IOSR Journal of Computer Engineering (IOSR-JCE)
e-ISSN: 2278-0661,p-ISSN: 2278-8727, Volume 17, Issue 2, Ver. IV (Mar – Apr. 2015), PP 58-65
www.iosrjournals.org

Methods Migration from On-premise to Cloud

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Abstract: *Cloud computing is evolving as a key computing platform for sharing resources that include infrastructures, software, applications, and business. An increasing number of companies are expected to migrate their applications to cloud environment. So when planning to move a legacy style application to the cloud various challenges arise. The potential size and complexity of such a project might especially discourage small or medium companies trying to benefit from the advantages the cloud promises. By analyzing the research achievements and application status, we divide the existing migration methods into three strategies according to the cloud service models integrally. Different processes need to be considered for different migration strategies, and different tasks will be involved accordingly. Moreover, we have also observed that there is hardly any guidance available for migrating existing systems to cloud computing in terms of software engineering aspects. In this paper, we propose an architecture that describes the cloud migration process, starting by understand application architecture, Choice of type of cloud environment and Identification and categorization of the various types of application migration to the Cloud and solutions for migrating architectural components.*
Keywords: *Cloud Computing, Cloud Migration Process, Meta Model, Software Migration*

I. Introduction

Cloud computing has become an active area of practice and research over the last few years. Although the term "Cloud Computing" is based on a collection of many old and few new concepts in several research fields like Service-Oriented Architectures (SOA), distributed and grid computing as well as virtualization. Cloud computing has become increasingly popular with the industry due to the clear advantage of reducing capital expenditure and transforming it into operational costs [1].

According to National Institute of Standards and Technology (NIST), Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

According to the virtualized resources, three cloud service models emerged: infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS) [1−3]. The business model of the cloud is pay-as-you-go, so enterprises can reduce capital expenditure by leveraging the cloud service [4−6]. Based on these characteristics, cloud computing provides many benefits needed by enterprise, such as no up-front investment, lower operating cost, high scalability, and so on [7] .Whereas, public, private, hybrid and community clouds are the categories of the deployment models.

In order to take advantage of cloud computing and protect the existing investment to legacy system, enterprise are eager to migrate legacy systems to the cloud today, and many companies consider moving entire applications or parts of them to the cloud. Application migration is the process of redeploying an application, typically on newer platforms and infrastructures, the migration of existing applications to the Cloud requires adapting them to a new computing paradigm.

A legacy system is an outdated computer system that remains in use even after more modern technology has emerged either because the organization may have invested considerable time and money in it or the legacy system holds valuable data. Some of organization wrote or rewrote software specially to run in the cloud.

However, there are cases where an organization has existing application software and wants to run this on a cloud platform. As with any decision about alternative ways to meet a business need, there should be a cost-benefit analysis applied when considering to migrate an application. As a result, the study in academia and the practice in industry on migrating legacy systems to cloud computing are very widespread today.

So far, much research has been done in this field. Some works [8-12] focus on decision making support for cloud migration in enterprise, since benefits, risks, costs, and organizational and socio-technical factors must be considered before migration. More researchers concentrate on migration methods, mainly about how to efficiently migrate legacy system to the cloud [13-18].

Some organizations devote themselves to providing development tool for migrating legacy system to the cloud [19−22]. Up to now, some innovative methods have been proposed, related tools have been developed, and lots of organizations have made some trials in migrating legacy systems to cloud computing. According to the cloud service model, the migration to the cloud is classified into three strategies integrally in this paper.

This paper is organized as follows. In Section 2 gives an overall view of Migration Strategy. Section 3 surveys Cloud migration process .Section 4 is reviewed Comparison between the migration strategies. Finally, the paper concludes and presents the perspective in Section 5.

II. Migration strategy

With regard to the migration types [15], we identify the following migration types that Cloud-enable applications through adaptation:

- **Type I:** Replace component(s) with Cloud offerings. This is the least invasive type of migration, where one or more (architectural) components are replaced by Cloud services. As a result, data and/or business logic have to be migrated to the Cloud service. A series of configurations, rewiring and adaptation activities to cope with possible incompatibilities may be triggered as part of this migration. Using Google App Engine Datastore in place of a local MySQL database is an example.
- **Type II:** Partially migrate some of the application functionality to the Cloud. This type entails migrating one or more application layers, or a set of architectural components from one or more layers implementing a particular functionality to the Cloud. Using a combination of Amazon SimpleDB and EC2 instances to host the data and business logic is an example of such a migration.
- **Type III:** Migrate the whole software stack of the application to the Cloud. This is the classic example of migration to the Cloud, where for example the application is encapsulated in VMs and run on the Cloud. For some of works like in papers [9], [12], [15] and [41], the focus is on Virtual Machines (VMs) as the means for migration.
- **Type IV:** Cloudify the application is a complete migration of the application that takes place. The application functionality is implemented as a composition of services running on the Cloud.

While Gartner [23] suggests information technology (IT) organizations consider the following five options when they seek to move legacy systems to the cloud:
-Rehost on infrastructure as a service,
-Refactor for platform as a service,
-Revise for IaaS or PaaS,
-Rebuild on PaaS,
-Replace with software as service.

However, Cisco considers three application migration options including SaaS, PaaS and IaaS in white paper for migration of enterprise application to the cloud.

They think the migration to SaaS is no longer an application migration but more of a replacement of the existing application with a SaaS. Migration to PaaS is an option for migrating business applications that are based on standard application server software such as JavaEE or .net platforms. Migration to IaaS involves deploying the application on the cloud service provider's servers. In addition, the criteria that are used for considering every application migration are discussed [24]. Similarly, Solentive software proposed three main approaches for migrating legacy system to the cloud in a white paper, namely Iaas, PaaS and SaaS. The white paper looks at these approaches in detail and analyzes the benefits and disadvantages of each [25].

Through comparing and analyzing, we can categorize the migration into three strategies integrally: migration to IaaS, migration to PaaS and migration to SaaS. The first strategy implements migration only by porting legacy system to the cloud by using IaaS. The legacy system will be migrated to the cloud by system refactoring according to the platform of PaaS in the second strategy. As to the migration to SaaS, it can be divided into three sub-strategies concretely, namely replacing by SaaS, revising based on SaaS and reengineering to SaaS.

After comparing and analyzing, we recap the migration types mentioned above. These results are shown in Table 1.

Table 1 Recap existing migration types

	Migration to IaaS	**Migration to PaaS**	**Migration to SaaS**
Paper [18]	Type III	Type I,II	Type I,IV
Paper [26]	Revise, Rehost	Revise, Refactor, Rebuild	Replace
Paper [27]	To IaaS	To PaaS	To SaaS
Paper [28]	To IaaS	To PaaS	To SaaS

III. Cloud Migration Process

Driven by the need to outsource their (or part of) IT-infrastructure, companies have shifted considerable amounts of their IT from their own premises to external companies. Therefore new delivery models for software have been emerging that allow the outsourcing of different aspects of an application. The

software as a service (SaaS) model is a prominent example of such an outsourcing model. Other delivery models such as Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) aim at providing (parts of) the necessary infrastructure and platform support to easily built and host applications at a provider.

How to move and migrate to the cloud is an unanswered question for many organizations. Application migration is the process of redeploying an application, typically on newer platforms, and infrastructure.

The process based on three main points:

- Understand application architecture based on decomposition into three layers: business, application, technical.
- Choice of type of cloud environment— SaaS, PaaS, or IaaS—the application is best suited and what part(s) of the application to move instead of the whole application.
- Identification and categorization of the various types of application migration to the Cloud and solutions for migrating architectural components

IV. Application Meta model

Today, many companies consider moving entire applications or parts of them to the cloud. Applications today are often composite, multi-tier applications, consisting of application components such as UIs, services, workflows and databases as well as middleware components such as application servers, workflow engines and database management systems [1, 26, 27]. When moving such a composite application into the cloud, decisions must be made about putting which tier and even which component of such an application to which cloud.

The application architecture will affect how an application can be migrated to cloud environments and sometimes whether an application is suitable for migration. The process begins with analysis of the factors for the application. Firstly, we have to look into how applications are usually built, we must understand what are the functionalities, architecture, technology, etc, of all these often huge legacy applications, a detailed assessment is carried out of the existing IT environment with a view to understand the applications that are appropriate for moving into the Cloud.

So in this paper the Meta model proposed having the architectural model helps to analyze the legacy system, and describes the different concerns to be considered to move the applications in cloud on three main artifacts will be provided:

(i) Business layer,
(ii) Application layer, and
(iii) Technical layer.

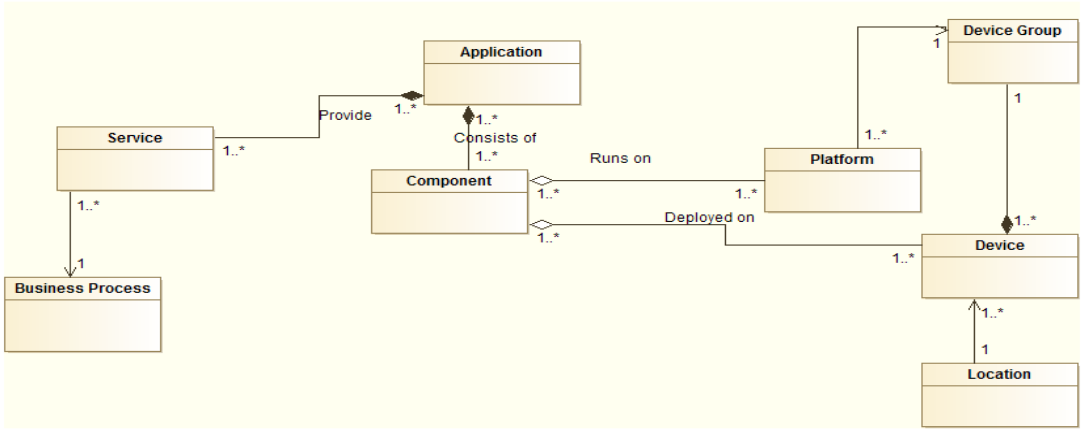

Figure 1: Meta-Model Architecture Application

Business layer identified business requirement through business process of legacy application. This step aims at elaborating the main motivation for migration and the objectives to be achieved. It also provides a foundation for the changes required in a system and describes system's behavior specific to cloud computing environment. Business applications are built based on the requirements from the business users. Also, these business applications are built to use certain kind of Business transactions or data items. It enables to identify the criticality of selected application functions and help the IT organization understand the business benefits of the application.

Application layer: Applications today are often distributed application, consisting of software components such as UIs, services, workflows and databases as well as middleware components such as application servers, workflow engines and database management systems. It describes the architectural components of the application and their relations .The various components of the architecture of the application

are realized based on different technologies that identified which component of the architecture is hosted by which of the containers. That determines which part of the application is moved to which cloud.

Technical layer: describe usage of the physical resource and the existing physical assets are not utilized completely resulting in energy loss, higher maintenance cost, etc...

A device is a physical computational resource such as a server, upon which artifacts may be deployed for execution.

The first activity is associated with identification of the business requirements that initiate the migration process. This step aims at elaborating the main motivation for migration and the objectives to be achieved. It also provides a foundation for the changes required in a system and describes system's behavior specific to cloud computing environment.

Based on the information collected about the Meta model legacy system, it provides a preliminary feasibility analysis of the viability and the migration strategies. It also provides preliminary estimates about the cost and the risks involved.

V. Application Meta model

After an application has been identified as a candidate for cloud migration, based on business and technical factors, it is necessary to consider for what type of cloud environment—SaaS, PaaS, or IaaS—the application is best suited. Based on the type of application, the choice of type migration need meet both business and technical needs.

As shown in Fig. 2 the meta-model describe different migration types to cloud:

- The first type replaces components with cloud offerings.
- The second type is the migration into three strategies integrally: migration to IaaS, migration to PaaS and migration to SaaS.

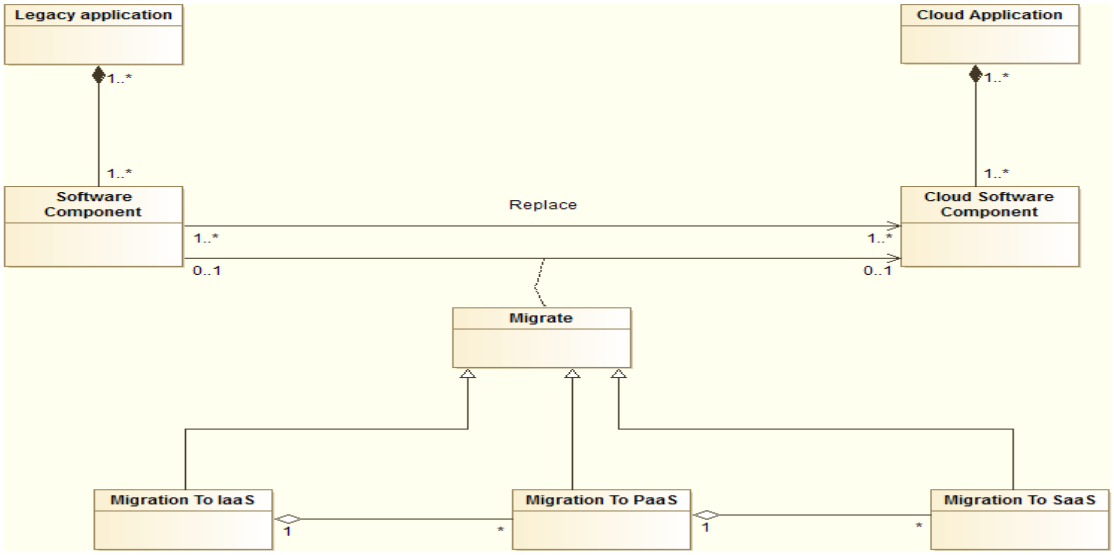

Figure 2: Migration types

The most ideal strategy for a special migration to the cloud relies on the individual needs of each organization and the condition of the legacy system, so organizations need to choose the most rational strategy before the migration.

With the PaaS strategy, organizations need to determine the extent of modifications required for the application to be compatible with the cloud platform. If extensive modifications are needed for PaaS, the IaaS strategy may be a better choice. As an effective software-delivery mechanism, SaaS could be an ideal choice for independent software vendors.

The concerns shall briefly be outlined:

- **SaaS:** Companies look for a migration solution to move their existing on-premises applications to a cloud environment. Application vendors frequently want to evaluate a cloud platform on which to deploy a new application or SaaS offering.
- **PaaS:** PaaS Migration is the process of moving from the use of one software operating and deployment environment to another environment. At this layer customers do not manage their virtual machines, but rely on the infrastructure layer's compute and storage resources. They merely create applications within an existing API or programming language.

- **IaaS:** IaaS migration is mainly offering virtual machines as a (compute) service to users, such as moving from one VM to another, or managing or interoperating the different VMs. In addition, storage or network capabilities can also be provided. Instead of purchasing servers or even hosted services, IaaS customers can procure and operate servers, data storage systems, or networking resources at will.

VI. Implementation

The final activity of this process aims at implementing the designed solutions for migrating a system to be deployed on a target cloud environment.

The proposed methods realize classification to cloud migration in essence, which can cover all migration cases.

According to the cloud service model, the migration to the cloud is classified into three strategies, we explain each one how they could be migrated to environment cloud as shown in fig 3.

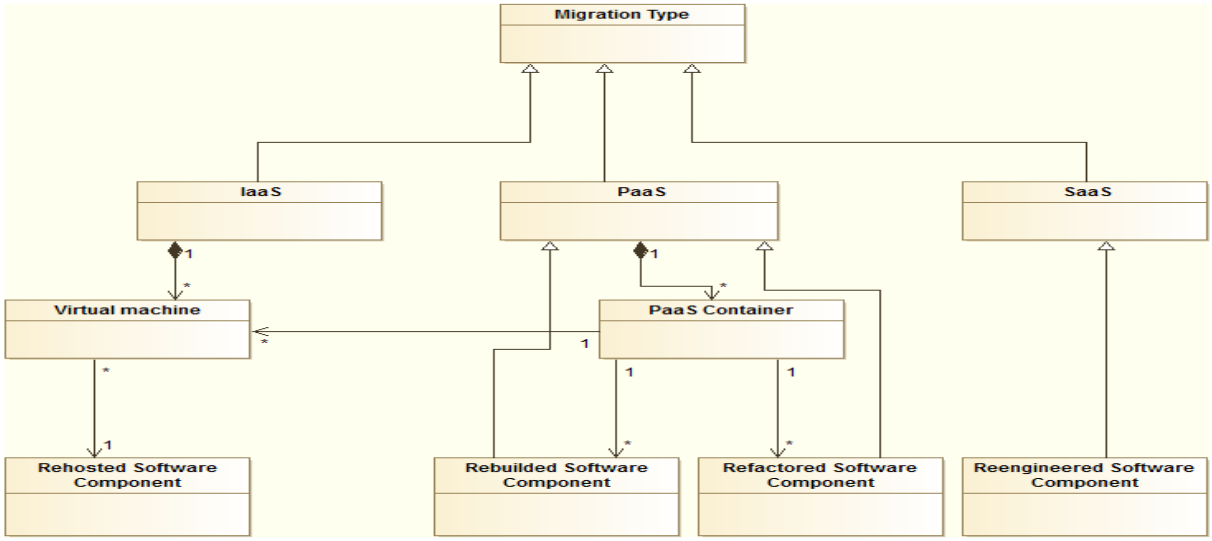

Figure 3: Process migration's Meta model

1.1 Migration to IaaS :

The emphasis of the existing work is on migrating the whole application based on virtualization technology .Migration to IaaS involves deploying the application on the cloud service provider's servers. For a number of works like paper [15], the focus is on Virtual Machines (VMs) as the means for migration.

A virtual machine is built for an application, which is loaded with all the software that will eventually run in the cloud. Then the virtual machine is uploaded to IaaS vendor's hosting environment and deployed to run. IaaS is the best choice for moving applications to the cloud when there is no time to reengineer the applications for a cloud [28].

Applications do not need modification before migrating to an IaaS model thus organizations can take advantage of the benefits quickly with minimal investment [15].

With respect to migration method, cloud computing service providers, such as Amazon and Cisco, provide the details for migrating legacy systems to their platforms [24, 25, 28, 29]. Zhang [30] conducted migration studies by migrating Hadoop and RUBiS to EC2 cloud platform.

1.2 Migration to PaaS :

Migration based on PaaS is not mandatory for resource management, but it is required to make the legacy system compatible to the requirement of PaaS provider. Microsoft, Cisco, and Solentive provide guide for migration to PaaS from technology domain [24, 31 and 32].

Existing applications may need modification to take full advantage of the platform, Depending on the chosen platformn, existing applications may need to be rewritten if they are not compatible. The legacy system will be migrated to the cloud by system refactoring or rebuild on Paas according to Gartner [23].

As an example, Tran et al [33] defined the scope of migration software system for the cloud. They identified all activities in migration that start from getting familiar with the application, the target cloud platform, and the third party tool, then to build the environment and get ready for migration, as well as to modify and test to ensure that the application properly runs in the cloud. Finally based on the experience of migrating PetShop DotNet to Windows Azure and migrating JavaPetStore to Amazon EC2, they compared the difference between migrating legacy system to PaaS and to IaaS.

1.3 Migration to SaaS :

The migration strategy through replacing legacy system by SaaS does not refer to reengineering the legacy system, and the only work needs to be done is to export local data to the cloud database. For the migration strategy of revising based on SaaS, some functionality of legacy system will be outsourced to the cloud, and then the business process is used to integrate cloud and non-cloud services. For the migration strategy of reengineering to SaaS Zhang and al [16] proposed a generic methodology to guide how to migrate legacy system to cloud platform. The generic methodology includes the following steps: representation of the legacy application, redesign the architecture model with identified services, model driven architecture (MDA) transformation, web service generation, invocation of legacy functionalities, selection of a suitable cloud computing platform, and provision of cloud web service to the end users. This seven-step methodology guides developers to migrate legacy systems step by step and improves the productivity and effectiveness of migration.

In addition to the migration methodology, some research on the implementation of migration to SaaS was carried out. Current approaches are often limited to specific cloud environments or do not provide automated support for the alignment with a cloud environment. Frey and Hasselbring[34] proposed a model-based approach CloudMIG for migrating legacy software system to scalable and resource-efficient cloud-based application. CloudMig concentrates on the SaaS provider perspective and facilitates the migration of enterprise software system towards generic IaaS and PaaS-based cloud environment. CloudMIG can generate considerable parts of a resource-efficient target architecture utilizing a rule-based heuristics, so it helps SaaS providers to semi-automatically migrate existing software to the cloud computing platform.

Through investigation of existing research, reuse and migration of legacy applications to interoperable cloud services (REMICS), a research project supported by the European Commission that started in 2010 for a period of three years, has identified further work that needs to be done in the project. Specifically, knowledge discovery involves business and rule recovery that are necessary for identifying services and designing new business processes except reverse engineering of legacy code. Comprehensive methodology is employed to address dedicated design patterns and transformations, especially for migration to the cloud. Migration tools and methods need integration with model-based development methods. PIM for SOA and cloud computing can adapt many different platforms in the cloud and diverging technologies. These problems have been partially addressed by developing methods, languages, transformations and tools. The REMICS methodology will integrate all these in an agile, model-driven, and service-oriented methodology for modernizing legacy systems in the end. The migration starts with the recover activity which extracts the architecture of the legacy application. The recover activity is implemented by knowledge discovery and reverse engineering. The source architecture helps to analyze the legacy system, identify the best ways for migration, and benefit from model-driven engineering technologies for generation of the new system. The migrate activity reforms the source architecture into target architecture for service cloud platform. In migration activities, SOA and cloud computing patterns are applied, legacy components may be replaced or wrapped, and architecture may be redesigned by service composition. After obtaining target architecture, the service cloud implementation is achieved by MDA. In short, REMICS proposes a leap progress in legacy systems migration to service clouds, which significantly improves the baseline ADM concept [35, 38]. This project involves the most advanced research in migrating legacy system to service cloud now.

Project ARTIST [39] proposes a comprehensive software modernization approach covering business and technical aspects. In particular, ARTIST employs Model-Driven Engineering (MDE) techniques to automate the reverse engineering of legacy software and forward engineering of cloud-based software in a way that modernized software truly benefits from targeted cloud environments. Therewith, ARTIST aims at reducing the risks, time, and costs of software modernization and lowers the barriers to exploit cloud computing capabilities and new business models.

MODAClouds [40] based on the migration of cloud-based software between cloud providers and their interoperability is primarily focused rather than the migration of legacy software to cloud-based software as a means of software modernization.

It is a rather coarse-grained modeling approach seems to be applied for selecting cloud providers. Run-time information is employed in MODAClouds to monitor and reconfigure running cloud-based software.

In summary, migration to SaaS requires to consider the specific migration strategy according to legacy system and existing SaaS. If existing SaaS has the same business functionality of legacy system, users can replace legacy system by SaaS. When some business functionality has been realized by existing SaaS, legacy system can be modernized by revising legacy system based on existing SaaS. Users can take full advantage of the virtue of the cloud by reengineering legacy system to SaaS, but the challenge cannot be ignored.

VII. Comparison Between The Migration Strategy

Evaluating applications, designing migration types, and migrating applications to a targeted cloud computing model or models is a demanding task. It requires detailed application migration process design

experience and deep understanding of cloud computing models as well as detailed knowledge of how the applications interact with both each other, the external (cloud) environment, and the underlying infrastructure. It also requires experience integrating IT systems and cloud management, and being a significant project in its own right a structured approach to program management.

The companies still ask about choice of which migration type is suitable for there; the most ideal approach depends on the individual needs of each organization. Business with existing applications that want to migrate to the cloud could consider the IaaS or PaaS approach. With the PaaS approach, companies need to determine the extent of modifications required for the application to be compatible with the platform.

If modifications are extensive, it would be best for an organization to select the IaaS approach. However, if modifications are minor, organizations would benefit from the PaaS approach.

Company's looking to develop new applications would benefit from the PaaS approach as they are given access to the underlying services to quickly develop a functional application. Business need to be wary that they do not get locked into a platform as moving to another platform could be difficult at a later stage.

Before developing their own cloud applications, organizations should take advantage of what is commercially available. SaaS could be an option for business is looking to quickly gain access to a business application without the initial outlay. Companies opting for the SaaS approach also benefit from automated updates and reduced maintenance costs. However, organizations need to be cautious of locking themselves into a vendor as switching could be difficult in the future.

There is another criteria used for considering a SaaS deployment, including SLAs, data portability, long-term costs, user management, and security, should be considered for a cloud migration.

VIII. Conclusion and perspectives

Migration to the cloud raises currently a range of questions. Software migration is the process of moving legacy systems from one operation environment to another, which is, in most cases, thought to be better. Migrating legacy system to cloud computing can effectively protect software assets and take advantage of cloud computing. Many research projects have been carried out, and some innovative methods and tools have been proposed so far.

In this paper we proposed a meta-model of legacy application to identify different level requirement and we classified migration types into three, in addition we proposed a meta-model to guide how the software component are migrated integrally in migration types. At the present we are working on elaborating the process to modernize a legacy system before to move to environment cloud, based on the Architecture Driven Modernization approach proposes to base the modernization activities on the architectural models rather than code artifacts. The major goal is the existing systems meet the new business need in cloud.

In this concept, modernization starts with the extraction of the architecture of the legacy application. Having the architectural model helps to analyze the legacy system, identify the best ways for modernization and benefit from Model-Driven Engineering (MDE) technologies for generation of the new system. This information will be then translated into models covering different aspects of the architecture: business architecture, application and data architecture, technical architecture. And finally redesign and redeploy existing applications in a model driven architecture (MDA) falls into this category.

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