Maturity Model for Cloud Computing Transformation: Assessing an Information System's Functional Block Maturity

M'barek El Haloui and Abdelaziz Kriouile

Abstract— **IT managers and decision makers permanently need support tools to make decision for adopting new solutions and services such as cloud computing. This paper introduces a maturity assessment model of an Information System architecture functional block in the aim of outsourcing to cloud services. This model considers the fundamental requirements arising from the literature, best practices, and standards in the domain. Thus, this model provides a new added value for the opening of enterprise architectures to new technologies.**

Keywords—**Cloud Computing, Information System, Maturity, Enterprise Architecture, Outsourcing**

I.   Introduction

In a competitive world, companies are always looking to optimize cost, increase productivity, and focus more on their core business and high added value activities. In this context, outsourcing activities are a suitable choice for these organizations. At IT sector, this orientation concerns mainly companies without specific expertise and skills in management of IT infrastructures in operational conditions. Also, companies seeking to minimize cost and improve quality are interested by such orientation.

Outsourcing is the practice of buying a product or a service that was produced or made internally by a provider or an external source [1]. IT outsourcing is an act of delegation or transfer of part or all IT as well as decision-making power related to, business processes, internal activities, and services to external providers which develop, manage, and administer these activities in accordance with a contractual agreement and agreed deliverables, performances, standards, and results [2].

Due to market technology diversity and multitude of service offers, outsourcing a component of its Information System (IS) is a real challenge for companies. In particular, outsourcing through the adoption of new solutions such as cloud computing is still difficult without decision support tools.

Cloud computing is based on the offer of hardware and software as a service through IT resources (distributed) [3].

Constituting a new service model, cloud computing is characterized by three service models: SaaS (Software as a Service), PaaS (Platform as a Service), and IaaS (Infrastructure as a Service); and four deployment models:

M'barek El Haloui and Abdelaziz Kriouile
ENSIAS, Mohammed V University in Rabat, Morocco

private cloud, community cloud, public cloud, and hybrid cloud [4][5].

The Cloud is not a solution for everything; we need to identify the strategic sourcing methodology according to our maturity and our needs [6]. When a company wants to verify whether to use cloud computing or not, the latter must analyze the improvement of management processes as well as the existing IT infrastructure support processes [7].

The study of the literature shows that support tools are needed to make the decision of outsourcing a functional component of an IS architecture. These tools are based on the assessment of the functional component maturity. This model will also be useful to anticipate the construction of IS evolution plan by studying the possible improvement scenarios especially the outsourcing to the cloud computing [4].

This paper presents a decision support model based on the maturity of an informational component (functional block of an IS architecture). The rest of this paper is organized as follows. Section 2 shows an overview of the maturity standards and their connection with the Enterprise Architecture (EA). Section 3 surveys related works concerning outsourcing models activities and presents some applicable models for IT. Section 4 deals with the concept and the layers of an Enterprise Architecture impacted by the transformation of a functional block. Section 5 describes our proposed model. Finally, Section 6 gives concluding remarks and directions of future work.

II.   Maturity and Information System Urbanism

The Capability Maturity Model Integration (CMMI) models are collections of best practices that help organizations improve their processes. These models are developed by a group of experts from industry, the US government, and the Software Engineering Institute (SEI) [8]. The CMMI model is presented in staged representation or continuous representation. The use of continuous representation allows to reach "capacity levels" while the use of staged representation allows to reach "maturity levels".

The staged representation expresses the evolution of practices based on a more global or organizational view. This may correspond to a whole society or just a subset of it: a division, a business line, or a geographical site. While the continuous representation expresses the capacity or ability

of each process considered separately within the organization [9].

The CMMI repository covers several process areas or disciplines by providing a way to integrate these process areas. Each process area is associated with several components, such as the linked process areas, the specific goals, the generic goals, and the practice-to-target relationships tables [10][11]. Table I provides a comparative overview on the staged and continuous representations. The CMMI version 1.3 is composed of three constellations: Development (DEV), Acquisition (ACQ) and Service (SVC), but we can imagine that other CMMI constellations will be added over time according to CMMI user community needs [9].

As a referential, the CMMI may constitute a problem for an organization because it does not provide a roadmap for the implementation or identification of key process improvement areas, but it only provides goals for each implementation level [10]. The baseline assessment enables an organization to identify the areas that will bring the greatest return on investment and show where immediate action will have an impact [12].

Information Systems Urbanism (ISU) or Enterprise Architecture (EA) is a concept inspired from town planning and used in Information Systems [4]. It refers to the IS architecture which allow a company to develop an evolution plan of it's IS in short, medium and long term. The functional layer of this architecture is structured in zones subdivided into neighborhoods or functional sectors that are composed by blocks. The block is the basic functional component of this architecture.

TABLE I.   CAPABILITY AND MATURITY LEVELS[5]

Level	Continuous Representation Capability Levels	Staged Representation Maturity Levels
Level 0	Incomplete	
Level 1	Performed	Initial
Level 2	Managed	Managed
Level 3	Defined	Defined
Level 4		Quantitatively Managed
Level 5		Optimizing

III. Decision support models for activities outsourcing

A. *Literature review*

The literature study on outsourcing activities approaches and models enabled to identify the key factors and the adopted criteria for an outsourcing activity. Table II summarizes the main characteristics helping an organization to make a decision and extracted from studied activities outsourcing models.

TABLE II.   ACTIVITIES OUTSOURCING FACTORS AND CRITERIA

Authors (year)	Outsourcing Factors and Criteria
Coase 1937 [13]; Williamson (1975 [14], 1985 [15])	Analysis by risk costs involved in outsourcing. A Insourcing / Outsourcing should minimize the sum of production and transaction costs.
Walker & Weber 1984 [16]	Volume, technological uncertainty, company experience, change in product specifications frequency, and the level of competition in the supplier market
Wernerfeldt 1989 [17]; Barney 1991 [18]	Competitive advantage is based on, among others, the resources that the company identifies, develops, deploys and protects. Access to these resources can be made directly (insourcing) or indirectly (outsourcing) through partners.
Fagan 1991 [19]; Gardiner & Monroe 1994 [20]; Belinski & Koehler 1995 [21]	Business core activities compared to non business core activities
Welch et al. 1992 [22]; Venkatesan 1992 [23]	Approaches based on (1) the technological process and its role in the competitiveness, (2) the maturity of the technological process, (3) the position of the technological process compared to competitors
Ford et al. 1993 [24]	Using policy approach and the cost-based approach
Proberts et al. 1993 [25]	Using the technology matrix for outsourcing
Quinn & Hilmer 1994 [26]; Dartina 1994 [27]	Reducing production costs and transaction costs
Gupa & Zhender 1994 [28]	importance of long-term planning for outsourcing
Brandes 1994 [29]	Evaluates insourcing / outsourcing decision by analysis of three criteria: (1) the strategic importance of the activity, (2) the risk of dependency with the external provider(s) (3) the cost of carrying out the activity
Kurokawa 1997 [30]	R & D capacity, expected lifetime of the technology, prior experience make / buy decisions, the managing capacity, and the degree of competition.
Lakhal 1998 [31]	Proposes a sequential approach based on three types of analysis: (1) Operational feasibility study, (2) a strategic analysis, (3) a cost analysis.
Lankford & Parsa 1999 [32]	Guidelines for the proper implementation of outsourcing
Mclover & Humphreys 2000 [33]	Applying the reasoning technique based on the CBR (Case-Based Reasoning)
Jahns, Hartmann, & Bals 2006 [34]	Outsourcing as a mode of governance among three possibilities: "Make" (internalize), "buy" (outsourcing), and "hybrid" (sharing the implementation of activities with a partner)
Wang , Lin, & Huang 2008 [35]	Using multi-criteria approach based on AHP and improved ELECTRE III

The review of different factors and criteria of outsourcing leads to identify the major points on which an outsourcing activity should be based on. These points are as follows:

- At the strategic level: need to examine the strategic importance of the activity as well as its competitive value (an activity in the business core must remain internal).

- At the economic level: external production cost must be competitive compared to internal one.

- At context level: need for availability of providers, competition, and a market maturity to be able to outsource.

- At risk level: risks of subcontracting, competition, dependency, and outsourcing, in general, should be mastered.

- At quality level: technology, skills, and expertise of external providers must be better than internal, and therefore offer better products and services line.

The identified criteria families may be completed or adapted depending on the context and according to the company's business. These criteria concern outsourcing activity in general; however IT domain also has its specificities that must be taken into account.

B. *Some Models Applicable on IT outsourcing*

1) **Using SOA Cloud Computing**

Service Oriented Architecture (SOA) is a systematic technology framework that allows all users, end-users, and developers to access to well-defined services, and information related to these services [6]. SOA provides agility to architecture that can deal with changes in runtime through configuration layer rather than constantly redevelop every time [6][36].

Goel & Singh [6] propose a five-step procedure for cloud adoption in the light of a service-oriented architecture. These steps are:

- Access Maturity which gives a deep insight into the degree of cloud adoption;

- Understand requirements which allows to specify the objectives;

- Make a business case for the Cloud;

- Stepwise procedure in light of SOA based on :
  - o   Works on the data to the Cloud;
  - o   Works on cloud services;
  - o   Works on processes to the cloud;

- Final architectural view.

This approach provides an overview of the aspects to consider in cloud computing adoption starting from the strategy, requirements, processes, data, services... However, this approach does not mention the means and criteria of analysis or assessment of each level.

2) **Decision Model for Strategic Outsourcing**

Ordoobadi propose a decision model for strategic outsourcing [1], this model is based on:

- A strategic assessment (Fig. 1) which evaluates both the competence core which means the skills, the knowledge, and the expertise that distinguish a company from its competitors. The company must invest in, protect, and control these activities to keep a competitive advantage;

- An economic assessment based on the difference between the internal and external achievement cost;

- A decision analysis based on return on investment.

This approach deals with the strategic aspect coupled with the cost aspects of implementation and an analysis of return on investment. However, it does not address other aspects such as risks and enterprise environment.

3) **Multi-Criteria Decision Support Method for Sustainable Insourcing-Outsourcing**

The multi-criteria decision support method [38] is inspired by the MEDIE model -Assessment Model of the Decision to Insourcing/Outsourcing (I/O) [39]- associated with SCOR/GreenSCOR repositories [40] related to Corporate Social and the Analytical Hierarchy Process (AHP) method. This method represents a decision support tool (Table III) while considering three assessments of I/O activities:

- Strategic Importance Assessment. It results in the analysis of I/O activities contribution in the creation of competitive advantage.

- Assessment of I/O activities potential to contribute to the creation of competitive advantage.

- Assessment of I/O activities aggregate performance (economic, environmental, and social criteria), using performance indicators from the SCOR / GreenSCOR repositories, the literature, and AHP method.
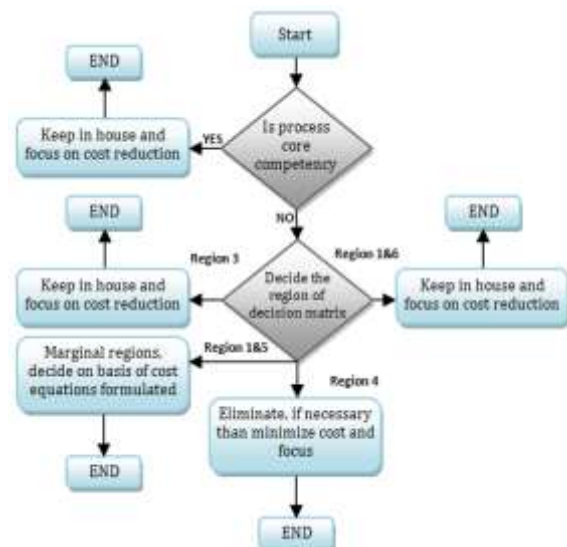

Figure 1.   Flowchart for strategic outsourcing [1] [37]

TABLE III.   STRATEGIC ANALYSIS GRID FOR UPDATED INSOURCING / OUTSOURCING [38]

Activities assessment			Potential strategic decisions	Potential strategic options
Importance	*Performance*	*Potential*		
-	-	-	Outsourcing	Outsourcing the activity if it a necessary one
				No longer do the activity
-	-	+	Outsourcing	Outsourcing the activity
			Sharing	Do the activity with a partner for whom the activity is important
+	-	-	Outsourcing	Outsourcing the activity
			Sharing	Proceeding to a reengineering of the activity / fragmentation / re-affecting the activity to another service, site, ... or to external service providers
			Insourcing	Working to improve the performance of the activity
-	+	+	Sharing	Do the activity with a partner for whom the activity is important
			Insourcing	Creating a subsidiary
-	+	-	Insourcing	Carry out the activity for other companies (internal or external companies)
				No longer do the activity
+	-	+	Insourcing	Working to improve the performance of the activity
+	+	-	Insourcing	Maintaining and supervising the activity
+	+	+	Insourcing/re-insourcing	Pay strategic constant attention to the activity

This method adds the performance and potential competitive dimensions; however, architectural and technical aspects are not addressed.

The literature review allows to identify a set of methods, models and factors of decision support for activities outsourcing, however there is a lack of approaches or models that deal with outsourcing an IS architecture functional block or component to cloud computing.

IV.   Functional Block Transformation

A functional block of an urbanized IS architecture is constructed through a project which constitutes a transformation to the target IS architecture of the company. The realization of this project will have impacts on different layers of an Enterprise Architecture. IS architecture layers impacted by a transformation project are illustrated in Fig. 2.
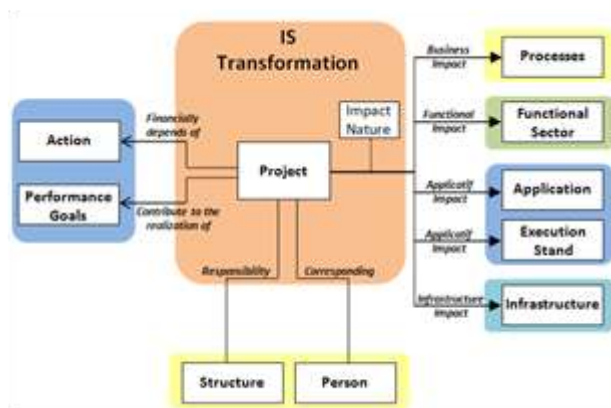

Figure 2.   IS Transformation : Impacted Views [41].

- Strategy view:
  - Project: A project is a set of tasks assigned to a team which transform all or part of the information system to achieve one or more specific targets in a given contractual context.

- Business view:
  - Process: A process is a value chain providing a product or service to a customer internal or external to the structure. A process is functionally represented by a sequence of activities enabling the delivery of a service or product to a customer (internal / external).

  - Actor: An actor represents a business role which can be carried by a person, group of persons, or a structure.

- Functional view:
  - Functional sector: A functional sector enables the classification of the two main objects of functional view, namely, the functionalities and the business objects.

- Applicative view:
  - Application: An application is a consistent set of computational objects (executables, programs, scripts, data, procedures, associated documentation ...) and which is the subject of IT operations.

- Infrastructure view:
  - Infrastructure: the infrastructure view describes the physical equipment

(hardware, network, etc.) that make up the IS or that are used by the IS.

We identify that the transformation by internal or external realization of a functional block requires to take into account these different concerned levels of the target IS architecture. The aim is to ensure agility and an easy integration or dissociation of each IS architecture block.

V. Maturity-Based Transformation Model

When studying the different decision support models for outsourcing activities, we observed that there is no one which support organizations to decide about outsourcing a functional component of its urbanized information system architecture to the cloud computing. Figure 3 provides an overview on the position of the proposed model. This model is a maturity assessment and decision support tool for the opening of enterprise IS on cloud computing [4].

Layers and evaluation criteria that constitute this model are based on the main factors and criteria of outsourcing raised from the studied models and methods [1][38], joined with the good practices of Enterprise Architecture and IS governance (Cobit, ITIL) as well as the CMMI Maturity repository.

The objective is to provide to enterprises a simple way helping to make decision of outsourcing a functional block to the cloud.

Our model is structured in assessment modules. These modules are made up of layers or views. Each view is checked through a set of criteria. The decision matrix will be based on the assessment criteria coverage level. Figure 4 illustrates the different assessment layers identified. Our model is structured around four assessment modules:

- Scope identification module: This module focuses on the verification of the correct definition of the functional block and processes to outsource, identifying its interactions with other blocks and the delimitation of data repository handled by the block.

- Outsourcing opportunity module: this module is based on the assessment of the strategic importance of the block-related activities, assessment of outsourcing economic gains, checking the context of the company and the availability of desired suppliers as well as the market maturity, and reviewing the risks related to this outsourcing.
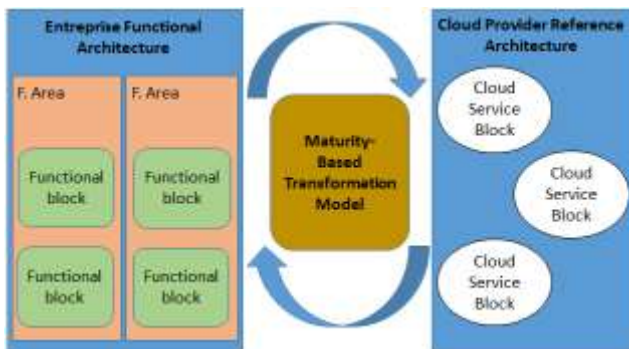
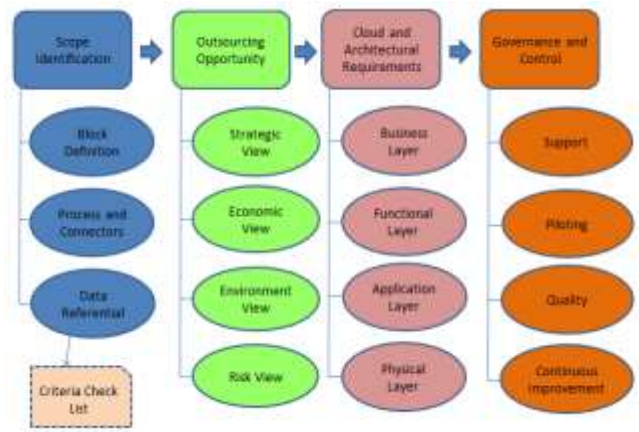Figure 3.   Maturity-Based Transformation Model [4]

Figure 4.   Transformation Model - Assessment Layers

- Cloud requirement module: this module consists of checking in advance the ability of the block against business, functional, applicative, and infrastructure requirements of a cloud environment.

- Governance and control module: this module consist in a checklist for the capacities of monitoring, support, control of quality, and continuous improvement by outsourcing projection.

The elaborated model is a structured approach based on standards and best practices in the IT field as well as the best outsourcing approaches. This model allows to highlight the main stages and the functional block assessment layers intended for cloud computing. This assessment modules and layers structuring adds value to existing methods by providing a simple, global, and proactive vision for better decision making in the specific case of cloud opened IS.

This paper is dedicated to the presentation of the components of the proposed model. The next step is to provide a fine definition of assessment criteria, a maturity level identification, and a decision matrix.

VI. Conclusion

One of the challenges of IS urbanism is the adoption of new solutions of the market which use a multitude of standards, best practices, and tools. Our functional block transformation model constitutes a simple method helping IT professionals to assess a functional component of their information system architecture to identify its level of maturity to be outsourced to cloud computing. Future work will involve the finalization of assessment criteria definition, the maturity and decision-making matrix, and the evaluation of our model on practical cases.

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About Authors:

M'barek El Haloui is a Ph.D. candidate, and member of the IMS team from the SIME laboratory, in the National School of Computer Science and Systems Analysis (ENSIAS), at Mohammed V University in Rabat, Morocco. He received the engineer degree in computer science and network systems engineering in 2004 from the Mohammadia School of engineering (EMI) at Mohammed V University in Rabat, Morocco. He excises from 2005 to 2009 the job of consulting and audit of information systems. Actually, he is a project manager at a telecom company and manages currently a Cloud Computing project.

Abdelaziz Kriouile is a Full Professor in the Software Engineering Department at National Higher School for Computer Science and Systems Analysis (ENSIAS), Mohammed V University in Rabat, Morocco. He is the head of SIME Lab. (Mobile and Embedded Information Systems Laboratory). He received his PhD in Computer Science from the Nancy University, France in 1990. He received a State doctorate from the Mohammed V University in Rabat, Morocco in 1995. His research activities focus on information systems, cloud computing, and context-aware service-oriented computing. He leads numerous projects related to the application of these domains.