Figure 50 depicts the resulting Technology Architecture from the previous ArchiSurance case (Jonkers et al. 2012, Iacob et al. 2012) which will be used as the Baseline Technology Architecture of the current case.

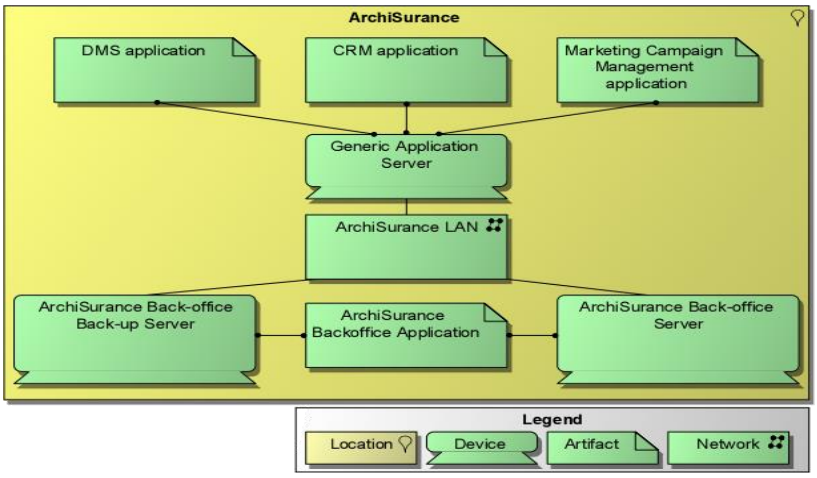


Figure 50: Baseline Technology Architecture (Iacob et al. 2012).

A gap analysis is useful to align business and IT objectives of Cloud Ecosystem and validates that architecture models adhere to established principles and guidelines to support expected technology consistency and accuracy. There must be a mechanism to close the identified Technology Architecture gaps by creating effective Target Technology Architecture. There must be also in place effective data governance policies and compliance procedures for the Cloud Ecosystem of ArchiSurance. The rest of the subsection refers to the ArchiMate models which form the Target Technology Architecture of ArchiSurance.

First the environments and location diagram (Figure 51) depicts the decomposition of the thin and fat clients their location (i.e. on-premise and outsourced) and the way they communicate together via the ArchiSurance Local Area Network (LAN).

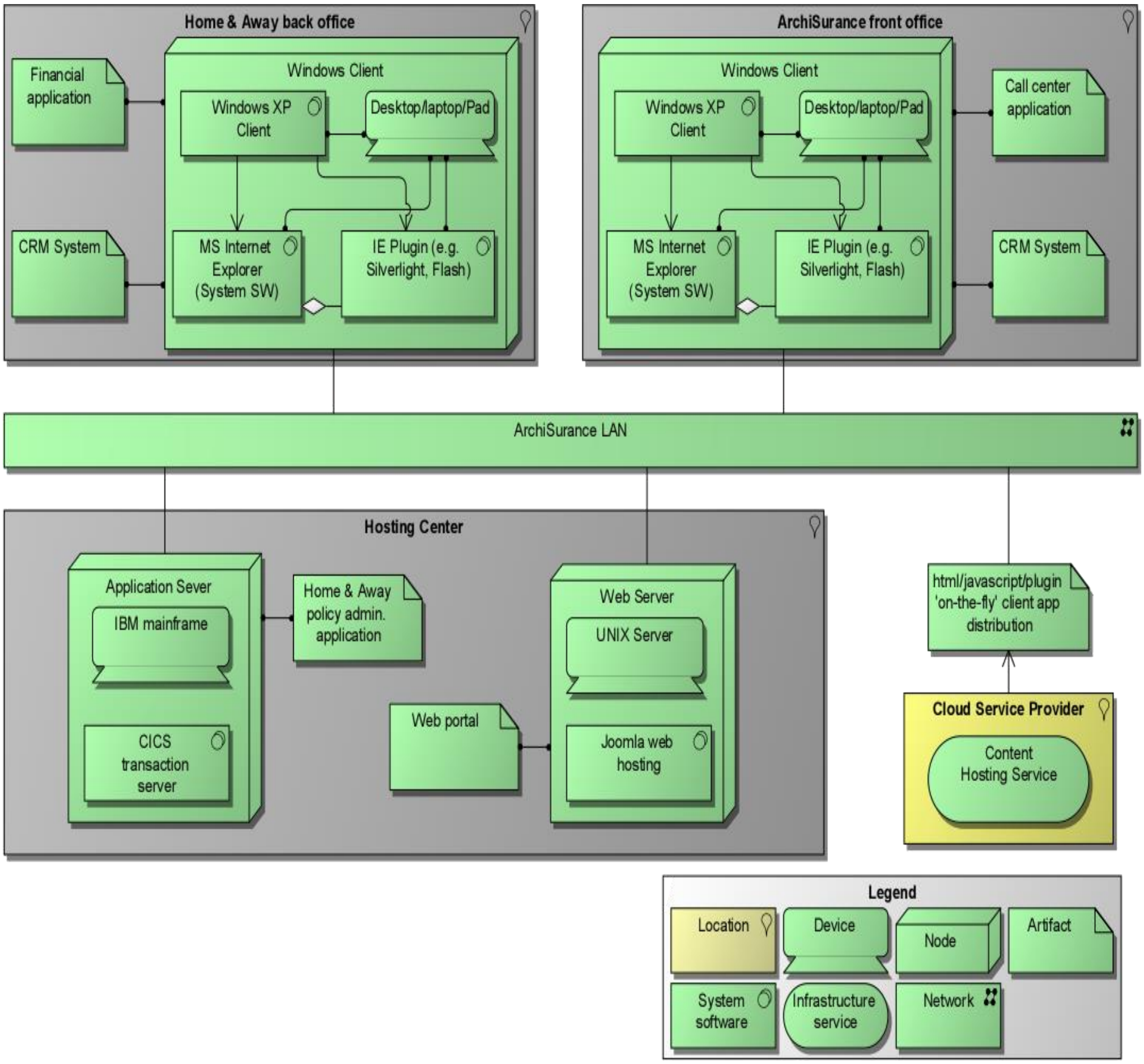


Figure 51: Environments and Locations Diagram.

The platform decomposition diagram is used to describe the internal structure of the hardware platform of ArchiSurance and the CSP. This diagram also shows the infrastructure services that the platform offers to the Application Architecture and also the software that realizes these services. The infrastructure of the CSP is abstracted because it is out of the scope of the current architecture work.

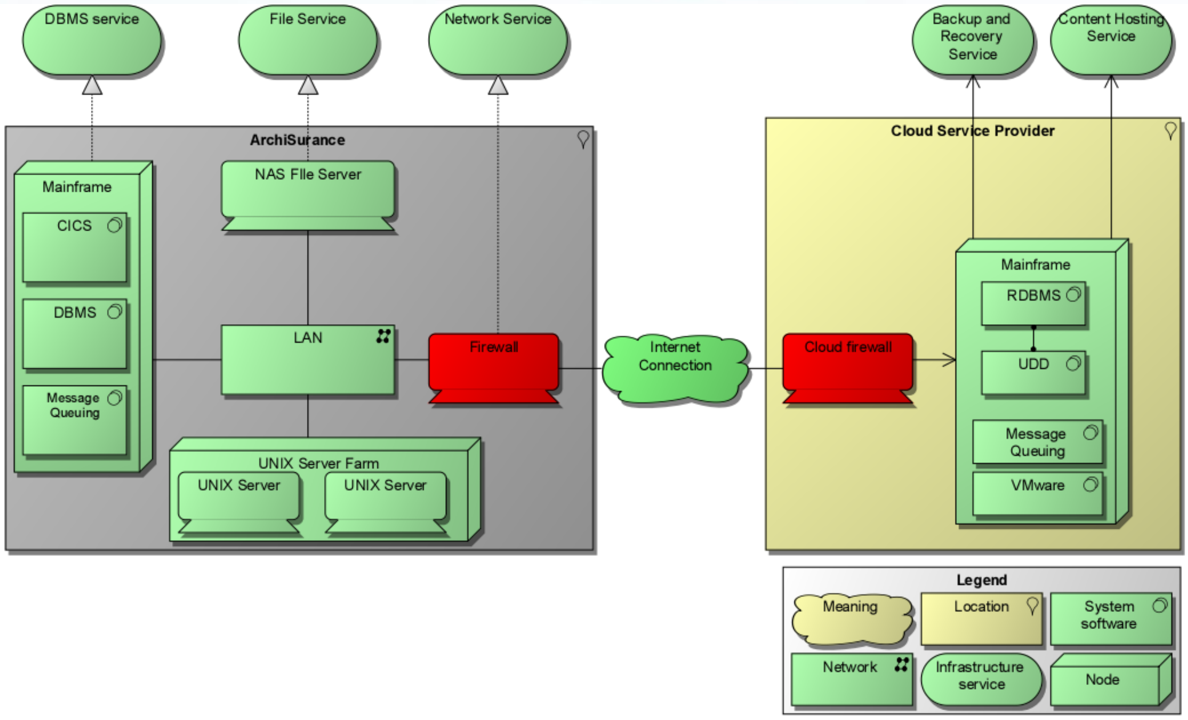


Figure 52: Platform Decomposition Diagram.

The Information Systems Architecture makes use of the services offered by the Technology Architecture. That means the software and data components are mapped to the technical components. The application usage view in Figure 53 shows the technical infrastructure components required to realize the CRM application.

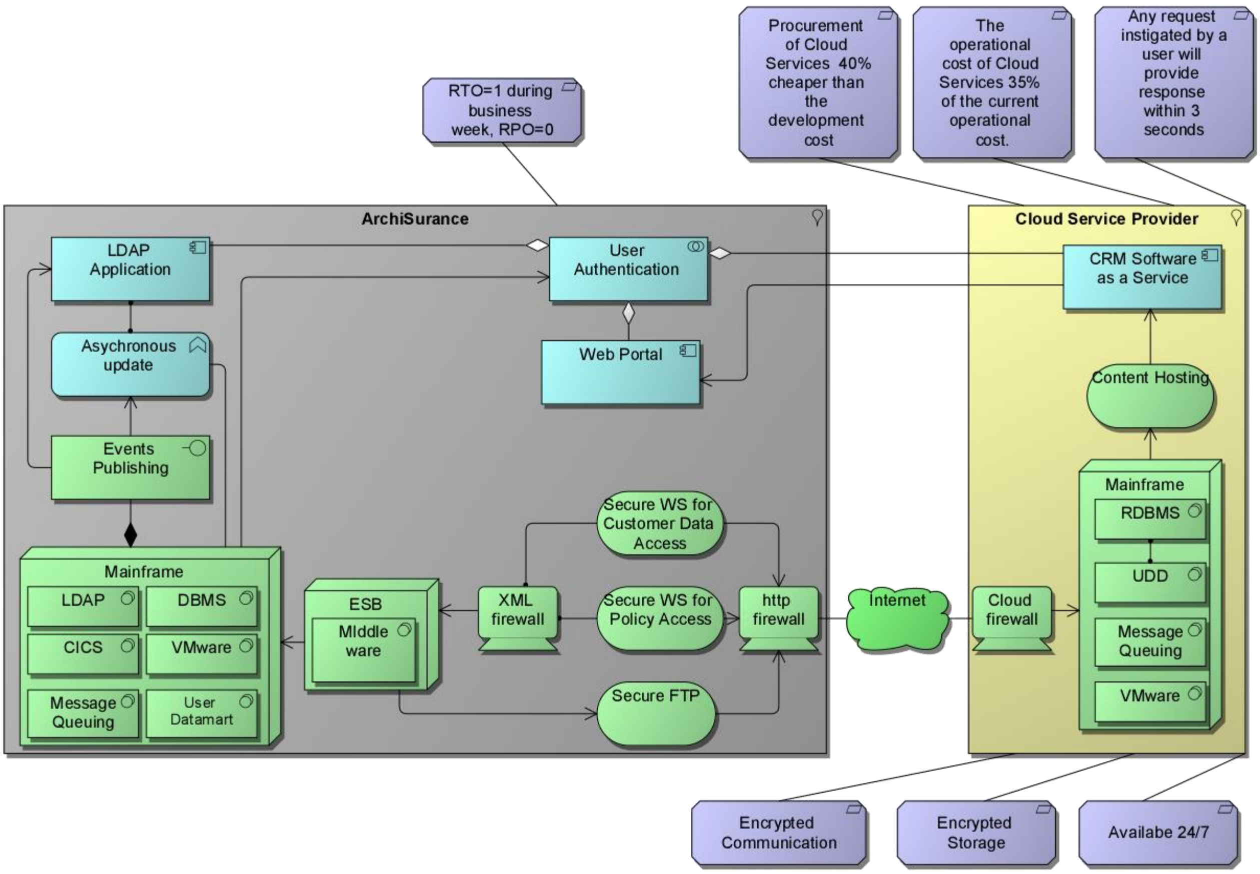


Figure 53: Application Usage View – Revisited.

The Application Usage view can be extended to include the Non-Functional Requirements (NFRs) that the SaaS solutions must be able to support. It shows also how the two systems are connected and the impact on the NFRs of the on-premises infrastructure. The NFRs are concerning mainly security and availability and they originate from the stakeholders and business needs. Some other NFRs form complex combinations (e.g., response time with large number of concurrent users) between the services, and that must be addressed before adopting the new Cloud-based CRM system.

Same with the previous viewpoints the CSP’s infrastructure is considered as a black box because it is out of the scope of the current architecture work. However the architecture team must consider the XML firewall that secures the ArchiSurance ESB and the HTTP/FTP firewall must be configured to take into account the new data flows between the ArchiSurance and the CSP.

In Figure 54 the CSP uses the ArchiSurance infrastructure to deploy the Cloud-based CRM. The internet browser is used as platform for a thin client to access the software. The browser-based application is created on the fly from the technical artifact (html/javascript/plugin 'on-the-fly' client app distribution) sent by the web server. So, in the Cloud CRM deployment, the CSP provides the server and the “presentation” application on-the-fly (Javascript) while ArchiSurance provides the platform that that application needs to run. Figure 54 also shows that the business logic runs remotely and the browser (presentation layer) is used to access the CRM system. Therefore the application component (CRM system) is the presentation layer and the application function (Customer Content Hosting) is the business logic (Wierda, 2012).

The Layered View (Figure 54) depicts several layers of the Enterprise Architecture in one view. The underlying idea is that each layer exposes a layer of services (realization relationship) which are “used by” the very next layer (Iacob et al. 2012). There is a distinction between the on-premises and off-premises infrastructure. The CSP is providing IaaS, PaaS and SaaS while ArchiSurance provides internet connection and the browser. The different applications are collaborating together via the “Application Adapter” and in that way the application services (online campaign management, printing, sales and customer administration services) can communicate together.

Lastly, Figure 55 depicts the dependencies between the ArchiSurance system software, applications, infrastructure services and functions and the SaaS CRM. The focus is on the integration of the SaaS CRM with the ArchiSurance infrastructure. These last two figures provide an overview of the Cloud Enterprise Architecture of ArchiSurance by combining all the architecture layers into one viewpoint.

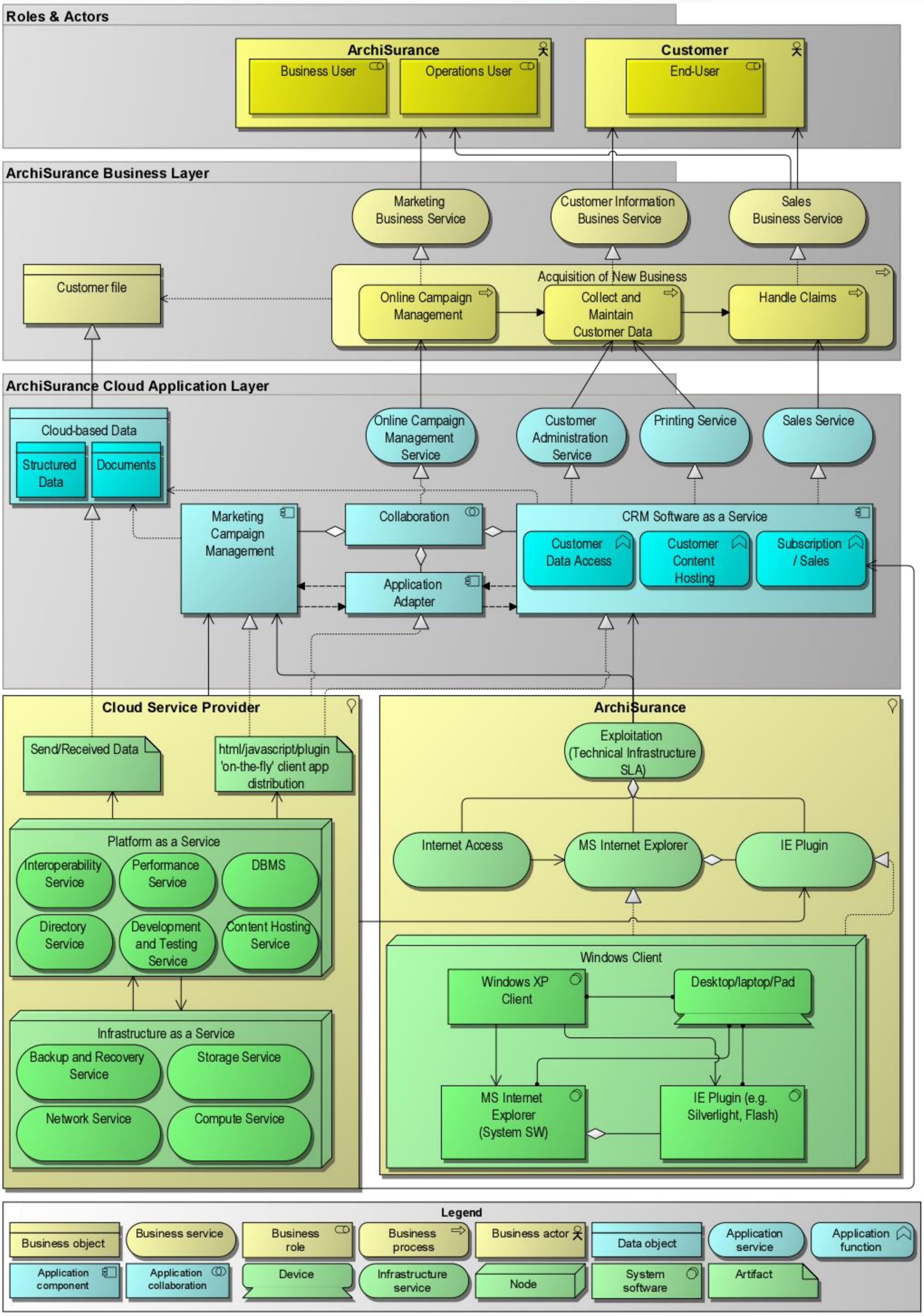


Figure 54: Layered View of ArchiSurance – Version 2.

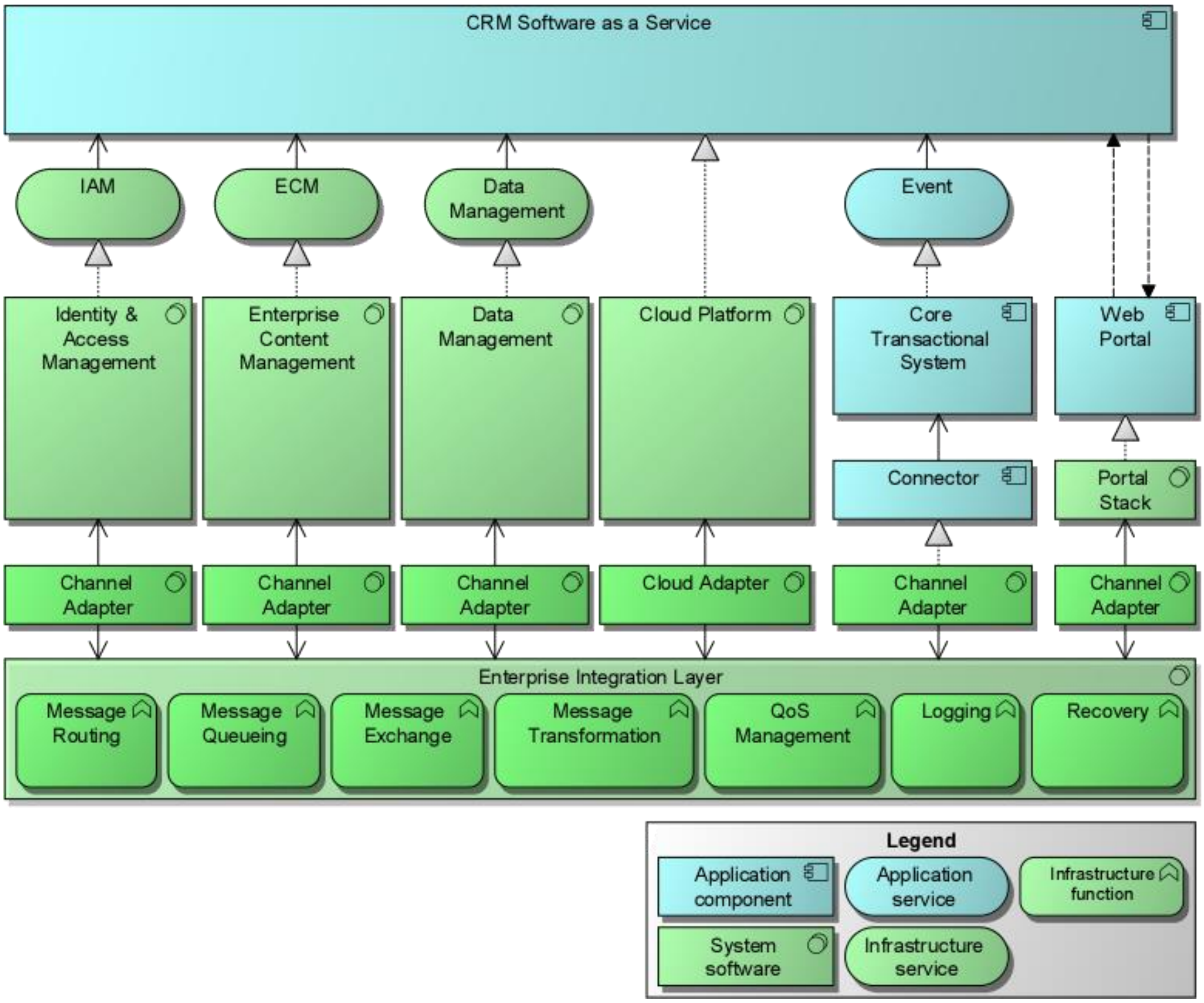


Figure 55: Strategic Technical Architecture (from the interview with I. Band).

Define Candidate Roadmap Components

The Technology Architecture roadmap is based on the gap analysis and is used to prioritize other architectural activities. The candidate technology roadmap will be integrated with the candidate business (Phase B) and information systems (Phase C) roadmap, utilized in Phase E (Opportunities & Solutions)

Resolve Impacts across the Architecture Landscape

The technical architecture capabilities enable delivery of on-demand Cloud services. This may impacts the Technical Architecture of ArchiSurance. Consequently the artifacts are analyzed in order to check:

- Does the Target Technology Architecture create an impact on any pre-existing architectures and whether associated assumptions are still valid for Cloud Ecosystem?
- Have recent changes been made that impact the Technology Architecture of Cloud Ecosystem? The changes may include any outsourced/built-in Cloud services, impact of new applicable business policies, and technology advancements.
- Identify any opportunities to standardize technology of Cloud Ecosystem and analyze the impact to stakeholders.

Conduct Formal Stakeholder Review

Check the resulting Technology Architecture against the original motivation for Cloud Ecosystem and the Statement of Architecture Work. Then it must be checked whether it supports the architecture work in other domains (i.e. business, application, and data). If there is any impact on the Application and Data Architecture of ArchiSurance then the Technology Architecture must be refined to resolve this impact and also to support all stakeholder concerns.

Create Architecture Definition Document

Include the Technology Architecture sections in the Architecture Definition Document. The Technology Architecture describes how the business policies and requirements are translated into Solution Building Blocks. Lastly the document must be reviewed by relevant stakeholders and then decide whether review of the document is once again required.

7.4 Conclusion

"Development of the Cloud Enterprise Architecture" includes all the activities and the steps from Phases B-D in order to get the architecture right. This is achieved by analyzing the results from the Gap Analysis between the "as-is" and "to-be" state of the architecture.

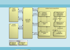
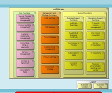
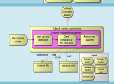
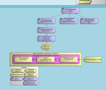
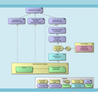
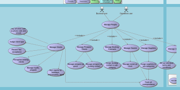
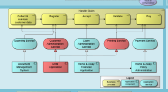
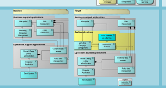
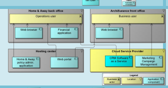
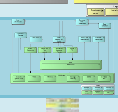
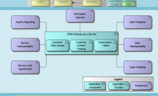
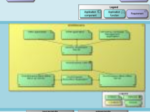
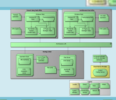
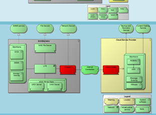
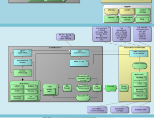
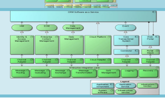
The Cloud Ecosystem extends the business environment and structures because the business services are realized by different Cloud service models and providers. Efficient IT management can address the impact of the Cloud services in the business processes and functions in order to achieve business agility. The business strategy, plans, functions, information flow, structure, governance and processes should be verified and updated in order to address the impact of the Cloud Ecosystem. Furthermore, business process redesign should be enabled to utilize new capabilities in order to create optimal business solutions for achieving target business objectives. New organizational roles are prominent and should be included in the Business Architecture. Moreover the SLAs must be negotiated carefully to ensure that the business and technical requirements as well as the risks are well balanced between the consumer organization and the CSPs.

Based on the approach (data-driven or application-driven approach) that is being followed in Phase C, the corresponding architecture (Data Architecture or Application Architecture) is developed first. Emphasis is given in the implementation and integration of the data and applications. Multi-tenancy (which is inherent characteristic of Cloud-based solutions) impacts the Logical Data and Data Security models as well as the applications interfaces. Interoperability, security and privacy are important NFRs that must be addressed in the Information Systems Architecture. Additionally, the impact on the business processes may require adjustment and redesign of the workflow. Data management approach should be adopted for effective information assessment and use of data; while data governance ensures data quality.

Modular Cloud-based solutions enable capabilities which bridge the gap between the Baseline and Target Architectures. Then trade-off analysis should be performed to decide whether the organization will build or rent the capabilities from external CSPs. In case of choosing services from CSPs the Technology Architecture must address the interactions and relationships of these architecture capabilities.

Table 23 summarizes all the diagrams/viewpoints that are used for communicating, deciding and designing the Enterprise Architecture of ArchiSurance in Cloud Ecosystems.

Table 23: Summary of the Architecture Diagrams of the Cloud Enterprise Architecture Development.

Phase	Viewpoint	Diagram Name	Thumbnail	Impact (High/Medium/Low)
Business Architecture	Actor Collaboration Viewpoint	Actor Collaboration		High
	Business Function Viewpoint	Business Communication		High
	Business Architecture Viewpoint	Business Product View		None
	Business Architecture Viewpoint	Functional Decomposition Diagram		Medium
	Business Architecture Viewpoint	Function Support Map		Low
	Business Process Viewpoint	Business Functions Related with Processes		Low
	Business Architecture Viewpoint	Relating Business Goals and Requirements to Business Architecture		Low
	Business Architecture Viewpoint	Business Footprint Diagram		Medium
Information Systems Architecture	Application Architecture Viewpoint	CRM System Use Case Diagram		None
	Application Usage Viewpoint	Application-Process Support		Low
	Application Cooperation Viewpoint	Application Cooperation View		Medium
	Application Architecture Viewpoint	Application and User Location Diagram		Medium
	Application Architecture Viewpoint	Application Model		High
	Layered Viewpoint	Layered View Version 1		High
	Data Architecture Viewpoint	Data Dissemination Diagram		High
	Data Architecture Viewpoint	CRM SaaS and Data Requirements		Medium
Technology Architecture	Technical Infrastructure Viewpoint	Baseline Technology Architecture		None
	Technology Architecture Viewpoint	Environments and Locations Diagram		Low
	Technical Infrastructure Viewpoint	Platform Decomposition Diagram		High
	Technology Architecture Viewpoint	Application Usage-Revised		High
	Layered Viewpoint	Layered View Version 2		High
	Technology Architecture Viewpoint	Strategic Technical Architecture		High

Chapter 8 – Business Transformation Planning

The outline of this chapter is the following: Section 8.1 and 8.2 explain TOGAF for Cloud Ecosystems approach to cope with the Opportunities & Solutions Phase and Migration Planning Phase respectively. All Phases are demonstrated in the context of ArchiSurance case with the use of ArchiMate modeling language. Lastly Section 8.3 gives the conclusions of this chapter.

8.1 Phase E - Opportunities & Solutions

Section 8.1 suggests a Cloud-enabled approach for the Opportunities & Solutions Phase of ADM, by suggesting guidelines and deliverables which are necessary to develop an enterprise Cloud Ecosystem. The TOGAF for Cloud Ecosystems approach adapts systematically the Architecture Development Method (ADM) of TOGAF in the ArchiSurance case study.

8.1.1 Approach

The aim of Phase E is to identify projects, programs or portfolios that effectively deliver the Target Architecture. The gaps between the Target and Baseline Architectures (from Phases B, C and D) are grouped into work packages within the organization's portfolios. This is the input to build the optimal roadmap based upon the identified opportunities and solutions, stakeholders' concerns, constraints and business transformation readiness. Overall Phase E emphasizes on how to structure and prioritize the change activities in respect to the IT portfolio (Iacob et al. 2012).

In the Opportunities and Solutions Phase the focus is given to consolidate the gaps from Phases B-D and based on that to identify target capabilities and business objectives. These capabilities are addressed by identifying the appropriate Architecture Building Blocks.

8.1.2 Guidelines

Every project, program or portfolio must deliver incremental business value to the Target Architecture (The Open Group 2011). The key is to focus on the final target while realizing incremental business value by following the guidelines below:

1. Identify potential sources for value generation in the enterprise Cloud Ecosystem. The value does not just mean financial value (i.e. Total Cost of Ownership, Return on Investment) but also technical value of the investment, customer value, seller-provider value, broker value, market brand value or corporate value.
2. Handle the IT resources (software and/or hardware) to be acquired, as shared assets and the business side must justify the initiative with operational expenditure (OpEx) outlines instead of standardized Return on Investment or Cost-benefit analysis. Therefore there is a shift from the capital expenditures (upfront investments, new product introduction trainings) to operational expenditures and different chargeback agreements between the Finance and Business units. So there is no need to adapt the enterprise-wide Reference Architecture to the needs of a standalone project.
3. Experiment with the Cloud (i.e. trial versions) in order to elicit the Cloud-specific requirements and to identify the Cloud resources which may exist or not. Consequently, a new step will also be dedicated to identify candidate services in the Cloud (Thorn 2010).
4. Confirm the organizations capability for undergoing change in order to develop an enterprise Cloud Ecosystem.

5. Derive Transition Architectures that deliver continuous business value through exploitation of opportunities to realize building blocks.

Phase E focuses on the delivery of the Target Architecture (which developed during Phases B-D) through projects, programs and portfolios. However the project lifecycle in Cloud Ecosystem is reduced significantly due to the rapid provisioning of services through SaaS, PaaS and IaaS. In the Cloud Ecosystem the Target Architecture consists of ABB services. Overall the organization must become service oriented where by the Target Architecture is defined in terms of services components. As a result the gap analysis (between target ABB and baseline ABB) is not directly relevant since Cloud Computing mandates infrastructure replacement.

Despite the reduced project lifecycle there are various implementation issues such as financial, technical and contractual that needs to be considered in a Cloud Ecosystem. Hence the implementation roadmap is influenced from the following factors:

- Time to market,
- Legacy applications dependency and phasing off
- Cost vs. Risk
- Capability of the organization
- Cloud readiness

8.1.3 Deliverables

The deliverables which are listed below are essential to capture the aforementioned aspects. The present research focuses only on the deliverables which can be modeled with the use of ArchiMate. Consequently, the deliverables which are created with other techniques or notations are not presented in the ArchiSurance case study. The Opportunities and Solutions Phase outputs may include the following but are not restricted to:

Table 24: Suggested deliverables of the Opportunities & Solutions Phase.

Opportunities and Solutions Outputs (The Open Group 2011)	Supporting ArchiMate Viewpoints (Iacob et al. 2012)
-Draft Architecture Requirements Specification, including: Consolidated gaps, Solutions, and Dependencies Assessment	N/A (matrix form)
-Architecture Roadmap, including: (i) Revised motivation, (ii) Identification of Transition Architectures, (iii) Implementation Factor Assessment and Deduction Matrix	(i) Requirements realization viewpoint, (ii) Migration viewpoint, (iii) N/A (matrix) form
-Implementation and Migration Plan v0.1	Project viewpoint
-Benefits diagram	Motivation viewpoint
-Project Context diagram	Implementation and migration viewpoint

8.1.4 Phase E in ArchiSurance

Step: Determine/Confirm Key Corporate Change Attributes

The new SaaS CRM brings many advantages and challenges to ArchiSurance. For this reason it is necessary to analyze carefully the business culture, knowledge, skills and abilities of employees for effective implementation of the EA. It is necessary to train the business users and support confidently the new outsourced deployment model.

The capability assessment defines whether the organization is ready to undergo the change. The result of the assessment is the basis to select which implementation and migration approach will be adopted. The factors evaluated in the capability assessment should be documented in the Implementation Factor Assessment and Deduction matrix which serves as a repository for architecture implementation to assist migration decisions.

Table 25: Implementation Factor Assessment and Deduction Matrix.

Factor	Description	Deduction
Change in application implementation	Application implementation on Cloud rather than on-premises	-Business to be aware of the new model. -Compliance to be assessed for moving business services to Cloud. -Essential skills training.
SaaS to address business need	Business Application assembled from SaaS to fulfil business requirements	-Capability to provide Identity management, access control and customize services. -Business units deploying their own applications due to low cost and ease of deployment thereby introducing security holes.
Scalability and elasticity	Applications able to scale as per the demand and auto shrink	-Skills to design applications to take advantage of scalability on demand.
Application integration	Integration of application services on Cloud and on-premises	-Skills to do integration with on-premises and legacy enterprise applications with Cloud.
Enterprise data segregated into Cloud silos	Each SaaS utilised creates its own data	-Integration challenges and Extract Transform Load data from various services. -Data integration and replication solutions.
Business functions and data	Traditional business functions and data reside locally on premises	-To establish a mechanism to determine the business functions and data that can be hosted in public / private / hybrid

Step: Determine Business Constraints for Implementation

At this step the business drivers (which are set during Phase A) for the SaaS CRM must be reviewed. Some important business drivers for the Cloud Ecosystem are quick response to business needs, improved performance, and buy instead of building software. The revised business drivers of ArchiSurance are given below.

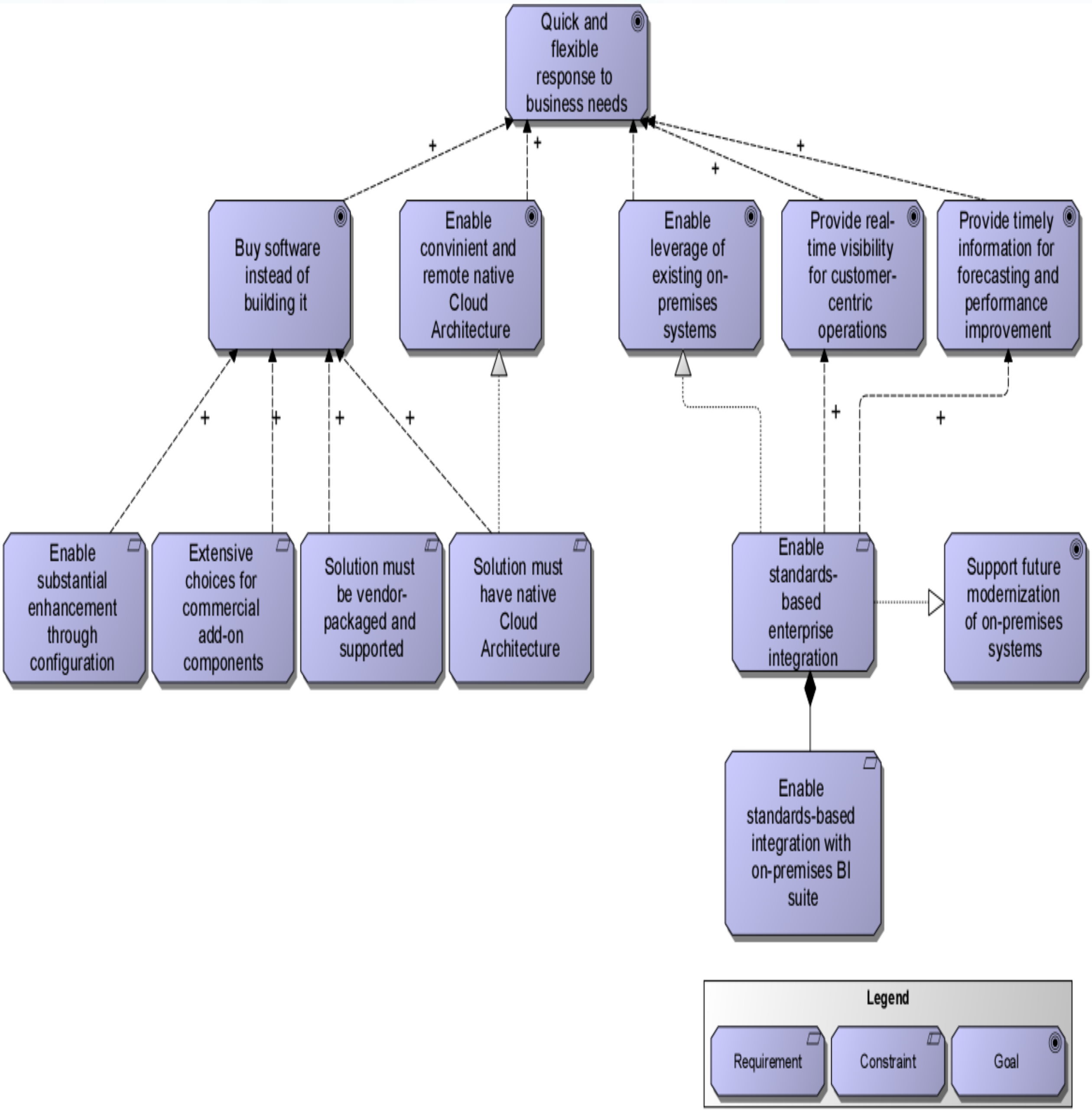


Figure 56: Revised motivation for the SaaS CRM of ArchiSurance (from the interview with I. Band).

The Cloud paradigm provides services that mandate the conversion of the manual processes to automated process through Business Process Management (BPM) tools. BPM tools have become a necessity for the business to be agile, to get control and ownership of the processes. BPM tools have evolved more towards open standards, not tied up to specific vendor and wide choice available and affordable due to Cloud enabled BPM tools model.

Step: Review and Consolidate Gap Analysis Results from Phases B-D

When an organization adopts Cloud-based solutions, it has to face challenges that arise due to the fact that business services are now provided from different vendors. The results of Gap Analysis in Phases B-D identify the consequences derived by changing the deployment model from packaged solution to service model.

Consideration must be given to the dependencies of applications in the Cloud Ecosystem as they span across the on-premises deployment model and Cloud deployment model. Also there may be inter-dependencies with Cloud services consumed from different Cloud Service Providers.

Table 26: Consolidated Gaps, Solutions, and Dependencies Matrix of ArchiSurance.

Architecture	Gap	Potential Solutions	Dependencies
Business	Organization has not performed Business Architecture work related with Cloud Ecosystem earlier by engaging external Cloud Service Providers (CSPs),	Impact on existing business processes need to have key stakeholders approval.	
Business	Business Agility	Business process assembled through services	Existing business process integration
Data	Data consistency and accuracy Implications of data in different SaaS providers	Ensure that there are effective data governance policies and compliance procedures are established for Cloud Ecosystem of ArchiSurance	
Technology	To support expected technology consistency and accuracy	To have an effective technology stack validation and selection process.	

Step: Review Consolidated Requirements across Related Business Functions

At this step, the review aims to evaluate the requirements, gaps, solutions and factors related to business functions as well as to identify the shared services that can be used by the enterprise through provision of shared resources. Integrating the set of requirements into work packages can lead to a more efficient and effective implementation of the Target Architecture. A high level view of the Implementation Plan is given below (Figure 60). The main work packages and phases are identified which are necessary to integrate the SaaS CRM with the Strategic Technical Architecture. The deliverables of each phase and work package are given in Phase F (Migration Planning).

Step: Consolidate and Reconcile Interoperability Requirements

One of the most important requirements in Cloud Ecosystem is interoperability due to the fact that business services can now be provided by one or more Cloud Service Providers. Depending on the solution, the services can be consumed from Information Systems deployed on PaaS or business services from SaaS. One has to take into account the interoperability between PaaS and SaaS.

Additionally, the Cloud Management Platforms (CMPs) differ as they can be based on different platforms like Openstack, CloudStack, Eucalyptus or OpenNebula. Except from interoperability, the API provided by the Cloud vendors helps to the consumption and future extension of the services.

Step: Refine and Validate Dependencies

Dependencies are refined in terms of Implementation and Migration Plan and assist in project bundling, milestones, project plan duration and sequencing. Specifically one takes into account the dependencies connected to existing implementation of business services and Information Systems or changes to them. It is highlighted that in Cloud Ecosystem, the implementation duration is minimized due to rapid infrastructure provisioning and business service deployment as SaaS.

Step: Confirm Readiness and Risk for Business Transformation

A review on Business Transformation Readiness Assessment, carried out previously in Phase A, is now made to define the impact on the Architecture Roadmap and the Implementation and Migration Strategy.

Since Cloud Ecosystem risks are very different from traditional technology projects, risks connected with Business Transformation need to be defined and categorized. Additionally, a risk reduction plan has to be determined.

Based on Cloud deployment model, the Architecture Roadmap is able to provide services in minimum time and in order to find the dependencies between the services; a complete analysis of solutions has to be done.

Step: Formulate High-Level Implementation and Migration Strategy

ArchiSurance architecture team decided to undergo a gradual and phased approach which will incrementally introduce the new elements of the architecture. This evolutionary approach allows the organization to reduce the risks and the impact of the new solution. The selected approach must be documented in the Implementation and Migration Plan (Iacob et al. 2012). Then the work packages should be grouped in a way to suit the migration strategy.

Step: Identify Transition Architectures

The number of the Transition Architectures is determined from the Migration Strategy (Greenfield, Revolutionary, or Evolutionary) and the Cloud service models (IaaS, PaaS, or SaaS). After considering carefully the gaps between the “as-is” and “to-be” architectures, the architecture team ended up with one Transition Architecture to fill the gap. In this way the new architecture will be introduced smoothly without interrupting the overall business operations. The Transition Architecture has to do with the replacement of the old, on-premises CRM system with Cloud-based CRM.

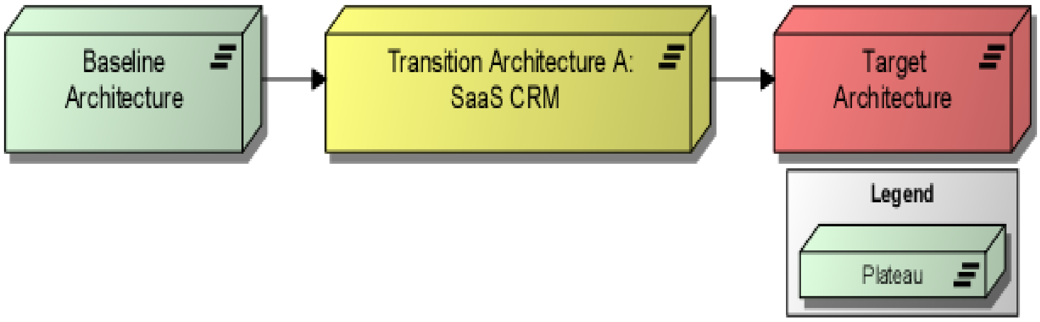


Figure 57: Baseline, Target and Transition Architecture of ArchiSurance.

Step: Identify Major Group Packages

Now the subsequent implementation projects can be planned based on the Transition Architecture. The Project Context diagram can be used to define the transformation roadmap by scoping the projects and the work packages (Iacob et al. 2012). The diagram in Figure 58 links the project with the technology and application components of the architecture.

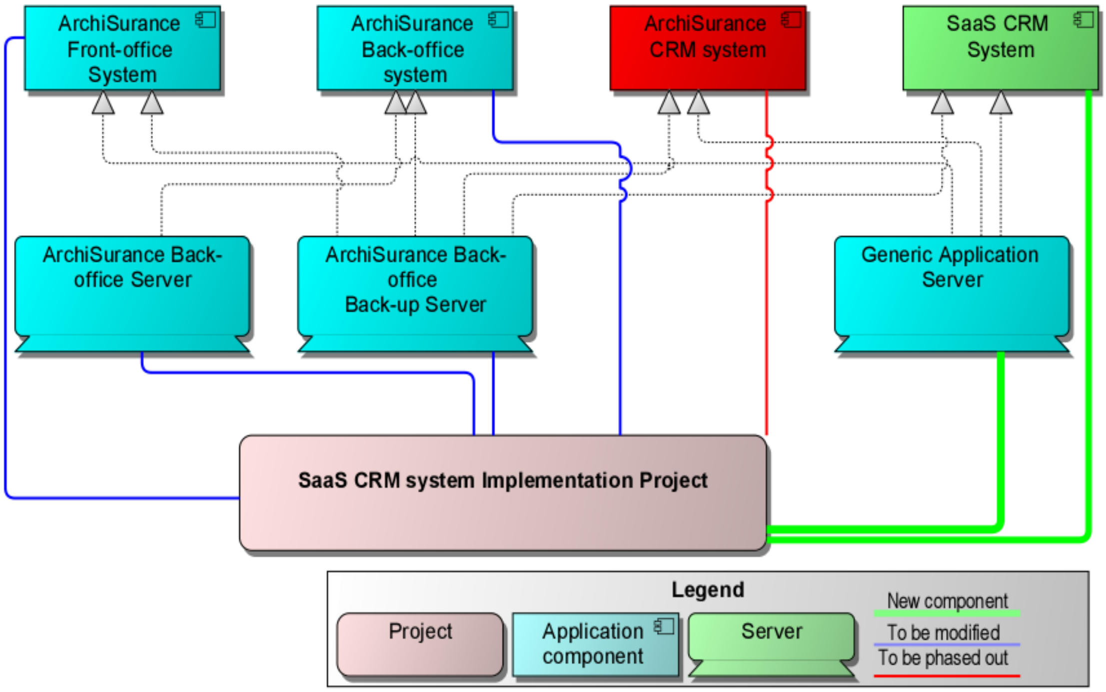


Figure 58: ArchiSurance Project Context Diagram.

Step: Create the Architecture Roadmap & Implementation and Migration Plan

The benefits diagram below shows the opportunities of the new architecture which are classified according to their complexity, priority and relative size. The realization of the Cloud-based CRM system is of medium complexity while the resulting benefits have high priority for the ArchiSurance executive board.

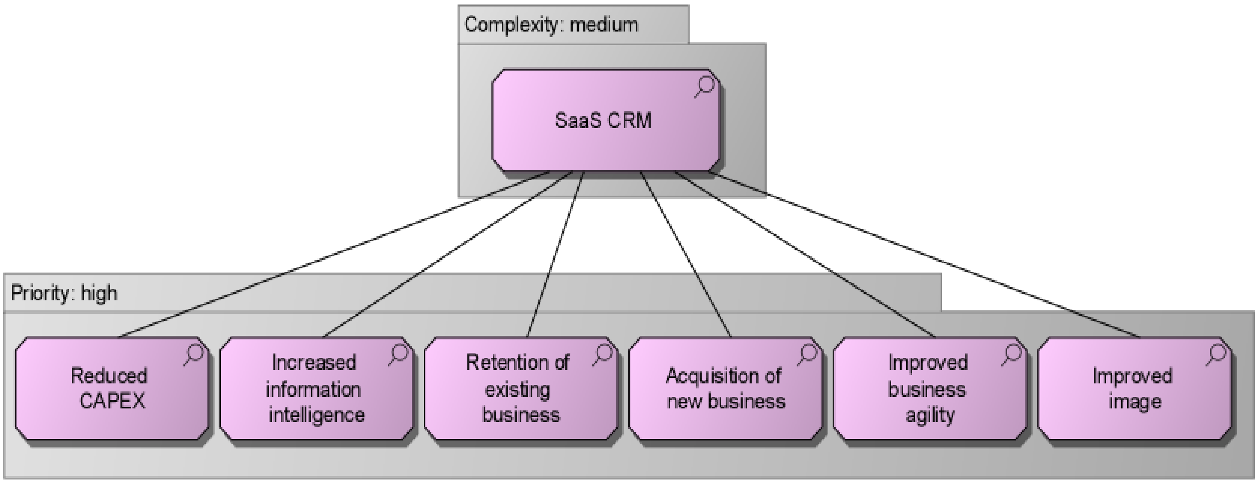


Figure 59: Benefits Diagram.

Lastly, the Architecture Roadmap is comprised from the Transition Architecture and the work packages of the SaaS CRM implementation project. The Architecture Roadmap is based on the Implementation and Migration Plan activities for the Cloud Ecosystem. Now there should be defined resource and project requirements that include Cloud Ecosystem considerations. Then during the application implementation the priority of the services is based on the business requirements identified earlier. A high level view of the Implementation and Plan of ArchiSurance is given in the Figure 60.

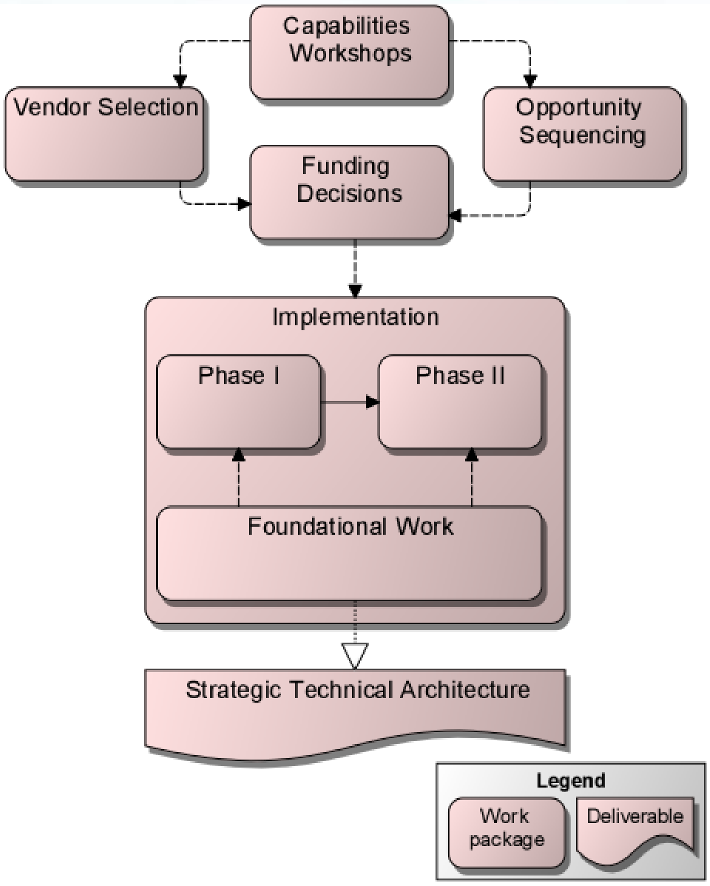


Figure 60: Overall View of the Implementation and Migration Plan.

8.2 Phase F - Migration Planning

Section 8.2 suggests a Cloud-enabled approach for the Migration Planning Phase of ADM, by suggesting guidelines which are necessary to develop an enterprise Cloud Ecosystem. The TOGAF for Cloud Ecosystems approach adapts systematically the Architecture Development Method (ADM) of TOGAF in the ArchiSurance case study.

8.2.1 Approach

The main objective of Phase F is to finalize the Architecture Roadmap and the Implementation and Migration Plan. The Implementation and Migration Plan is broken into smaller parts whereby each independent project will cover and implement these parts. For each migration project assess the dependencies, costs, benefits and whether they remain conformant with the architecture design models (The Open Group 2011). Then the projects can be prioritized by assigning business value to each project.

8.2.2 Guidelines on how to develop the Implementation & Migration Plan

The value does not just mean financial value, so the products (software and/or hardware) that need to be acquired must be handled as shared assets and the business side must justify the initiative with operational expenditure (OpEx) outlines. Therefore there is a shift from the capital expenditures (upfront investments, new product introduction trainings) to operational expenditures and different chargeback agreements between the Finance and Business units. So there is no need to adapt the enterprise-wide Reference Architecture to the needs of a standalone project. The prioritized list of projects is the basis for the Implementation and Migration Plan. Figure 61 is describing a process to reach a sound Implementation and Migration Plan for Cloud Ecosystem.

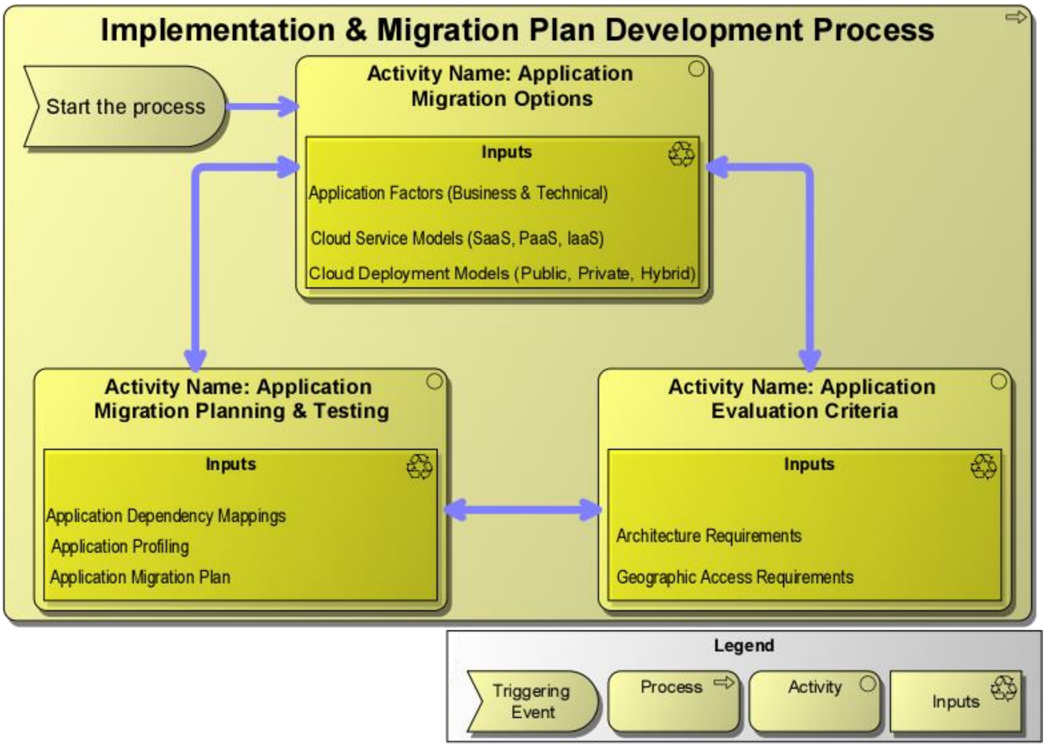


Figure 61: Implementation and Migration Plan Development Process.

The process starts by analyzing the application-specific factors and comparing them with the different types of Cloud deployment and service models. The next steps are to analyze and measure application details that help in building a migration plan, as well as a plan for testing each phase of the migration. The process is iterative (based on the case) because new data might arise on the way and that leads to the reevaluation of the results in prior phases. This process determines the applications suitability and also helps to define and perform a smooth migration. However there must be always an alternate plan; before the actual implementation, decide upon using some alternative solutions to how the migration is made.

8.2.3 Deliverables

The deliverables which are listed below are essential to capture the aforementioned aspects. The present research focuses only on the deliverables which can be modeled with the use of ArchiMate. Consequently, the deliverables which are created with other techniques or notations are not presented in the ArchiSurance case study. The Migration Planning Phase outputs may include the following but are not restricted to:

Table 27: Suggested deliverables of the Migration Planning Phase.

Migration Planning Outputs (The Open Group 2011)	Supporting ArchiMate Viewpoints (Iacob et al. 2012)
- Implementation and Migration Plan v1.0, including: Project and portfolio breakdown of the implementation	Project viewpoint

8.2.4 Phase F in ArchiSurance

Step: Prioritize the Migration Projects and Generate the Implementation and Migration Plan

In Phase E only one Transition Architecture was identified for the application rationalization process of ArchiSurance. Therefore the Target Architecture is realized by identifying implementation projects and the order that will be carried out. The order of the projects depends on which project is necessary as an input for the next one. Based on Figure 60 the Implementation Plan is divided into two phases which will reuse existing architectural assets (Foundational work) from previous Enterprise Architecture programs. The new SaaS CRM solution should be aligned with the Strategic Technical Architecture of ArchiSurance in order to exploit maximum value from the Enterprise Architecture. The sequencing and deliverables of the Strategic Technical Architecture and each phase are given in Figures 62-64.

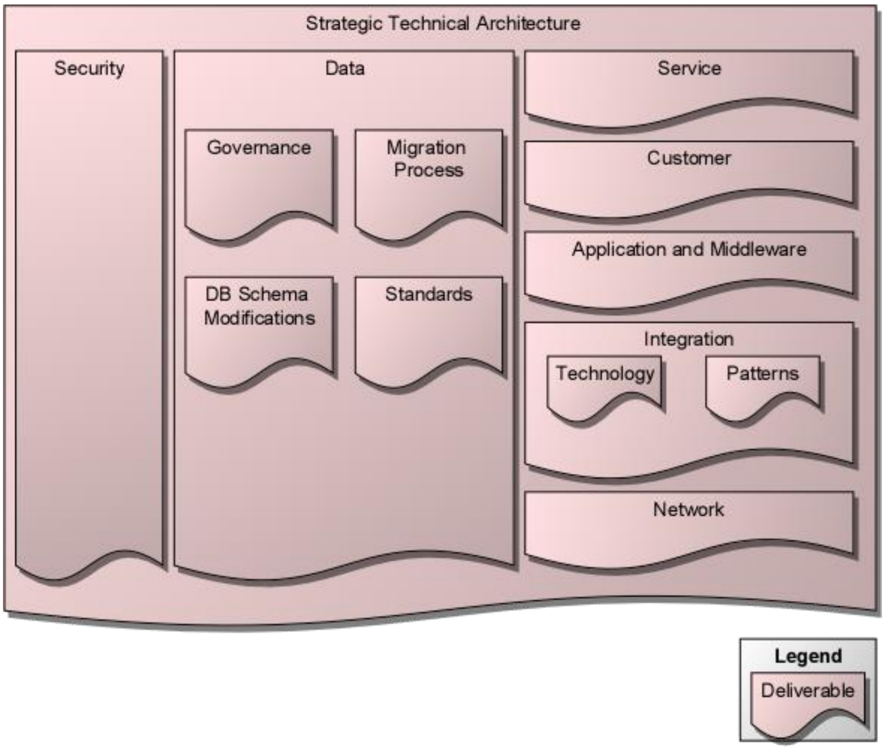


Figure 62: Strategic Technical Architecture deliverables from Foundational work (from the interview with I. Band).

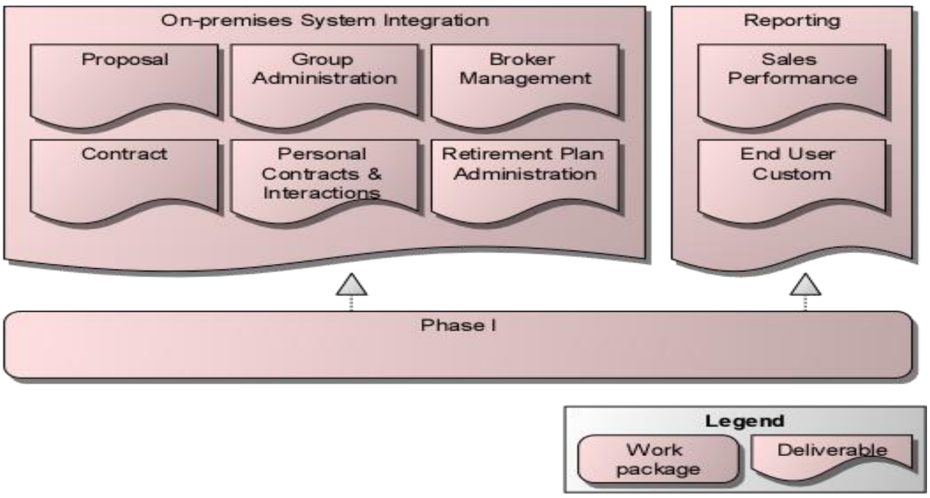


Figure 63: SaaS CRM implementation –Phase I deliverables (from the interview with I. Band).

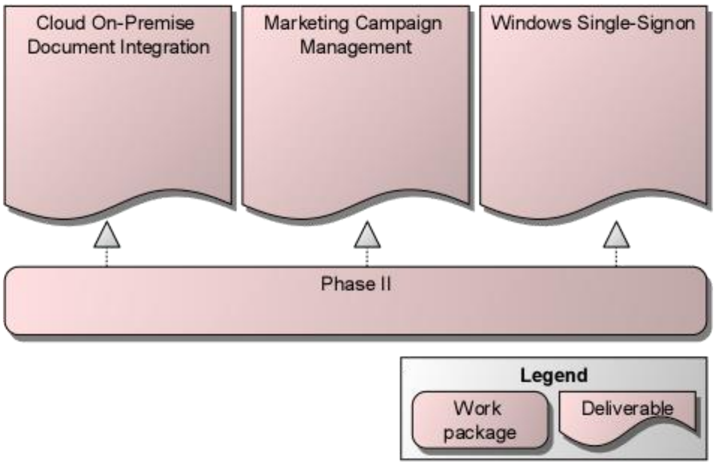


Figure 64: SaaS CRM implementation –Phase II deliverables (from the interview with I. Band).

The implementation and migration viewpoints of ArchiMate can be used to depict the identification, prioritization and deliverables of the projects and can be included in the Implementation and Migration plan v1.0.

8.3 Conclusion

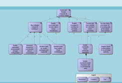
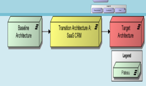
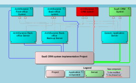
"Business Transformation Planning" includes all the activities and the steps from the Opportunities and Solutions and Migration Planning Phases, in order to plan the implementation and migration of the Target Architecture.

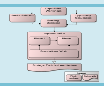
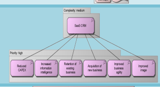
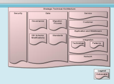
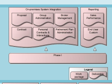
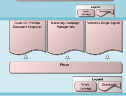
In Cloud Ecosystem the IT resources are handled as shared assets, where by the projects are justified with OpEx instead of CapEx. Additionally the project lifecycle is reduced significantly because the Target Architecture is built upon service components. As a result there is no need to adapt the organization-wide Reference Architecture for a standalone project. However the manual processes need to be automated by using the appropriate BPM tools. The set of requirements (Requirements Management Phase) will guide such decisions and also the requirements must be integrated into projects' work packages.

The implementation and migration plan development process assists in the creation of the Implementation and Migration Plan in order to perform a smooth migration. Consequently the main implementation phases are identified together with the corresponding deliverables and work packages which are needed to realize the Target Architecture.

Table 28 summarizes the all the diagrams/viewpoints that are used for communicating, deciding and designing the Enterprise Architecture of ArchiSurance in Cloud Ecosystems.

Table 28: Summary of the Architecture Diagrams of the Business Transformation Planning.

Phase	Viewpoint	Diagram Name	Thumbnail	Impact (High/Medium/Low)
Opportunities & Solutions	Requirements Realization Viewpoint	Revised motivation for the SaaS CRM		High
	Migration Viewpoint	Baseline, Target and Transition Architecture		Low
	Implementation and Migration Viewpoint	Project Context Diagram		Medium

Phase	Viewpoint	Diagram Name	Thumbnail	Impact (High/Medium/Low)
	Project Viewpoint	Overall View of the Implementation Plan		High
	Motivation Viewpoint	Benefits Diagram		Low
Migration Planning	Project Viewpoint	Strategic Technical Architecture Deliverables		High
	Project Viewpoint	SaaS CRM implementation – Phase I deliverables		High
	Project Viewpoint	SaaS CRM implementation – Phase II deliverables		High

Chapter 9 – Delivery and Governance

The outline of this chapter is the following: Section 9.1 and 9.2 explain TOGAF for Cloud Ecosystems approach to cope with the Implementation Governance Phase and the Architecture Change Management Phase respectively. Both Phases are demonstrated in the context of ArchiSurance case with the use of ArchiMate modeling language. Lastly Section 9.3 gives the conclusions of this chapter.

9.1 Phase G – Implementation Governance

Section 9.1 suggests a Cloud-enabled approach for the Implementation Governance Phase of ADM, by suggesting guidelines which are necessary to develop an enterprise Cloud Ecosystem. The TOGAF for Cloud Ecosystems approach adapts systematically the Architecture Development Method (ADM) of TOGAF in the ArchiSurance case study.

9.1.1 Approach

The Implementation Program can be defined based on the Implementation and Migration Plan which is defined in the previous phases. The Implementation Program is decomposed into individual implementation projects and deployment schedule. For each implementation project, clear goals, responsibilities and recommendations must be defined (Iacob et al. 2012). Therefore all the information needed for successful management and implementation of the projects is brought together in this phase. In order to realize the business value, benefits and risks of the new architecture work, the Target Architecture must be deployed as a series of transitions whereby each transition represents incremental steps (each step delivers benefits and value on its own) towards the target situation (The Open Group 2011). This must not be seen as a standalone effort but as an aligned activity that supports the organizations corporate, IT, and architecture governance.

9.1.2 Guidelines

The Implementation Governance Phase activities should focus on the following aspects:

1. Ensure that the implementation projects conform to the Cloud Ecosystem Target Architecture, defined in the previous phases. This should be handled as an activity that conforms and supports organizations corporate, IT, and architecture governance. Conformance can be achieved with proactive architecture compliance checks. The compliance process must be applied throughout the implementation at agreed compliance check points and not at the end of the implementation of the program.
2. Perform the actual relocation (physical and logical relocation) of the business processes, applications, data and technical services (Thorn 2010). The security must be implemented during the relocation of these business and IT elements to ensure that the Target Architecture meets the non-functional requirements.

9.1.3 Deliverables

According to the experts (Iacob et al. 2012, Jonkers et al. 2012) the outputs of Phase G cannot be specified using ArchiMate, that is the reason why there are no models to support the Implementation Governance Phase.

9.1.4 Phase G in ArchiSurance

Step: Confirm Scope & Priorities for Deployment with Development Management

In Phase G the ArchiSurance governance body scopes and prioritizes the implementation governance activities. Here it is necessary to review, catalogue, and mark for development the architecture and project artifacts, newly introduced Cloud Ecosystem Solution Building Blocks (SBBs) and deployment challenges.

Step: Identify Deployment Resources & Skills

The Cloud implementation resources should be integrated in the architecture compliance process. As a result the details and expectations of the implementation resources are known, which is helpful for effective resource allocation during the implementation of the project.

Step: Perform Enterprise Architecture Compliance Reviews

Furthermore for each ArchiSurance implementation project the respective goals, plans and objectives are reviewed and conformance recommendations are made. Then the architecture compliance process is proactively executed by reviewing the individual implementation projects to ensure compliance with the Target Architecture and business objectives.

Step: Implement Business & IT Operations and Perform Post-Implementation Review

The utilization of DevOps[1] helps ArchiSurance to enhance collaboration between the implementation teams and IT operations. As a result the implementation of the projects requires less time and risks. By the end of the implementation the results are reviewed and then published.

9.2 Phase H – Architecture Change Management

Section 9.2 suggests a Cloud-enabled approach for the Implementation Governance Phase of ADM, by suggesting guidelines and deliverables which are necessary to develop an enterprise Cloud Ecosystem. The TOGAF for Cloud Ecosystems approach adapts systematically the Architecture Development Method (ADM) of TOGAF in the ArchiSurance case study.

9.2.1 Approach

The Architecture Change Management Phase ensures that changes are incorporated in the Enterprise Architecture in a consistent way. Phase H is responsible for the maintenance of the architecture and in that way it increases business agility and the organization can react to the changing business environment (Iacob et al. 2012).

The activities of this phase ensure that the Target Architecture will deliver maximum business value. To do so, it is required constant architecture assessment to ensure that the architecture capabilities address adequately the change in the business and technology sides.

The architecture change management process evaluates whether the target business objectives and value are realized by the architecture work. The process also addresses, evaluates and evolves the external and internal factors which contribute to the overall business performance. Consequently it must be specified

[1]. DevOps is a software development method that stresses communication, collaboration and integration between software developers and information technology (IT) professionals. DevOps is a response to the interdependence of software development and IT operations. It aims to help an organization rapidly produce software products and services.

which governance process will steer the Enterprise Architecture from now on. At this step the architects have to decide if a new ADM iteration will take place or not and under which circumstances. So the output of Phase H will be the input of the new ADM iteration (if a new iteration will be triggered).

9.2.2 Guidelines

The following factors need to be appropriately addressed and assessed during the lifecycle of the Enterprise Architecture:

1. Define business requirements to address the new way of interaction between customers, suppliers, partners and the organization; and to enhance the value proposition of the new architecture work.
2. Perform incremental improvements which are critical to business process transformation through automation.
3. Identify new performance improvement opportunities which enhance customers' experience.
4. Create service contracts with CSPs that allow the organization to change, exit or migrate to another solution without negatively impacting the Cloud service delivery.
5. Monitor the utilization of the Cloud services and perform routine risk assessments on CSPs, in order to identify possible timely adjustments on the Cloud Enterprise Architecture.

9.2.3 Deliverables

The deliverables which are listed below are essential to capture the aforementioned aspects. The present research focuses only on the deliverables which can be modeled with the use of ArchiMate. Consequently, the deliverables which are created with other techniques or notations are not presented in the ArchiSurance case study. The Migration Planning Phase outputs may include the following but are not restricted to:

Table 29: Suggested deliverables of the Architecture Change Management Phase.

Architecture Change Management Outputs (The Open Group 2011)	Supporting ArchiMate Viewpoints (Iacob et al. 2012)
-New Request for Architecture Work	N/A (document form)
-Architecture Contract	N/A (document form)
-Cloud Compliance Assessments	N/A (document form)

9.2.4 Phase H in ArchiSurance

Step: Establish Value Realization Process

ArchiSurance should establish Cloud business policy to realize the benefits and exploit the Enterprise Architecture for value realization. This requires changes to the business projects, processes, performance matrices and organizational culture. The investment decision should be taken after careful consideration of the business case, business model and risk assessment. Benchmarking is a useful technique to assess the overall costs, service levels and maturity level of business capabilities enabled by the enterprise Cloud Ecosystem of ArchiSurance.

Step: Deploy Monitoring Tools

The Cloud Program Management Office (CPMO) established a Cloud compliance process to achieve services/application reuse and service optimization utilization. With these monitoring capabilities, ArchiSurance can assess the impact of business and technology changes in the Cloud Ecosystem. The business performance, maturity assessment of services and Quality of Service (QoS) are monitored also to assess the overall viability of the new architecture work. The following ABBs are listed in the Cloud Ecosystem Reference Model (Figure 6) and help to realize the aforementioned monitoring capabilities.

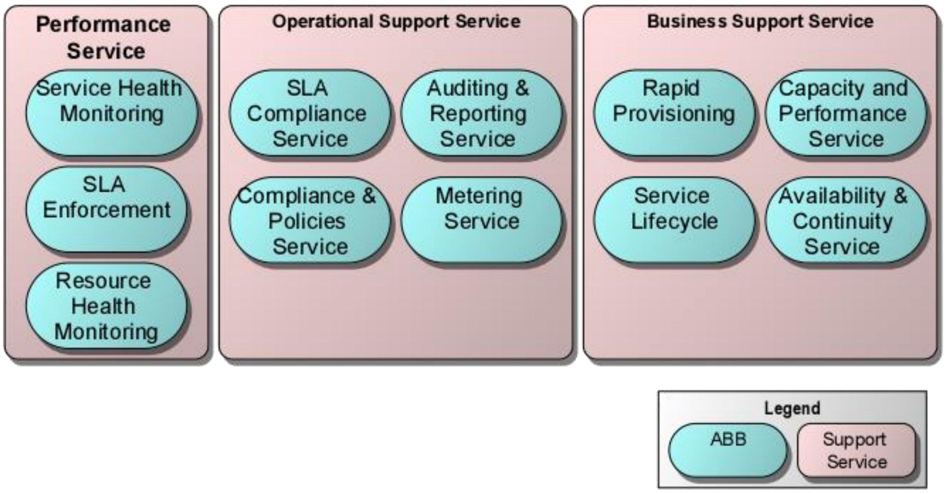


Figure 65: Example ABB to realize monitoring capabilities for ArchiSurance.

These monitoring capabilities are used to analyze and identify business performance benchmarks. Based on that, ArchiSurance can perform routine maturity assessments of the Cloud Ecosystem. At this step the Cloud services maturity indicators are analyzed to identify opportunities for improvement in the business capabilities of the enterprise Cloud Ecosystem. Consequently change requests to business capabilities are identified and should be adhered to established EA governance guidelines, policies and processes.

Step: Manage Risks

The risk management is executed in routine base and evaluates the financial position, performance and leadership of existing (and potential) CSPs of ArchiSurance. The risk management identifies potential points of pain which can be mitigated by enforcing desired behavior to the CSPs through the SLAs and/or OLAs.

Step: Manage Governance Process

ArchiSurance uses the established governance process by including the necessary exceptions of the Cloud Ecosystem. Any change occurred in the services must be addressed in the Cloud Ecosystem reference architecture. The EA governance board of ArchiSurance should meet regularly to identify and decide on the architectural changes of the enterprise Cloud Ecosystem. The governance process should be assessed and refined periodically.

Step: Activate the Process to Implement Change

The business performance objectives will guide the decision for a new change process. The Architecture Definition Document is created then, to include how the architecture change addresses new business requirements and policies. The document must be reviewed by all stakeholders. Any changes implemented in this phase must be captured in the architecture repository.

9.3 Conclusion

"Delivery and Governance" includes all the activities and the steps from the Implementation Governance and Architecture Change Management Phases in order to manage prioritize and control the architectural requirements.

Phase G ensures that the implementation projects conform to the Cloud Ecosystem Target Architecture by performing well defined architecture compliance checks. The actual relocation of the business processes, application, data and technical services is taking place, but it is important to ensure that the Target Architecture meet all the NFRs (e.g., security, interoperability, privacy, scalability).

On the other hand, Phase H ensures that the business objectives, value and performance improvements are met by optimizing the business processes. Furthermore, business requirements must be defined to address the new way of interaction with the extended business environment. The service contracts must be well defined by enabling safe exit or migration to another CSP(s), while routine risk assessments and monitoring of the Cloud services will identify possible timely adjustments on the enterprise Cloud Ecosystem.

Chapter 10- Feedback from Practice

The outline of this chapter is the following: Section 10.1 explains the interview protocol and the interview questions. Section 10.2 provides the summary of the interview transcripts and Section 10.3 concludes the chapter.

10.1 Interview Protocol and Questions

The interviews were conducted in order to gain feedback on the current practice of Enterprise Architecture and Cloud Computing. After that the TOGAF for Cloud Ecosystems approach is evaluated and the feedback is applied to the approach in order to improve it. The interviews follow a semi-structured approach in order to allow spontaneous feedback and in-depth discussions for additional issues. The interviews were conducted in three parts:

1. Presentation
2. Feedback
3. Answer questions

The presentation provided an overview of the TOGAF for Cloud Ecosystems approach by using examples from the ArchiSurance case. Where necessary immediate feedback was provided by the interviewee. Lastly, the questions that were prepared beforehand have been asked, with the exception of the ones that have already been answered.

The interview questions focused on three areas:

1. How EA framework support can facilitate Cloud Computing migration and usage.
2. Current EA and Cloud Computing practice in the participants' organizations.
3. The rigor and the relevance of the TOGAF for Cloud Ecosystems approach to develop an enterprise Cloud Ecosystem.

The questions that were used for the interviews can be found in Appendix III. The first group of questions aimed to identify best practices in EA and Cloud Computing, while the second group investigated the inadequacies of the current practices to facilitate Cloud Computing migration and usage. The last group evaluated the efficiency and relevance of TOGAF for Cloud Ecosystems approach.

10.2 Interview Summary

<u>Interview No 1 – Migration of the claim handling system (on-premise) to the ClaimVantage (Cloud-based)</u>

Name: Confidential
Organization: Confidential
Function: Senior Enterprise Architect
Date: 19/07/2013
Duration: 1hr & 45min

Role of Interview No1

The role of interview No1 was to check the relevance and applicability of the TOGAF for Cloud Ecosystems approach for a similar case with ArchiSurance. The case was about the *"Name of the company 1",* which is an insurance company and they wanted to migrate the old Case Management system to a new one (ClaimVantage Cloud application). Consequently we investigated the EA framework(s) and modeling language(s) that were used for developing an enterprise Cloud Ecosystem together with possible extensions and improvements for them.

Furthermore interview No1 revealed significant information about the motivation and concerns towards the Cloud Computing solutions, and important principles and requirements which guided the ClaimVantage EA program. It is also explained how to address the integration, interoperability, and security problems that arose in the ClaimVantage migration, in terms of logical and physical design. Based on these, the interviewer and the interviewee discussed how TOGAF for Cloud Ecosystems approach can be improved in order to be applicable in the ClaimVantage EA program. The most important changes were in the ArchiMate models (revised motivation, data dissemination, layered, implementation and migration viewpoints) of the TOGAF for Cloud Ecosystems approach. The feedback applied to TOGAF for Cloud Ecosystems approach.

EA framework support to facilitate Cloud Computing migration
"Name of the company 1" facilitates EA by using a tailored version of TOGAF and the modeling language ArchiMate for all aspects of the architecture of the claims modernization program as well as for a strategic evaluation of the SaaS solution (ClaimVantage). The interviewee identified a correlation between TOGAF, ArchiMate and Cloud Computing because all three are layered approaches to create the EA (TOGAF), design the EA (ArchiMate) and provide the services (Cloud Computing).

ArchiMate is used massively in the ClaimVantage case to demonstrate the core layers, the Motivation Extension and the Implementation and Migration Extension. It is also addressing effectively the NFRs (e.g., interoperability, portability, security, privacy) and the integration issues that arose during the Cloud migration.

Current EA and Cloud Computing practice
"Name of the company 1" consumes public Cloud service called ClaimVantage, from www.force.com as the basis of the new Case Management solution. The EA team configured the ClaimVantage application and integrated it with other applications in order to support the existing claims lifecycle. In *"Name of the company 1"* the Enterprise Architecture practice is well defined, with clear roles and responsibilities in order to ensure that the right business services are provided to the customers.

According to the interviewee, the primary benefit of the program is risk mitigation due to the replacement of an old and fragile system. There are other aspects of the program that increase capacity and modernize related aspects of the existing on-premises systems. *"Name of the company 1"* does need less servers and storage, and consequently less infrastructure engineering and operations capacity, but it is not at all clear whether it is saving money. SaaS is not cheap, so essentially paying others to do what the EA team would have to do anyway in the infrastructure domain. *"Name of the company 1"* gets a better hosting service than it could build for itself, but it is likely paying a high price for this. A number of the future planned ClaimVantage implementations, however will likely result in significant labor savings and faster and better service for *"Name of the company 1"* customers.

Evaluation of TOGAF for Cloud Ecosystems approach to facilitate Cloud Computing migration in the EA based on the ClaimVantage scenario
First of all, in the *"Name of the company 1"* was needed to replace an aging and increasingly failing system for post-intake case management of disability claims (there are three statements necessary: from the employee, the employer, and the attending physician). The process of handling claims in *"Name of the company 1"* is the following:

Once the basic information necessary to adjudicate (decide whether and how much to pay) a claim is in place, the claim is considered *"intake complete"*, and is passed from the claim intake system into a case management system to take the claim through the states of adjudication, payment and ongoing management, and if necessary, contested claims, in case the claimant is unhappy with the decision and tries to change it. *"Name of the company 1"* compared two approaches to solve this problem:

1. ClaimVantage, which runs on the www.force.com platform.
2. IBM Advanced Case Management.

The IBM solution would have run on-premises and tightly integrated with IBM FileNet P8, the on-premises document management system (which manages the three statements and any subsequent documentation). ClaimVantage has an on-premises-to-Cloud adapter (using a web service) that informs it when a relevant document has arrived, so it can trigger additional workflow if necessary. Ultimately, ClaimVantage is chosen because it is preferable to buy instead of build, and the IBM solution would have to be developed and customized. ClaimVantage does require complex configuration and a bit of custom code to get the job done, but it is much faster and low-risk than implementing the IBM solution.

So the principles for the ClaimVantage EA program were "*buy before build*, *configure before code*, and *do a like-for-like replacement for our aging, failing system"*. The key requirements concerned data structures and business logic specific to group disability insurance both in general and specific to *"Name of the company 1"*. ClaimVantage is one of the few commercial vendors in this space, and certainly simpler, cheaper and faster to implement than some of the big on-premises group insurance claims packages, e.g., from Oracle and Fineos. The requirements were around integrating with the Claim Intake System (CIS) via the ESB using reliable queuing so nothing gets lost, and integration with the on-premises FileNet P8 document management system. The constraints concerned rapid implementation with knowledge transfer to an internal team that will ultimate maintain and enhance the solution.

The selection of the Force.com platform provides to the *"Name of the company 1"* much more performance, scalability and even security than they could ever afford to build for themselves. There is a tremendous amount available on the platform. The integration with the on-premises applications demands performance, scalability and security. For this reason they use the IBM Cast Iron Live, which is a Cloud-based Cloud adapter that gives access to the Salesforce.com/ClaimVantage object model, and they talk to Cast Iron using web services via the ESB of *"Name of the company 1"*.

In the ClaimVantage EA program a mixture of ArchiMate and written requirements is used to address the aforementioned issues. The ArchiMate Motivation extension works equally well for both functional and non-functional requirements. Also, the profile extension mechanism can be used to specify NFRs for specific components.

However the *"Name of the company 1"* CRM system uses sensitive data and information and must be carefully assessed in order to decide what stays on-premises and what not. This very sensitive information, including the identities of institutional customers and the issues they are trying to resolve with *"Name of the company 1"*. ClaimVantage contains legally protected and highly sensitive information about individuals' health, income and fitness for work. This is handled in several ways. First is by always keeping a copy of customers' data on-premises using a third-party backup utility, and the second is ClaimVantage reliance on the Force.com platform, which is heavily scrutinized by many customers with sensitive information and has a number of security-related certifications. *"Name of the company 1"* integration channels are strongly encrypted and mutually authenticated. Finally, it is implemented

Windows Single-Sign On using Active Directory Federation Services, which makes personal authentication easier to manage and more convenient, reducing the risk of a user writing down their password. All individual sessions go over strongly encrypted, mutually authenticated channels.

These integration issues (e.g., message flow, shared access to data, interfaces, system software, services, networks, communication paths) can be modeled with ArchiMate and also the ArchiMate concepts and relationship symbols can be labeled and annotated to provide additional information. The most appropriate ArchiMate viewpoints which visualized the impact of ClaimVantage migration are:

- Motivation
- Infrastructure Usage
- Data Dissemination (a TOGAF diagram that is commonly produced using ArchiMate)
- Layered
- Implementation and Migration viewpoints

Interview No 2 – Cloud Computing practice in one of the world's biggest organization

Name: Confidential
Organization: Confidential
Function: Senior Enterprise Architect
Date: 05/08/2013
Duration: 1hr & 45min

Role of Interview No2

The role of interview No2 was to check the relevance and usefulness of the TOGAF for Cloud Ecosystems approach for the EA department of one of the biggest companies in the world. *"Name of the company 2"* is an aircraft manufacturer and that requires fully-fledged Enterprise Architecture in order to manage effectively the operations, business processes and functions, and the whole IT landscape of the company. Consequently we investigated the EA framework(s) and modeling language(s) that are being used in *"Name of the company 2"* for developing an enterprise Cloud Ecosystem together with possible extensions and improvements for them. Based on these, the interviewer and the interviewee discussed how TOGAF for Cloud Ecosystems approach can be improved in order to be applicable in the future EA programs of *"Name of the company 2"*. The feedback applied to TOGAF for Cloud Ecosystems approach.

EA framework support to develop, manage and govern enterprise Cloud Ecosystems

In *"Name of the company 2"* they use EA frameworks and modeling languages to create the EA for the Cloud Ecosystem. They do so in order to ensure consistency in all activities of architecture function across the enterprise. A TOGAF-based customized framework is built by leveraging several industry frameworks, utilizing standardized modeling languages. The framework is extensible and enables the development of a broad range of architectures consistently. Currently the EA practitioners are quite busy extending and evolving the current EA framework to address the changing landscape of Cloud Computing.

Current EA and Cloud Computing practice

"Name of the company 2" consumes both public and private Cloud services from different vendors. The EA practice is well defined with clear roles and responsibilities. The Enterprise Architecture Office, Cloud Program Management Office, Enterprise Procurement Office and IT-Business Partner's Office are the entities which are responsible for the EA in the *"Name of the company 2"*.Enterprise Architecture works

collaboratively with business side to ensure that the end-users get quality products and services and also whether the right Cloud business solutions are provided.

There are many challenges in a Cloud Ecosystem for *"Name of the company 2"* such as ensure information assurance so that information is available to the right person timeliness. There are also many benefits that the Cloud Ecosystem brings to *"Name of the company 2"* such as pay as you go, easy to set up environments for testing and business agility. All these are addressed in the EA by Cloud vendor assessments and careful planning to what information will be exposed on the public cloud and what on the private cloud.

Evaluation of TOGAF for Cloud Ecosystems approach

According to the interviewee there are many modifications which are necessary in the TOGAF for Cloud Ecosystems approach. The extended EA framework must ensure that the Target Architectures are easily developed and maintained as well as existing applications maintenance and modernization activities are consistently performed.

The interviewee stated that the combination of ArchiMate and TOGAF, in the TOGAF for Cloud Ecosystems approach, is appropriate to facilitate the development of an enterprise Cloud Ecosystem because it helps create and manage the Business Architecture which is a unique characteristic of ArchiMate and other EA modeling languages lack. However TOGAF for Cloud Ecosystems approach has some disadvantages. It still misses a pragmatic approach to easily map BPMN to ArchiMate for the Business Architecture and mapping to UML could be further elaborated. Even though ArchiMate is quite good with addressing various integration issues, this should be done similarly to UML or SYSML. Furthermore TOGAF for Cloud Ecosystems approach is missing important reference models namely the Cloud Ecosystem Reference Model (Figure 6) and the Enterprise Ecosystem Model (Figure 5). The Enterprise Ecosystem Model (The Open Group 2013) developed in order to identify the role of the EA frameworks, EA modeling languages and EA activities on the Business Capability Management. Then the Cloud Ecosystem Reference Model (The Open Group 2013) is suitable to identify (based on the capabilities found before) the relationships, actors and ABBs that can be used in the development of the enterprise Cloud Ecosystem.

Apart from the weaknesses, TOGAF for Cloud Ecosystems viewpoints can adequately visualize the impact of the migration to the Cloud. Some of the important viewpoints of the resulting approach (including others) are the following:

- Actor co-operation
- Layered
- Landscape map
- Implementation and Migration
- Data Dissemination Diagram

According to the interviewee, the significance of the viewpoints changes based on architecture principles. Some of the principles associated with the Cloud Ecosystem of ArchiSurance are resource pooling, rapid elasticity, performance measurement, and self-service capabilities of Cloud over standard network access. Based on them, NFRs can be identified that must be addressed in the enterprise Cloud Ecosystem of ArchiSurance. Indicative NFRs are capacity planning, response time, security and interoperability. These can be addressed by incorporating them in the design (ArchiMate viewpoints) and ensure that they are part of SLAs. Additionally after careful assessment in the sensitive information that the CRM handles the

Personal Identifiable Information and the Financial Information of the customers must be kept on-premise in the Cloud migration of ArchiSurance.

Overall Cloud Computing increases the need for EA since decisions are to be made to keep extended organizational boundaries. The TOGAF for Cloud Ecosystems approach can bring many benefits since it allows describing and visualizing inter-relationships among various stakeholders of an organization. It unambiguously describes and realizes the functional capabilities of business solutions and documents the behavior of the system for future use.

Interview No 3 – Cloud Computing and Enterprise Architecture consultancy

Name: Daniel Jumelet
Organization: BiZZdesign
Function: IT Infrastructure Consultant
Date: 14/08/2013
Duration: 1hr & 45min

Role of Interview No3

The role of interview No3 was to check the relevance and applicability of the TOGAF for Cloud Ecosystems approach in the field of Enterprise Architecture and Cloud Computing consultancy. BiZZdesign is a leading consultancy company providing consultancy, training and tool support in the field of Enterprise Architecture and Business Process Management. Nowadays more and more customers of BiZZdesign need to adopt and adapt Cloud solutions in their Enterprise Architecture landscape. Consequently we investigated the EA framework(s) and modeling language(s) that are being used in BiZZdesign for developing an enterprise Cloud Ecosystem together with possible extensions and improvements for them. Interview No3 focuses on the decision making process for EA teams which consider adopting Cloud solutions in their organization. Based on these, the interviewer and the interviewee discussed how TOGAF for Cloud Ecosystems approach can be improved in order to be applicable in the future EA programs of BiZZdesign. The feedback applied to TOGAF for Cloud Ecosystems approach.

EA framework support to develop, manage and govern enterprise Cloud Ecosystems

At BiZZdesign they use EA frameworks and modeling languages to create EA in Cloud Ecosystems. The consultancy team uses ArchiMate combined with customized versions (based on the demands of the project) of TOGAF. Although TOGAF is an efficient framework to define the Business Architecture and identify capabilities that help realize the target situation, when it comes to the Technical Architecture (infrastructure) and the Data Architecture the guidance is too general to solve specific problems. For these domains they use Open Infrastructure Architecture Method (OIAm) (Schoonderbeek et al. 2013) because it translates the desired functionality to devices, services or applications. As Daniel Jumelet, states first the desired functionality must be defined and then the supporting services or applications can be identified. He continues saying that, for an architect it is not suitable to transfer directly from process to infrastructure, because usually an architect starts from the to-be situation to the as-is which contradicts with TOGAF.

Current EA and Cloud Computing practice

BiZZdesign consumes some standalone public Cloud services like WebEx (teleconferencing service). However BiZZdesign has significant experience with Cloud Computing and Enterprise Architecture consultancy. According to Daniel Jumelet, the successful Cloud use cases concerning niche solutions and very specialized services (which are difficult to be built or very expensive to buy) like super computers as a service to deploy scientific experiments, for example. Some other successful use cases have to do with small desktop/administrative applications (like Google Docs or storage services) for small non IT-intensive companies. These use cases are successful examples because they have to do with highly standardized applications (=>reduced integration and interoperability issues) while the business importance is low (=>less risks and threats to mission critical applications). Apart from these it is difficult to identify other successful Cloud migrations.

In a traditional on-premises infrastructure, the organization is aware of its own IT resources and this situation can be characterized as maximum flexibility, high capacity, homogenous environment, and transparency. Now the outsourced infrastructure can bring many drawbacks, such as need for higher bandwidth, monitoring, compliance, quality, secure login issues, because the organization is not responsible for the supporting services and that complicates the situation. The biggest benefit is that the organization does not have to buy or built the services or infrastructure, but then tax (VAT) is added the price.

Evaluation of TOGAF for Cloud Ecosystems approach

Following it is provided the opinion of the interviewee on how TOGAF for Cloud Ecosystems approach can be improved in order to facilitate better decision making towards the Cloud by delineating risks and concerns. According to Daniel Jumelet, Cloud Computing may solve the problem of buying the infrastructure, but it creates indirect problems to the Cloud consumer organization by losing control of its own infrastructure. Hence the main motivation for the Cloud should be quick response to business needs rather than cost reduction. For a successful deployment of enterprise Cloud Ecosystem you need a strong direction from the demand side to the supply side to be well controlled, in order to direct many parties not only from a contract point of view but also from a content point of view. The desired functionality and quality must be very specific both in the contract and in the content of the enterprise Cloud Ecosystem. Then the decision making should be based on the application landscape (and application functions) and not from the infrastructure point of view. So the decision (what to migrate to the Cloud and what to keep on-premises) is made based on what functionality you want to migrate to the Cloud rather than applications or devices. It is important to know how the applications interact in order to do the migration successfully.

The following matrix helps decide what applications are better to migrate to the Cloud than others. The ideal situation is where the standardization of the candidate service is high while the business importance is low (3rd quadrant).

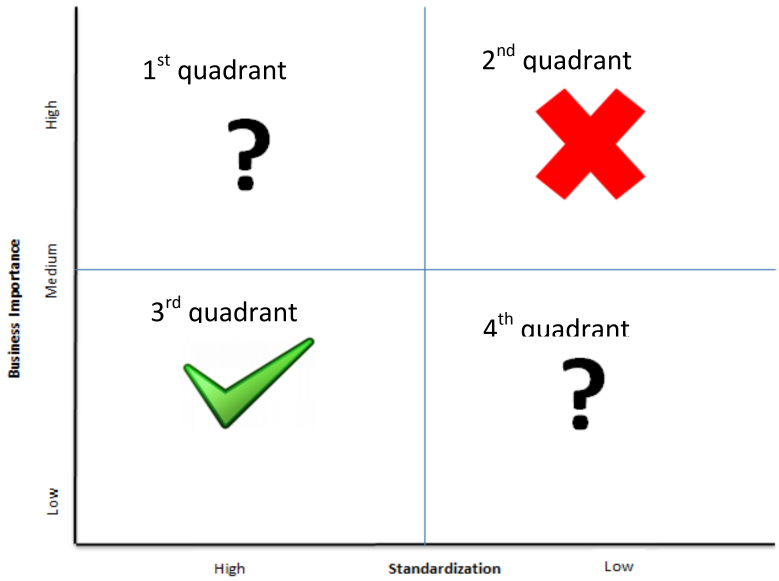


Figure 66: Decision support matrix of what applications to migrate to the Cloud.

The mission critical applications and hardware should remain always on premises (2nd quadrant). The other two quadrants correspond to low standardization and low business importance (and vice versa) so the decision towards Cloud migration should be justified with other techniques as well. The EA can help on identifying feasible Cloud candidates and also the corresponding processes and applications. Then the EA identifies all these interdependencies and interconnections in order to have a second check and having in place some guidelines. The functionality and the architecture requirements attached to the EA documentation, guide the process of developing an enterprise Cloud Ecosystem.

Daniel Jumelet stated, what should be considered in order to avoid integration and interoperability problems with the Cloud. An organization that desires to be SOA-enabled, needs to control the ESB because if it wants to connect another external party it needs to be connected through the ESB. When you start with one CSP who provides networking, capacity, storage and ESB then you start creating another vendor log-in because if you want to connect another party you have to connect it through the external ESB. Then it needs to consider (from Figure 6) interoperability, security and operational support services so that you can manage your cloud providers. The CSP must be auditable but the organization needs some short of monitoring, administering and log-in information in order to have access to this log-in information by enforcing contract agreements. The CSP must allow consumers to connect other service provider and by making use of their own integrating capabilities.

The interviewee suggested some more important NFRs that should be considered in the development of an enterprise Cloud Ecosystem of ArchiSurance. These NFRs are: self-service, manageability of the solution, adaptability, scalability (not an issue most of the time), availability, business continuity and resilience. For the CRM the important information that must be kept on-premises depends on the organization and the auditability (important quality aspect) of the provider.

Regarding TOGAF for Cloud Ecosystems approach Daniel Jumelet believes that Cloud Computing is not tightly connected with Enterprise Architecture because at the end the organization will have the same processes and the same services. Enterprise Architecture helps to identify what service are going to be impacted and interrelated to each other. But Cloud is not about defining and designing other services but other way of delivering services. Architecture helps align requirements with the delivered architecture. Lastly TOGAF for Cloud Ecosystems approach can accelerate the adoption of Cloud-base solutions but it depends on the way the models are created. If models are lacking information and refer only to services and application components and the functionality that is delivered is not clear then there is no value for the resulting architecture. The resulting models of the approach should be focused on the right aspects and they should be function-based (desired functionality) instead of component-based (desired applications and hardware). That is because in a Cloud Ecosystem it is not described the components that are being deployed but only the delivered functionality. Functionality must take place before construction.

10.3 Conclusion

Throughout this chapter TOGAF for Cloud Ecosystems approach was evaluated by specialists in the field of Cloud Computing and Enterprise Architecture from both the Netherlands and from U.S.A. The response to the approach is the summarized in the sequel. The original version of TOGAF (The Open Group 2011) can facilitate the development, management and governance of an enterprise Cloud Ecosystem by tailoring its content in order to become Cloud-enabled. It means that it is more useful to provide specific guidelines and model-based support, for the existing knowledge base of TOGAF, rather than creating yet another new methodology. Developing a new methodology would not bring any value to the academic and practice communities because people prefer using methods and tools which feel comfortable with them.

A TOGAF-based EA program requires a lot of time, effort, and resources because of its size and unnecessary activities (for the Cloud Ecosystem context) which suggests. However in an enterprise Cloud Ecosystem project one of the main motivators towards the Cloud is rapid service provisioning in order to achieve business agility. Consequently the original version of TOGAF (The Open Group 2011) is not appropriate for developing an enterprise Cloud Ecosystem. Specifically the interviewees suggested the following improvements:

1. TOGAF for Cloud Ecosystems approach, must be enriched with new concepts and reference models like the Cloud Ecosystem Reference Architecture (Figure 6) and the Enterprise Ecosystem (Figure 5). In that way the overall context of the organization and its problems are well understood in the sense that stakeholders, roles & relationships, ABB, business processes, services, monitoring capabilities and desired functionality of the Target Architecture can be identified. Additionally, these reference models help identify architectural viewpoints for designing the enterprise Cloud Ecosystem.

2. Before initiating an enterprise Cloud Ecosystem program the organization must be carefully consider which capabilities should be outsourced and why, by performing assessments (need assessment, readiness assessment, sensitive information and data assessment, monitoring and capacity planning assessment) and providing financial data (i.e. Business Case for using Cloud from Isom & Hawley, 2010) to justify the adoption of a Cloud solution. However, it is important to think in terms of desired functionality rather than specific solutions because the solutions may change rapidly (especially in the Cloud Ecosystem), while the need for a specific functionality that can be addressed by adopting a traditional service or a Cloud-based service lasts as long as there is sufficient demand for it. Consequently, the enterprise Cloud Ecosystem documentation stays for longer time unchanged or with small modifications.

3. Apart from the assessments, the decision of using Cloud services can be justified from the motivation, stakeholder concerns, and the EA design (ArchiMate viewpoints). The requirements and principles should guide all the enterprise Cloud Ecosystem activities. It is prominent to address effectively not only the functional but also all the non-functional requirements. The interviews revealed significant information on the impact of integration, interoperability, security and privacy issues on the enterprise Cloud Ecosystem design. Careful assessment of the sensitive information is important in order to decide whether the information stays on-premises or off-premises. Mutual authentication and strong encryption on the integration channels should be considered as well.

4. The combination of ArchiMate and TOGAF can provide significant guidance and model-based support through the development, management and governance of the enterprise Cloud Ecosystem. However, TOGAF is not used in the participants' organizations as a standalone EA framework, but always customized to address the specific needs of each EA program. On the other hand, ArchiMate addresses effectively all the NFRs and design issues by developing, documenting and communicating the enterprise Cloud Ecosystem.

Several suggestions were made by the participants in these interview sessions which improved the approach. TOGAF for Cloud Ecosystems approach can bring many benefits since it allows us to describe and visualize inter-relationships among various stakeholders of an organization. Our approach unambiguously describes and realizes the functional capabilities of business solutions and documents the behavior of the system for future use. Lastly it is important in a new Cloud EA program to assess carefully what is the desired functionality or capabilities that the organization wants to realize by migrating its infrastructure or applications to the Cloud.

Chapter 11 – Conclusions

The outline of this chapter is the following: Section 11.1 concludes this thesis based on the studied literature, the TOGAF for Cloud Ecosystems approach and the demonstration and evaluation of it. Section 11.2 is about the limitations of the research. Section 11.3 provides recommendations for further research and Section 11.4 presents the contribution for BiZZdesign.

11.1 Answer to the Research Questions

The scope of the present research is made clear by investigating how the most suitable EA framework can be tailored to facilitate the development, management and governance of an enterprise Cloud Ecosystem. The TOGAF for Cloud Ecosystems approach that is presented throughout this thesis proposes a Cloud-enabled version of TOGAF. The end result of the thesis is comprised from two parts:

i. Specific guidelines are given for TOGAF ADM, which focus on the Cloud-enabled approach, steps and deliverables of each ADM Phase. The set of guidelines steer the development, management and governance of enterprise Cloud Ecosystems with the use of TOGAF and ArchiMate.
ii. Model-based support for the enterprise Cloud Ecosystems. The aforementioned guidelines are demonstrated in the context of the ArchiSurance case study in order to provide information on how to develop an enterprise Cloud Ecosystem with the Cloud Ecosystem Reference Model (Figure 6). ArchiMate is used to model the deliverables of every ADM Phase for the ArchiSurance CRM Cloud migration scenario. The models can be used as reference models for various insurance companies.

The list below is summarizing why TOGAF is chosen as the most appropriate EA framework for Cloud Ecosystems:

- Widely accepted and used from various companies which operate in different industries.
- Integrated architecture modeling language (ArchiMate).
- The architectural domains in TOGAF are divided into layers which can be applied to Cloud Computing.
- Integrated with other frameworks (COBIT, ITIL, PRINCE2, PMBOK, MMI, and MSP).
- ADM process completeness and reference model guidance.
- Vendor neutrality and information availability.

On the one hand, TOGAF is a general EA framework which can be applied to various Enterprise Architecture programs and industries. The disadvantages of TOGAF are long winded documentation which does not cover Cloud Computing at all; and also it is time intensive, provided that you follow all the ADM Phases and steps. On the other hand, Cloud Computing is not a new architectural style but a new way of delivering services to organizations and end-users. Consequently there is no need to create a new EA framework for Cloud Ecosystems. However it is necessary to tailor the existing EA framework to become Cloud-enabled. For this reason Cloud-specific guidelines and reference models are created for TOGAF. This would save significant amount of time and effort for the Enterprise Architects because they can focus only on the relevant aspects when developing, managing and governing an enterprise Cloud Ecosystem.

The starting point in a Cloud Enterprise Architecture program is to investigate what the organization wants to do with the Cloud. So it is important to assess carefully the current and target business capabilities, the business readiness to undergo the change and the existing Cloud-based solutions. Cloud-specific principles, goals and requirements guide and motivate the Cloud Enterprise Architecture program. The Business Scenario helps to identify a business solution (and not architectural style) to the business problem. Then, this solution can be translated to desired functionality that the Target Architecture should have. The development of each architecture domain (Business Architecture, Information Systems Architecture and Technology Architecture) is focusing on the interconnections/interdependencies between actors, processes, functions, information systems and devices in the extended Cloud Ecosystem. It is also important to address effectively the non-functional and functional requirements in the Cloud Enterprise Architecture while additional focus is given on the integration of the Cloud solution with the on-premise infrastructure. The transition from the Baseline to the Target situation should ensure that the right Cloud and Business services are provided to the end-user (either customer or employee). Then monitoring and auditing capabilities should be in place together with robust contract agreements to ensure business continuity and that the desired content and functionality are provided in order to achieve the business goals.

ArchiMate is used to visualize all these issues. ArchiMate is the only modeling language that connects the Business with the Application, Data and Technology Architectures. Also it addresses effectively all the integration issues (information exchange, message handling, interfaces), functional and non-functional requirements and the relationships between actors, processes, applications and infrastructure in the extended Cloud Ecosystem. The produced models can be used as reference models for an organization that wants to adopt SaaS in the insurance industry.

At the end of the research we performed three interviews in order to gain feedback from practice to evaluate the resulting approach. The feedback revealed that the Cloud Ecosystem Reference Model (Figure 6) the Enterprise Ecosystem Model (Figure 5) together with the suggested guidelines can steer effectively the development, management and governance of enterprise Cloud Ecosystems. The feedback from practice applied to improve the TOGAF for Cloud Ecosystems approach while the inadequacies which are not addressed in the approach are listed in Sections 11.1 and 11.2.

All in all, Cloud Computing increases the need for Enterprise Architecture since decisions are to be made to keep extended organizational boundaries. The model and guideline support that is provided in this thesis help to describe and visualize the inter-relationships among various stakeholders, processes, Information Systems and infrastructure in extended business environments. It also describes the functional capabilities of business solutions and documents the behavior of the system for future use.

11.2 Limitations

Although the research has reached its aims there were some unavoidable limitations. Even though there is a lot of research going on, on Enterprise Architecture and Cloud Computing there was no scientific research on the topic at all, while the only reference materials that were available were only some personal opinions mainly in blogs and virtual community websites. This did not allow checking whether the research is aligned with the scientific or practitioners' community in the field.

Furthermore, TOGAF for Cloud Ecosystems approach is focusing only on guidelines (how to use TOGAF in Cloud Ecosystems) and model-based support. Even though it provides efficient guidance for an enterprise Cloud Ecosystem program there are more techniques and tools that can assist the development, management and governance of enterprise Cloud Ecosystems with TOGAF. It is missing financial data to justify the decision *"go"* or *"no go"* to the Cloud. Moreover TOGAF suggests many assessment techniques namely, need, readiness, sensitive information/data, monitoring and capacity planning assessments. It would be useful to study how these techniques are impacted from the Cloud Ecosystem and provide examples of their applications. Elaboration on the gap analysis (between the Baseline and Target Architectures) would bring more information on the decision making during the architectural development of the enterprise Cloud Ecosystem. Additionally TOGAF for Cloud Ecosystems approach is focusing on the ADM process and its guidelines rather than TOGAF as a whole.

Apart from these, TOGAF has its own limitations. TOGAF is very good with developing the Business Architecture but in other architecture domains (Data, Application and Technology Architectures) is a bit abstract. To avoid this shortcoming it would be interesting to combine TOGAF with other EA frameworks and configure it in a way to be more specific in these domains as well. Also TOGAF is time intensive meaning that the framework is not appropriate when fast decisions must be made (e.g., what capabilities to migrate to the Cloud).

Another limitation refers to, in the use of only qualitative research methods (case study and interviews). The strength of qualitative research consists in collecting information in many ways, rather than choosing one. Although the information gathered for analysis conferred important data for answering the research questions, proper evaluation of the TOGAF for Cloud Ecosystems approach would bring more opinions and consequently, more information concerning the research.

11.3 Recommendations for Future Work

There are several aspects that have not been addressed from the thesis because of time limitation and because it was outside of the scope.

First of all it would be interesting to investigate the impact of Cloud Computing on the Enterprise Continuum, Architecture Capability Framework and Architecture Content Framework. Practical guidelines about creating the contract with the CSPs would be excellent to ensure the architecture has clarity about logical and physical terms of service.

It is suggested also to explore the creation of a Cloud discovery workshop or adding a separate phase for it in the ADM. As it is pre-mentioned TOGAF ADM is time intensive process which may not be suitable for fast decision making. The Cloud discovery workshop (or phase) will enable the organization to identify its business problem, potential solution together with its Cloud readiness state (how ready the organization is to adopt Cloud-based solutions). The decision towards or against the Cloud migration should be justified with financial data and the business case.

Another idea for reliable decision making for Cloud Ecosystems can be the integration of probabilistic distribution to the ArchiMate meta-model, so someone can reach decisions based on the ArchiMate models. Also mapping BPMN with ArchiMate for Business Architecture and mapping to UML for the IS or Technology Architectures could be further elaborated.

11.4 Contribution for BiZZdesign

When using TOGAF for Cloud Ecosystems approach in an organization there are several aspects that need to be taken into account. In order to use the method effectively, for each phase of the approach need to be allotted the necessary time and resources for gathering information, designing, analyzing and reaching decisions concerning the Enterprise Architecture for Cloud Ecosystems. It does not offer a one-time fix for organizations. In the contrary it offers the right guidance for managing the development of the Enterprise Architecture and the migration of capability(ies) in the Cloud, as an on-going process. Another aspect that needs to be taken into account, when using TOGAF for Cloud Ecosystems approach, is that knowledge of TOGA framework, techniques and modeling notations which are included in the approach is required.

By following TOGAF for Cloud Ecosystems approach, BiZZdesign can develop its own enterprise Cloud Ecosystems by integrating all stand-alone Cloud solutions that consumes in a fully-fledged EA for CE. Furthermore this piece of research can provide valuable input to future projects for migrating some of the processes to the Cloud. For example BiZZdesign may need to migrate to the Cloud some processes (e.g., delivering BiZZdesign software products through the Cloud instead of the traditional way of the CD-ROM) or adopting a new Cloud-based solution (e.g., CRM, workspace, bulk e-mail). Then the new EA program can be supported from TOGAF for Cloud Ecosystems approach.

Moreover TOGAF for Cloud Ecosystems approach can support the development, migration, delivery and governance of the enterprise Cloud Ecosystem for the customers of BiZZdesign. BiZZdesign provides consultancy, training and tool support in the field of Enterprise Architecture and Business Process Management. However the frameworks and the training materials refer to situations where the IT landscape resides on-premises. Consequently, this thesis, can support the consultants of BiZZdesign when undertaking an EA program for Cloud Ecosystems with specific guidelines and model-based support. Additionally the materials of this research can be used to create a new training in the field of Enterprise Architecture, TOGAF and Cloud Computing. In that way the portfolio of BiZZdesign includes new training session(s) and EA framework support for emerging technologies (i.e. Cloud Computing). As a result new revenue streams are identified for BiZZdesign and that can increase the profitability and performance of the company.

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Acronyms

Short Form	*Description*
EA	Enterprise Architecture
ABB	Architecture Building Block
SBB	Solution Building Block
CSP	Cloud Service Provider
IaaS	Cloud Infrastructure as a Service
KPI	Key Performance Indicator
PaaS	Platform as a Service
PMO	Program Management Office
CPMO	Cloud Program Management Office
QoS	Quality of Service
SaaS	Software as a Service
SLA	Service Level Agreement
FTP	File Transfer Protocol
ESB	Enterprise Service Bus
DaaS	Data as a Service
HTTP	Hyper-Text Transfer Protocol
CRM	Customer Relationship Management
LDAP	Lightweight Directory Access Protocol
LAN	Local Area Network
NFR	Non-Functional Requirement
XML	Extensible Markup Language
BPM	Business Process Management
CMP	Cloud Management Platforms
IT	Information Technology
TOGAF	The Open Group Architecture Framework
ADM	Architecture Development Method
FEAF	Federal Enterprise Architecture Framework
OpEx	Operational Expenditures
CapEx	Capital Expenditures
DevOps	DevOps
SOA	Service-Oriented Architectures
EIM	Enterprise Information Model

Appendix I: Cloud Ecosystem Reference Model ABBs Taxonomy

Business Support Services	
Architecture Building Blocks (ABBs)	**Description**
Accounting & Billing Service	The Accounting & Billing Service generates and manages bills for the Cloud Service usage data using a set of predefined billing policies. Cloud Service Providers could allow production of one bill for multiple subscriptions of Cloud Services for the consumer and combining usage from multiple subscriptions to qualify for volume pricing discounts. It also manages other accounting-related activities (process payments, track invoices, etc.).
Auditing & Reporting Service	The Audit & Reporting Service provides a mechanism to record activities (including exceptions and events) and keeps them for an agreed time period to assist future investigations. Care must be taken to minimize the performance degradation and the risk of disruption to business processes. It generates reports to effectively perform client-facing business operations activities.
Availability & Continuity Service	The Availability & Continuity Service controls the redundancy, workload mobility between different Cloud Service Providers, and ensures that Cloud Services are built with high availability design practices and considerations.
Compliance & Policies Service	The Compliance & Policies Service defines, integrates, and aligns activities such as corporate governance and corporate compliance with applicable laws and regulations. It maintains an organizational structure, process, tools, and business policies to ensure adherence to applicable laws and regulations.
Consumer Service	The Consumer Service (*aka* Customer Management) provides an authoritative view to Cloud Service Consumers' information to ensure effective care is provided and information about consumer relationships is well managed.
Contract & Agreement Service	The Contract & Agreement Service handles contract life cycle (set-up, negotiate, close, terminate, etc.) and the ways in which various aspects of Cloud Services are offered and managed for Cloud Service Consumers. The contract states the terms and conditions for service usage (constraints, costs, and billing information) by the Cloud Service Consumer and includes applicable Cloud Service policies, Service-Level Agreements (SLAs) – availability, performance, etc. – to ensure that Cloud Service Providers provision services that meet the defined agreement.
Metering Service	The Metering Service is essential for billing/charging Cloud Services and their underlying resource usages (i.e., Cloud Services and resources allocation and consumption). It provides a metering capability with some level of abstraction appropriate to the type of service (e.g.,, storage, processing, bandwidth, and active user accounts).
Order Service	The Order Service controls the life cycle of Cloud Service orders (from a Cloud Service provisioning request capture to de-provisioning). It utilizes Cloud Service configuration, service life cycle, service orchestration (if required), and accounting and billing services.
Service Demand Service	The Service Demand Service is to understand the business demand for Cloud Services (e.g.,, in the case of IaaS, demand in the form of bandwidth, memory, CPU capacity, support personnel, etc.) based on the past business activity patterns combined with the future business growth estimate.
Subscription Service	Cloud Service Providers could enable multiple subscription models for charging Cloud Services' usage by utilizing the Subscription Service. These subscription models may include fixed, tier-based (e.g.,, Gold, Silver, and Platinum), pay-as-you-go payment terms (monthly, quarterly, annually). The Cloud Service Provider monitors allocation and consumption of Cloud Services and chargeback to its subscribed consumers based on subscription models.

Operational Support Services	
Architecture Building Blocks (ABBs)	**Description**
Capacity & Performance Service	The Capacity & Performance Service (*aka* Workload Management) allows efficient allocation and optimal use of underlying Cloud Resources. It analyzes performance of running Cloud Services in real-time and automatically adjusts the workload. If applicable, it utilizes external Cloud Service Providers' computing services by using inter-cloud connection services to meet the defined SLAs.
Incident & Problem Handler Service	The Incident & Problem Handler Service deals with any service-related incidents and associated problems and performs root cause analysis. It could store information in a knowledge support repository for further analysis that may include trend analysis to enable the evolution of the Cloud Services to prevent future incidents.
Inter-Cloud Connection Service	The Inter-Cloud Connection Service serves as a seamless connector from one cloud environment to another cloud environment (e.g.,, private cloud environment to external/public cloud environment) to enable Cloud Service interoperability. A Cloud Service connection ensures secure connectivity, traverses different network boundaries seamlessly, and enables performance improvement capabilities (e.g.,, compression).
IT Asset & License Service	The IT Asset & License Service controls licensing agreements of various aspects of Cloud Services that can be purchased and sold. Some Cloud Service Providers also allow Cloud Service Consumers to directly lease or buy licenses from the software/solution vendors or provide licenses on-demand.
Rapid Provisioning	Rapid Provisioning delivers architectural capabilities to quickly scale in or scale out computing resources normally delivered by at least one of the participating entities. Once self-subscribed to a catalog service, Rapid Provisioning capabilities automatically deploy Cloud Services based on a requested service capability. In a mature cloud environment, the Cloud Service Consumer could also have the capability to customize experience based on their role within the organization.
Service Life Cycle	Service Life Cycle (*aka* Service Delivery Management) controls the Cloud Services (including underlying Cloud Resources) life cycle from provisioning to de-provisioning dynamically (some Cloud Service Providers utilize workflow to manage the process). It also provides the visibility, control, and automation across cloud environments (e.g.,, private, public, and hybrid environments) to address business-critical challenges.
Service Orchestration	Service Orchestration serves as an efficient way to manage the Cloud Services (including underlying Cloud Resources) capacity and performance (it even instigates an external service gateway for workload management) automatically. It seamlessly coordinates Cloud Services in multiple cloud environments (e.g.,, internal/private and public cloud environments).
SLA Compliance Service	In order to ensure a high-level of service standards on Cloud Services, Cloud Service Consumers demand strict implementation of SLAs from Cloud Service Providers. Any degradation of service performance could have severe impact on revenue and end-user satisfaction. The SLA Compliance Service helps define SLAs and ensure their compliance and improve relationships with Cloud Service Providers. This service provides real-time assessment and SLA compliance reporting on Cloud Services.
Template Service	The Template Service provides re-creatable instances from service templates. In case of IaaS, the Template Service describes how the instances are to be configured (machine images, network connectivity, storage requirements, etc.) and deployed on a dynamic infrastructure environment. The Template Service also enables auto provisioning/re-deploying applications on a Cloud Service platform.

Cloud Security Services	
Architecture Building Blocks (ABBs)	**Description**
Data Protection	"In the information age, data is an asset. However, most data remains valuable only if it is protected. Data Protection needs to cover all data life cycle stages, data types, and data states. Data stages include create, store, access, roam, share, and retire. Data types include unstructured data, such as word processing documents, structured data, such as data within databases, and semi-structured data, such as emails. Data states include Data At Rest (DAR), Data In Transit (DIT) (also known as "data in motion" or "data in flight"), and Data In Use (DIU). The controls of Data Protection are data life cycle management, data leakage prevention, intellectual property protection with digital rights management, and cryptographic services, such as key management and PKI/symmetric encryption." The Enterprise Data Management function described below consistently applies security policies to all data types, data life cycle stages, and states.
	Enterprise Data Management In a knowledge economy, information/data is a crucial enterprise asset that has to be managed in order to securely share information within an enterprise Cloud Ecosystem. The Enterprise Data Management functions have to execute for all of the life cycle phases for all classes of data. The key Enterprise Data Management functions (refer to The Open Group White Paper: An Information Architecture Vision) are data governance, information planning and architecture, information provisioning, records and archives provisioning, and information privacy. All manner of information/data has to be managed. Data can be classified as unstructured (human-processable only, such as an image); semi-structured which is machine-readable (e.g.,, an e-document), or structured which is machine-processable. Information is used by business users and consists of one or more classes of data (refer to The Open Group White Paper: An Information Architecture Vision). Metadata is data about the data (e.g.,, creator, date/time of creation, security classification, and so on) that has to be standardized and managed within an enterprise Cloud Ecosystem. Refer to The Open Group Guide: Cloud Computing Portability and Interoperability for detailed information.
Governance Risk & Compliance	"Governance Risk & Compliance encompasses, integrates, and aligns activities such as corporate governance, enterprise risk management, and corporate compliance with applicable laws and regulations. Components include compliance management (which assures compliance with all internal information security policies and standards), vendor management (to ensure that service providers and outsourcers adhere to intended and contractual information security policies applying concepts of ownership and custody), audit management (to highlight areas for improvement), IT risk management (to ensure that risks of all types are identified, understood, communicated, and either accepted, remediated, transferred, or avoided), policy management (to maintain an organizational structure and process that supports the creation, implementation, exception handling, and management of policy that represent business requirements), and technical awareness and training (to increase the ability to select and implement effective technical security mechanisms, products, process, and tools)."
Infrastructure Protection Services	"Infrastructure Protection Services secure server, end-point, network, and application layers. This discipline uses a traditional defense-in-depth approach to make sure containers and pipes of data are healthy. The controls of Infrastructure Protection Services are usually considered as preventive technical controls such as IDS/IPS, firewall, anti-malware, white/black listing, and more. They are relatively cost-effective in defending against the majority of traditional or non-advanced attacks."

Cloud Security Services	
Information Security	The main objective of Information Security (*aka* Information Security Management) is to implement the appropriate measurements in order to minimize or eliminate the impact that security-related threats and vulnerabilities might have on an organization. Often Information Security will address privacy and confidentiality concerns; especially in international enterprises where national legislation may differ significantly and impact the transit and storage of data/information. Information Security is reliant on cloud-consistent security labeling (e.g.,, security classification) and compartmentalization as necessary. This is imperative if the cloud uses information rather than network-centric security. Other controls will dictate the security during data states including matters such as encryption protocols when data is in use, in transit, or at rest (DIU, DIT, DAR).
	Risk Management Risk Management starts with the categorization and costing of information and related technology assets. Subsequently, risks are identified and classified along with the resultant management decisions to accept, mitigate, transfer, or avoid them. Risks are constantly monitored and reviewed whenever there are any changes to the cloud architecture. Dashboards for security management and risk management are used to measure and report the level of effectiveness of decisions and help the organization make new decisions that will maintain and improve that effectiveness. Analysis and plans for remediating residual risks are also part of the overall risk management framework.
Privilege Handler Service	The Privilege Handler Service (*aka* Privilege Management) ensures that users have the access and privileges required to execute their duties and responsibilities with Identity and Access Management (IAM) functions such as identity management, authentication services, authorization services, and privilege usage management. This security discipline enables the right individuals to access the right resources across increasingly heterogeneous technology environments and meet increasingly rigorous compliance requirements. The technical controls of the Privilege Handler Service focus on identity provisioning, passwords, multi-factor authentication, and policy management. This security practice is a crucial undertaking for any enterprise. It is also increasingly business-aligned, and it requires business skills, not just technical expertise.”
Threat and Vulnerability Service	This discipline (*aka* Threat and Vulnerability Management) deals with core security, such as vulnerability management, threat management, compliance testing, and penetration testing. Vulnerability management is a complex endeavor in which enterprises track their assets, monitor and scan for known vulnerabilities, and take action by patching the software, changing configurations, or deploying other controls in an attempt to reduce the attack surface at the resource layer. Threat modeling and security testing are also part of activities in order to identify the vulnerabilities effectively.
Policy & Standards	“Security policies are part of a logical abstraction of enterprise security architecture. They are derived from risk-based business requirements and exist at a number of different levels, including information security, physical security, business continuity, infrastructure security, application security, as well as the overarching business operational risk management. Security policies are statements that capture requirements specifying what type of security and how much should be applied to protect the business. Policies typically state what should be done, while avoiding reference to particular technical solutions. Security standards are an abstraction at the component level and are needed to ensure that the many different components can be integrated into systems. Internationally recognized standards for various aspects of security from standard bodies include ISO, IETF, IEEE, ISACA, OASIS, and TCG. Direction can also be provided in the form of operational security baselines, job aid guidelines, best practices, correlation of regulatory requirements, and role-based awareness. One way to approach security policy and its implementation is to classify information and associate policies with the resulting classes of data.”

Performance Services	
Architecture Building Blocks (ABBS)	**Description**
Resource Health Monitoring	Resource Health Monitoring provides an integrated view of Cloud Resources health to achieve better performance, accountability, and business results to support cloud operational events and generate Cloud Resources performance reports. It also provides instrumentation capabilities to monitor defined SLAs.
Service Health Monitoring	Service Health Monitoring provides an integrated view of Cloud Services health to achieve better performance, accountability, and business results to support cloud operational events and generate Cloud Services performance reports. It also provides instrumentation capabilities to monitor defined SLAs.
SLA Enforcement	SLA Enforcement ensures that SLAs defined in the service contract are rigidly enforced in order to avoid any applicable penalties. Captured data related to SLAs also provide opportunities to make adjustments to contracts and agreements during the subscription renewal process.

Interoperability and Portability Services	
Architecture Building Blocks (ABBs)	**Description**
Information/Data Interoperability	Information/Data Interoperability provides the Cloud Service Consumer with the ability to effectively manage the life cycle of both structured and unstructured data of an enterprise. It provides mechanisms to classify data, access policies, and information protection to adhere to compliance regulations and legislation. Information/data interoperability requires a consistent structure for behavior data interoperability (i.e., rules and data behavior). Semantically consistent information allows data to be shared and re-used across applications and enterprises boundaries. This could include the use of cloud-specific metadata-based semantic standards such as The Open Group Universal Data Element Framework (UDEF) (refer to The Open Group UDEF webinar) or the US Government National Information Exchange Model (NIEM). This would enable the information/data to be shared and re-used within an enterprise Cloud Ecosystem. Refer to The Open Group Guide: Cloud Computing Portability and Interoperability for detailed information.
Service Interoperability	Service Interoperability is the ability of Cloud Service Consumers to use their data and services across multiple Cloud Service Providers with a unified management interface (refer to NIST SP 500-292). The following highlights interoperability/portability as service model levels. Refer to The Open Group Guide: Cloud Computing Portability and Interoperability for detailed information.
	IaaS Interoperability IaaS Interoperability (*aka* System Portability – refer to NIST SP 500-292) provides a mechanism for Cloud Service Providers to provision a workload (e.g.,, compute) either an internal environment or onto an external Cloud Provider's environment and seamless migration of information about the service and its underlying resources.
	PaaS Interoperability The PaaS level of interoperability focuses on the ability to provide seamless coordination in the development and deployment of platform services and associated licenses. Currently there is little or no portability provided at the PaaS level.

Interoperability and Portability Services	
	SaaS Interoperability Cloud Service Consumers expect to have the ability to support critical SaaS applications' features on a variety of channels (e.g.,, web, mobile, smart phone, etc.). Interoperability on common features is usually supported (where possible) by utilizing presentation abstraction.
Data Portability	**Data Migration** Data Migration provides an automated mechanism to transfer data from one cloud environment to another or to other computing systems.
	Data Synchronization Data Synchronization is the mechanism to ensure consistency across the Cloud Ecosystem to a single set of source data for all duplicated target data storage and *vice versa*. It ensures the continuous coherency of the data over time. It is a fundamental requirement for globally distributed applications (e.g.,, file synchronization between regions, and base information synchronization between catalogs). For example, a common service catalog data model that allows data synchronization capabilities between a Cloud Service Provider's service catalog and a Cloud Service Consumer's product catalog.

Resource Catalog Services	
Architecture Building Blocks (ABBs)	**Description**
Change & Configuration Service	The Change & Configuration Service for resources ensures that the configuration of Cloud Services remains compliant with the changes in policies and compliance. It maintains an accurate configuration of the Cloud Services offered in the catalog. It also ensures that CMDB information is highly available, secured, and in compliance with applicable licensing terms and conditions.
Resource Catalog	The resource catalog manages information about the resources required to support Cloud Services provisioning requests captured through the self-service Cloud Service management provisioning channel. The resource catalog also includes technical, business, and compliance constraints.

Product Catalog Service	
Architecture Building Blocks (ABBs)	**Description**
Change & Configuration Services	The Change & Configuration Services ensure that the configuration of Cloud Services remains compliant with the changes in policies and compliance. It maintains an accurate configuration of Cloud Services offered in the catalog. It also ensures that the Configuration Management Database (CMDB) information is highly available, secured, and in compliance with applicable licensing terms and conditions.
Service Catalog	The Service Catalog provides flexible and easily configurable catalog information (description, type, associated base SLAs, etc.) and enables a mechanism for Cloud Service Consumers to subscribe to listed services. The information is generally collected through a self-service Cloud Service provisioning portal and allows cloud consumers to describe and manage Cloud Services easily. The service catalog includes information about the Cloud Service (pricing, payment terms and conditions, etc.), could support multiple pricing models (pay-as-you-go, tiered models, etc.), and includes technical, business, and compliance constraints. The cloud service catalog integrates with the CMDB to define and manage information about instances of catalog services and their relationship with physical and virtual infrastructure resources. The service catalog seamlessly

	integrates with the cloud security service and Cloud Services management tools (business and operational management tools). The service catalog could also describe the Cloud Service Provider's ability to meet a cloud performance rating (a common way to evaluate and determine competitive advantage).

Appendix II: Principles Description

Business Principles

Principle name	**Increase business value through measured continual improvement**
Description	The productive use of technology to deliver business value should be measured via a process of continual improvement.
Rationale	All investments into IT services need to be clearly and measurably related to delivering business value. Often the returns on major investments into strategic initiatives are managed in the early stages but then tail off, resulting in diminishing returns. By continuously measuring the value which a service is delivering to a business, improvements can be made which achieve the maximum potential value. This ensures the use of evolving technology to the productive benefit of the consumer and the efficiency of the provider. Adhered to successfully, this principle results in a constant evolution of IT services which provide the agile capabilities that a business requires to attain and maintain a competitive advantage.
Implications	The main implication of this principle is the requirement to constantly calculate the current and future return from investments. This governance process needs to determine if there is still value being returned to the business from the current service architecture and, if not, determine which element of the strategy needs to be adjusted.

Principle name	**Minimize human involvement**
Description	The day-to-day operations of a Cloud should have minimal human involvement.
Rationale	The resiliency required to run a Cloud cannot be achieved without a high degree of automation. When relying on human involvement for the detection and response to failure conditions, continuous service availability cannot be achieved without a fully redundant infrastructure. Therefore, a fully automated fabric management system must be used to perform operational tasks dynamically, detect and respond automatically to failure conditions in the environment, and elastically add or reduce capacity as workloads require. It is important to note that there is a continuum between manual and automated intervention that must be understood. A manual process is where all steps require human intervention. A mechanized process is where some steps are automated, but some human intervention is still required (such as detecting that a process should be initiated or starting a script). To be truly automated, no aspect of a process, from its detection to the response, should require any human intervention.
Implications	Automated fabric management requires specific architectural patterns to be in place, which are described later in this document. The fabric management system must have an awareness of these architectural patterns, and must also reflect a deep understanding of health. This requires a high degree of customization of any automated workflows in the environment.

Principle name	**Seamless user experience**
Description	Consumers of an IT service should not encounter anything which disrupts their use of the service as a result of crossing a service provider boundary.
Rationale	IT strategies increasingly look to incorporate service from multiple providers to achieve the most cost effective solution for a business. As more of the services delivered to consumers are provided by a hybrid of providers, the potential for disruption to consumption increases as business transactions

Principle name	Seamless user experience
	cross provider boundaries. The fact that a composite service being delivered to a consumer is sourced from multiple providers should be completely opaque and the consumer should experience no break in continuity of usage as a result. An example of this may be a consumer who is using a business portal to access information across their organization such as the status of a purchase order. They may look at the order through the on premise order management system and click on a link to more detailed information about the purchaser which is held in a CRM system in a public Cloud. In crossing the boundary between the on premise system and the public Cloud based system the user should see no hindrance to their progress which would result in a reduction in productivity. There should be no requests for additional verification and they should encounter a consistent look and feel, and performance should be consistent across the whole experience. These are just a few examples of how this principle should be applied.
Implications	The IT provider needs to identify potential causes of disruption to the activities of consumers across a composite service. Security systems may need to be federated to allow for seamless traversal of systems, data transformation may be required to ensure consistent representation of business records, styling may need to be applied to give the consumer more confidence that they are working within a consistent environment. The area where this may have most implications is in the resolution of incidents raised by consumers. As issues occur, the source of them may not be immediately obvious and require complex management across providers until the root cause has been established. The consumer should be oblivious to this combined effort which goes on behind a single point of contact within the service delivery function.

Principle Name	Horizontal scaling enablement
Description	Cloud Service Providers seek horizontal scaling (simultaneous process of data across multiple machines) to take advantage of larger virtual machine capabilities that could rapidly and automatically provisioned to meet the requirements of parallel processing.
Rationale	Where possible, Cloud Service Providers are looking for utilizing their larger virtual machines. Comparatively, horizontal scaling allows Cloud Service Consumers to process large amount of data efficiently with minimum investment (e.g., the use of Hadoop and MapReduce types of applications).
Implications	• Cloud solutions will have to be designed specifically for loosely coupled distributed computing with fine grained processing which could also promote easier workload movement. • Larger data sources might require partitioned into smaller set of data sources.

Principle name	Customer Oriented Systems
Description	The services and the systems of the organization should be user friendly and deliver additional value to the customer.
Rationale	The extended Cloud Ecosystem demands integration of services from multiple providers to achieve the most cost effective solution for a business. All these services should be user friendly by providing a seamless user experience. The fact that a composite service being delivered to a consumer is sourced from multiple providers should be completely opaque and the consumer should experience no break in continuity of usage as a result.
Implications	The Cloud solutions are commonly standardized solutions and they are not customized to the specific needs of every user or organization

Architecture Principles

Principle name	Automated ways to measure and optimize Cloud Solutions
Description	Cloud services solutions should enable automated ways to measure allocation and consumption of Cloud services and optimize the service usage by leveraging metering capability.
Rationale	In order to minimize investment on Cloud services, Cloud services solutions should provide real-time transparency on Cloud services utilization to both Cloud Service Provider and Cloud Service Consumer.
Implications	• Cloud services solutions should be designed with built-in mechanisms to capture resources allocation, consumption, and produce measurements data. • Provide real-time (or near real-time) assessment reports to efficiently respond to demand/usage of Cloud services solutions. • Although profiling resource usage by any Cloud solution in a multi-tenant Cloud environment will be challenging, but it would be required to optimize the usage to ensure accurate metering. • Evaluate measurements data and make any changes to optimize Cloud services solutions.

Principle name	Technology independence
Description	Applications are independent of specific technology choices and therefore can operate on a variety of technology platforms.
Rationale	Independence of applications from the underlying technology allows applications to be developed, upgraded and operated in the most cost-effective and timely way. Otherwise technology which is subject to continual obsolescence and vendor dependence, becomes the driver rather than the user requirements themselves. Realizing that every decision made with respect to IT makes us dependent on that technology the intent of this principle is to ensure that Application Software is not dependent on specific hardware and operating systems software.
Implications	• Require standards which support portability. • For Commercial Off-The-Self (COTS) and Government Off-The-Self (GOTS) applications are technology and platform dependent. • Subsystems interfaces will need to be developed to enable legacy applications to interoperate with applications and operating environments developed under the enterprise architecture. • Middleware should be used to decouple applications from specific software solutions.

Principle name	Common vocabulary and Data definitions
Description	Data is defined consistently throughout the organization, and the definitions are understandable and available to all users.
Rationale	A metadata repository is a centralized repository of information about data such as meaning, relationships to other data, origin, usage, and format. The term may have one of several closely related meanings pertaining to databases and database management systems (DBMS). The extended business boundaries mandate use of data from various CSPs and systems. In order to avoid interoperability, portability and integration headaches it is necessary to create a common vocabulary for the data definitions.
Implications	• Multiple data formats • Interoperability/Portability • Integration

Principle name	Loosely coupled Cloud Services
Description	Ensure that software, platform and infrastructure as Services are loosely coupled. For example, Cloud Service Consumer of PaaS does not control the underlying Cloud infrastructure resources (e.g., compute, storage and network).
Rationale	Cloud services are designed to support dynamic and scalable Cloud environments.
Implications	• Minimize customization of Cloud services to effectively support multi-tenant deployment model. • Well defined separation of concerns in a Cloud environment. The following illustrates the scope of control between Cloud Service Provider and Cloud Service Consumer.

Principle name	Multi-tenancy
Description	A Cloud Computing model must support tenant and solution isolation among multiple tenants of the Cloud.
Rationale	Cloud Computing stores clients' assets (information and operational processes applications) in servers distributed "who knows where", so it is critical that each client's assets are kept securely separated from the assets of other clients, irrespective of the storage media and processing resources that each client may also use in the Cloud.
Implications	Cloud providers offer assurances that they provide secure isolation between the assets of each of their clients. While this is difficult for them to evidence, their isolation control mechanisms seem to demonstrate success over this capability.

Principle name	Perception of infinite capacity
Description	From the consumer's perspective, a Cloud service should provide capacity on demand, only limited by the amount of capacity the consumer is willing to pay for.
Rationale	IT has historically designed services to meet peak demand, which results in underutilization that the consumer must pay for. Likewise, once capacity has been reached, IT must often make a monumental investment in time, resources and money in order to expand existing capacity, which may negatively impact business objectives. The consumer wants "utility" services where they pay for what they use and can scale capacity up or down on demand.
Implications	A highly mature capacity management strategy must be employed by the provider in order to deliver capacity on demand. Predictable units of network, storage and compute should be pre-defined as scale units. The procurement and deployment times for each scale unit must be well understood and planned for. Therefore, Management tools must be programmed with the intelligence to understand scale units, procurement and deployment times, and current and historical capacity trends that may trigger the need for additional scale units. Finally, the provider (IT) must work closely with the consumer (the business) to understand new and changing business initiatives that may change historical capacity trends. The process of identifying changing business needs and incorporating these changes into the capacity plan will be critical to the providers Capacity Management processes.

Principle name	Take a holistic approach to availability design
Description	The availability design for a solution should involve all layers of the stack and employ resilience wherever possible and remove redundancy that is unnecessary.
Rationale	Traditionally, IT has provided highly available services through a strategy of redundancy. In the event of component failure, a redundant component would be standing by to pick up the workload. Redundancy is often applied at multiple layers of the stack, as each layer does not trust that the layer below will be highly available. This redundancy, particularly at the Infrastructure Layer, comes at a

Principle name	Take a holistic approach to availability design
	premium price in capital as well as operational costs. A key principle of a Cloud is to provide highly available services through resiliency. Instead of designing for failure prevention, a Cloud design accepts and expects that components will fail and focuses instead on mitigating the impact of failure and rapidly restoring service when the failure occurs. Through virtualization, real-time detection and automated response to health states, workloads can be moved off the failing infrastructure components often with no perceived impact on the service.
Implications	Because the Cloud focuses on resilience, unexpected failures of infrastructure components (e.g., hosting servers) will occur and will affect machines. Therefore, the consumer needs to expect and plan for machine failures at the application level. In other words, the solution availability design needs to build on top of the Cloud resilience and use application-level redundancy and/or resilience to achieve the availability goals. Existing applications may not be good tenants for such an infrastructure, especially those which assume a redundant infrastructure.

Principle name	Perception of continuous service availability
Description	From the consumer's perspective, a Cloud service should be available on demand from anywhere and on any device.
Rationale	Traditionally, IT has been challenged by the availability demands of the business. Technology limitations, architectural decisions and lack of process maturity all lead to increased likelihood and duration of availability outages. High availability services can be offered, but only after a tremendous investment in redundant infrastructure. Access to most services has often been limited to on-premises access due to security implications. Cloud services must provide a cost-effective way of maintaining high availability and address security concerns so that services can be made available over the internet.
Implications	In order to achieve cost-effective highly available services, IT must create a resilient infrastructure and reduce hardware redundancy wherever possible. Resiliency can only be achieved through highly automated fabric management and a high degree of IT service management maturity. In a highly resilient environment, it is expected that hardware components will fail. A robust and intelligent fabric management tool is needed to detect early signs of eminent failure so that workloads can be quickly moved off of failing components, ensuring the consumer continues to experience service availability. Legacy applications may not be designed to leverage a resilient infrastructure and some applications may need to be redesigned or replaced in order to achieve cost-effective high availability. Likewise, in order to allow service access from anywhere, it must be proven that security requirements can be met when access occurs over the internet. Finally, for a true Cloud-like experience, considerations should be made to ensure the service can be accessed from the wide array of mobile devices that exist today.

Principle name	Cloud Service Abstraction and control
Description	Ensure that Cloud services are securely exposed with appropriate level of abstraction and hide implementation details of a Cloud Service.
Rationale	Cloud Service abstraction provides the right separation and hide the implementation details to ensure service agility.
Implications	• Ensure there is a level of abstraction that separates the concept/interface and implementation details of Cloud services. • Ensure that all essential characteristics of Cloud services (e.g., Resource pooling, broad

Principle name	Cloud Service Abstraction and control
	network access, measured service, rapid provisioning, etc.) are maintained without exposing implementation details. For example, in the case of IaaS, resource abstraction components include software elements such as hypervisors, virtual machines, virtual data storage, and other computing resource abstractions. Ensure there are appropriate controls in place to provide secure and reliable usage of underlying service resources.

Principle name	Auto provisioned sharable system infrastructure.
Description	The underlying computing resources of IaaS (e.g., Storage, Compute, and Network) are shared and auto-provisioned to support an efficient system infrastructure.
Rationale	In order to meet business objectives to maximize profit, IaaS Cloud Service Provider's underlying computing resources serve using a multi-tenant environment. IaaS can seamlessly move workloads around to lower overhead and meet defined SLAs.
Implications	• IaaS should have a built-in capability of automated provisioning and dynamically move workload to meet defined SLAs. • Business and Service performance impact due to shared IaaS infrastructure should be well understood to avoid any undesired outcome. • Cloud Service Providers should enable mechanisms to protect one tenant from other tenants. • Auto provisioning must prepare for peaks in load (e.g., higher volume of order and usage of Computing resources due to advertised sale) with the use of Cloud bursting. Cloud bursting is a way to address peak load by augmenting computing resources with external IaaS provider's computing environment.

Principle name	Optimization of resource usage
Description	The Cloud should automatically make efficient and effective use of infrastructure resources.
Rationale	Resource optimization drives efficiency and cost reduction and is primarily achieved through resource sharing. Abstracting the platform from the physical infrastructure enables realization of this principle through shared use of pooled resources. Allowing multiple consumers to share resources results in higher resource utilization and a more efficient and effective use of the infrastructure. Optimization through abstraction enables many of the other principles and ultimately helps drive down costs and improve agility.
Implications	The IT organization providing a service needs to clearly understand the business drivers to ensure appropriate emphasis during design and operations. The level of efficiency and effectiveness will vary depending on time/cost/quality drivers for a Cloud. In one extreme, the Cloud may be built to minimize the cost, in which case the design and operation will maximize efficiency via a high degree of sharing. At the other extreme, the business driver may be agility in which case the design focuses on the time it takes to respond to changes and will therefore likely trade efficiency for effectiveness.

Principle Name	Elasticity
Description	Cloud Service Providers seek horizontal scaling (simultaneous process of data across multiple machines) to take advantage of larger virtual machine capabilities that could rapidly and automatically provisioned to meet the requirements of parallel processing. Cloud solutions use common and public network using Internet Protocol (IP) should expect unreliable service resulting due to performance variance, variable latency, and network failure.
Rationale	One of the essential characteristics of Cloud Computing is to have Cloud capabilities accessed through standard and public internet. Cloud solutions should be designed to address unreliable IP service and

Principle Name	Elasticity
	variance in latency. Where possible, Cloud Service Providers are looking for utilizing their larger virtual machines. Comparatively, horizontal scaling allows Cloud Service Consumers to process large amount of data efficiently with minimum investment (e.g., the use of Hadoop and MapReduce types of applications).
Implications	• Cloud solutions will have to be designed specifically for loosely coupled distributed computing with fine grained processing which could also promote easier workload movement. • Larger data sources might require partitioned into smaller set of data sources. • Cloud solutions should be designed to seamlessly handle network failure and performance variance.

Appendix III: Interview Questions

1. Do you consume Cloud services in your organization?
    a. If yes, what kind of deployment models and from which vendors?
    b. If not, why?

2. What are the challenges (security, privacy, integration) and benefits (e.g., cost savings, flexible response to business needs, better capacity utilization or resource allocation) that the adoption of Cloud services brings to the organization's EA?
    a. How do you address them in the EA?

3. How does the Enterprise Architecture (EA) practice takes place in your organization?
    a. Who is responsible for it?
    b. What is your role in it?

4. How structured is the EA practice in your organization?

5. Do you use EA framework(s) and/or modeling language(s) for the development, management and governance of the (Cloud) EA in your organization?
    a. If yes, why do you use the specific EA framework(s) and/or modeling language(s)?
    b. If not, why don't you use EA frameworks and/or modeling languages for the development of the EA?

6. What are the strengths and weaknesses of the EA framework(s) and/or modeling languages that you use regarding Cloud Computing?

7. What are the necessary modifications (e.g., extend the framework, guidelines on how to use it, develop a new Cloud-specific framework) that you think are necessary in the EA framework and/or modeling languages to develop the EA in Cloud Ecosystem?

8. Is the combination of TOGAF and ArchiMate appropriate to facilitate the development, management and governance of enterprise Cloud Ecosystem?
    a. What do you think is missing from them and what are their strong points?

9. How can we model in ArchiMate (or with another notation) the integration issues that arise (e.g., information exchange among applications, message handling etcetera)?

10. What are the most appropriate (or most impacted) ArchiMate viewpoints that adequately visualize the impact of the migration to the Cloud?

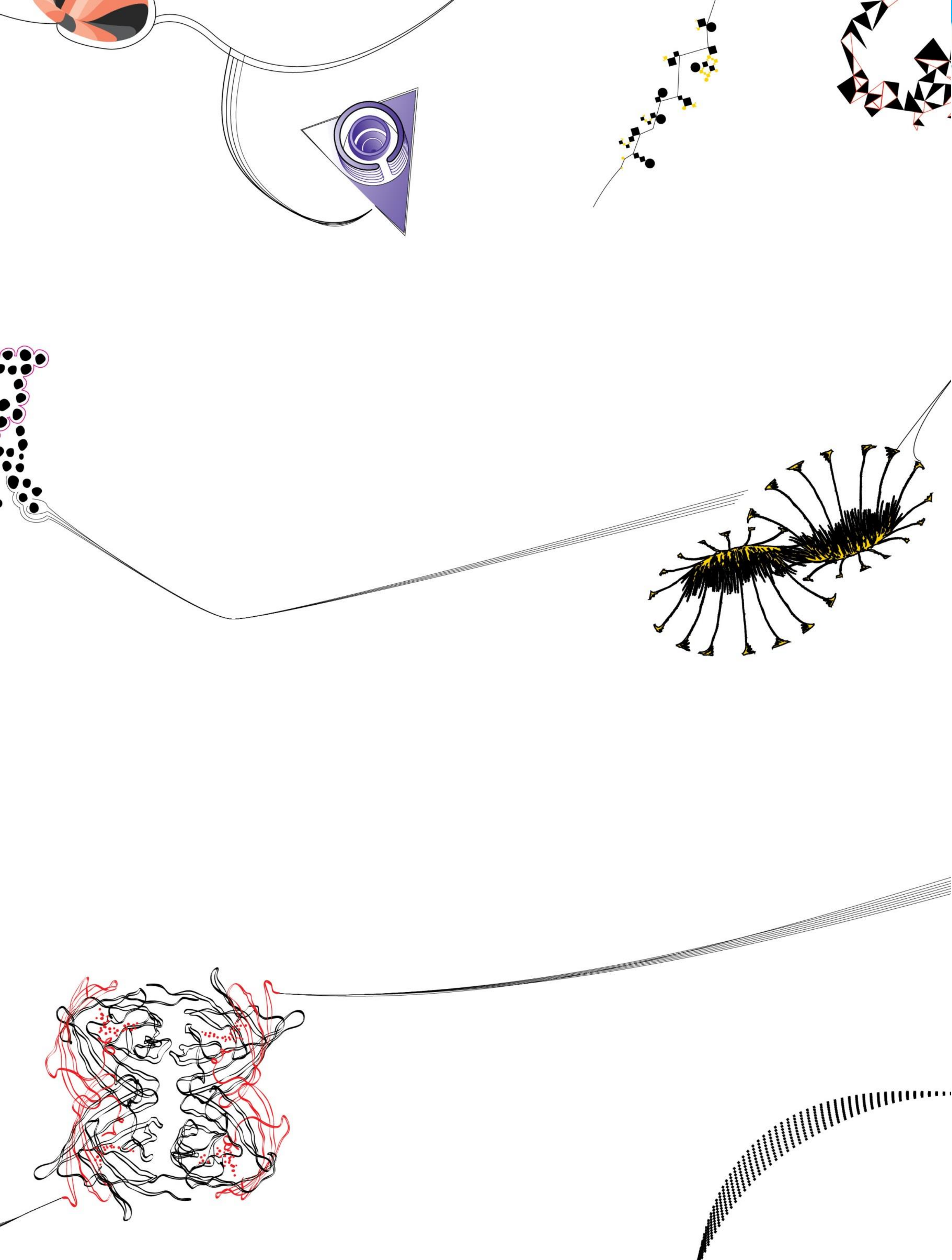
11. What are the important principles, requirements, drivers/goals and constraints that guided the development of the Enterprise Architecture in a Cloud Ecosystem?

12. What are the most important nonfunctional aspects that someone must address in the EA for Cloud Ecosystem?
    a. How did you address these nonfunctional aspects in the Cloud Ecosystem?

13. What are the sensitive data and information in a CRM migration scenario, in order to decide what must be kept on-premise and what off-premise?

14. Does the adoption of Cloud Computing in an organization increases or eliminates the need for EA? Why?

15. Are there any benefits in using the TOGAF for Cloud Ecosystems approach (TOGAF & ArchiMate) to accelerate the adoption of Cloud-based solutions in organizations?
    a. What are the strengths and weaknesses of the TOGAF for Cloud Ecosystems approach?



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