A Conceptual Framework to Implement and Manage a Cloud Computing Environment

Gerard Conway, Marian Carcary, Eileen Doherty
Innovation Value Institute, Maynooth University
Maynooth, Ireland
emails: {gerard.conway, marian.carcary, eileen.doherty}@nuim.ie

***Abstract*-The proliferation of cloud adoption in recent years is driven by the potential for realizing benefits, such as reduced costs, improved agility and better resource utilization. However, there are many challenges to successfully delivering cloud-based services and these need to be understood and managed prior to cloud migration. Organizations need a systematic means of reviewing their business needs, so that the transition and subsequent management of a cloud environment is strategically planned. To address this requirement a Cloud Management Framework has been conceptualized that can be used for both the migration and the ongoing management of cloud-based services.**

Keywords-Cloud; Life cycle; Framework; Outsourcing; Cloud implementation.

I. INTRODUCTION

This paper describes a detailed organizational level conceptual framework for cloud implementation and management, developed through adopting a design science approach that involved collaboration with key academics and subject matter experts in the area of cloud technology.

A. An evolving landscape: Drivers and Barriers for Cloud adoption

In recent years, cloud computing adoption rates have proliferated, with the complete spectrum of businesses from large multinationals to smaller organizations migrating their Information Technology (IT) services to cloud platforms. There are multiple factors driving this organizational transition to a cloud environment, which include benefits such as cost reduction [1][2][6][8][18], increased scalability and agility [2][5][7][14][15][17], improved resource utilization [2][9][14][15], improved mobility and collaboration [1][10][14], and business continuity and disaster recovery capabilities [10]. However, despite this potential for benefits, it is not a panacea for all problems faced by organizations; in fact there are many challenges to successfully delivering cloud-based services [25]. Such challenges or barriers include security, and data protection [8][2][4][17], business continuity [2][10], statutory and legal requirements and restrictions on the flow of data across boundaries [8][16], lack of standardization and the resulting technology integration issues [10][17], and latency incurred in transferring data [2][18].

B. Approaches to cloud implementation

As cloud computing is a new and rapidly evolving area that presents many challenges, there are few detailed guidelines or best practices available to support an organization in its migration and ongoing management of a cloud environment. Various approaches to cloud adoption are highlighted in the literature, a number of which are discussed in this section.

Migration to the cloud computing environment reshapes a company's IT landscape. Hence, prior to transitioning to cloud, organizations need to weigh up the potential for benefit realization against the associated barriers and challenges. As such, organizations need a systematic means of reviewing their business needs, so that the transition to cloud computing is strategically planned and managed throughout the migration, and the associated implications are understood. Some prior studies have focused on such areas as cloud deployment and delivery models [3][11], and strategies for cloud adoption [4][8][12]. Others tend to deal with specific cloud issues such as security [22] and risk management [19], or are geared to specific areas such as Mobile clouds [20], are proprietary (e.g., Intel, Unisys, HP), or are based on existing frameworks such as the Information Technology Infrastructure Library (ITIL).

Previously, Conway and Curry proposed a life cycle approach to managing Cloud [4]. This combined Cullen's [26] outsourcing life cycle, with the Innovation Value Institute's (IVI) IT Capability Maturity Framework (IT-CMF). IT-CMF is an innovative and systematic framework, enabling Chief Information Officers (CIOs) and Chief Financial Officers (CEOs) to understand and improve their organization's maturity in order to enable optimal business value realization from IT investments [21]. The framework identifies 35 critical IT capabilities and defines maturity models across five levels for each capability. A core function of IT-CMF is to act as an assessment tool and a management framework.

The approach taken by Conway and Curry was to adapt Cullen's work on outsourcing to produce a life cycle for Cloud, and to map the critical capabilities, as defined by IT-CMF, to each lifecycle step - see Figure 1 and Tables 1, 2 and 3 for details.

This approach was used to develop an Executive (i.e., high-level) assessment framework to provide an organization with a management structure to assess the following:

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- The readiness/maturity of an organization to move to cloud.
- The day-to-day management of an organization's cloud environment.
- The identification of services that can be provided by cloud.

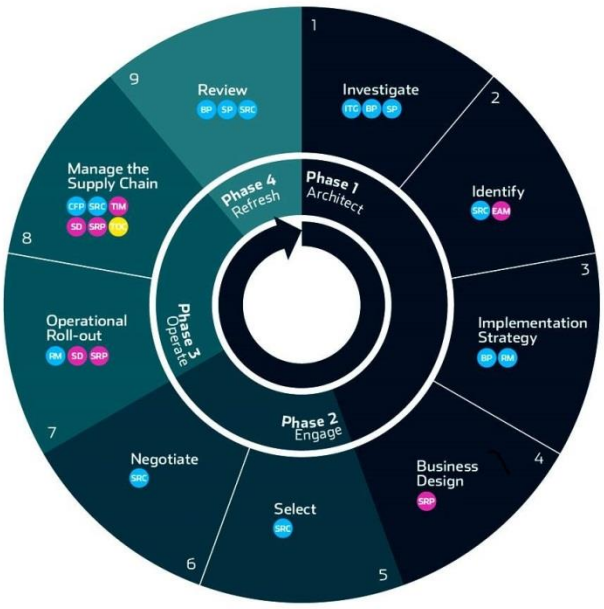

Figure 1. Cloud Executive Level Framework

TABLE 1. CLOUD LIFECYCLE PHASES (EXECUTIVE LEVEL)

Lifecycle Phase	Description
Architect	Investigate and plan the cloud project.
Engage	Select a service provider that can deliver the required cloud service.
Operate	Implement and manage the cloud service on a day-to-day basis.
Refresh	Review cloud services on an ongoing basis.

TABLE 2. CLOUD LIFECYCLE STEPS (EXECUTIVE LEVEL)

Lifecycle Phase	Description
Investigate	Provide insight and an understanding of what an organization wants to achieve by moving to the cloud, and what goals and expectations are to be met.
Identify	Objectively assess what areas of the business are appropriate to outsource to the cloud and what impact this will have on the current delivery model.
Implementation strategy	Define at a strategic level how the cloud services that are to be outsourced will be rolled out.
Business design	Design what is to be outsourced to the cloud and what the future state will look like.
Select	Based on the requirements and the other criteria defined by the Architect phase, select the best supplier based on value, sustainability, and quality.
Negotiate	Complete the final negotiation, pick the preferred supplier, get internal approval and sign the contract(s).
Operational roll out	Put together a project team that will manage the transition of the agreed services to the new cloud environment.
Manage Cloud Services	Manage cloud service(s) as efficiently and effectively as possible.
Review	Review cloud service requirements based on: the cloud service itself, other changes within the business, changes within the supplier organization, or the need to change the supplier.

TABLE 3. CLOUD LIFECYCLE CAPABILITIES (EXECUTIVE LEVEL)

Phase	Step	Capability
Architect	*Investigate*	IT Leadership and Governance (ITG)
		Business Planning (BP)
		Strategic Planning (SP)
	Identify	Sourcing (SRC)
		Enterprise Architecture Management (EAM)
	Implementation Strategy	Business Planning (BP)
		Risk Management (RM)
	Design	Service Provisioning (SRP)
Engage	*Select*	Sourcing (SRC)
	Negotiate	Sourcing (SRC)
Operate	*Roll-out*	Risk Management (RM)
		Solution Delivery (SD)
		Service Provisioning (SRP)
	Manage the Supply Chain	Capacity Forecasting and Planning (CFP)
		Sourcing (SRC)
		Technical Infrastructure Management (TIM)
		Solution Delivery (SD)
		Service Provisioning (SRP)
		Total Cost of Ownership (TCO)
Refresh	*Review*	Business Planning (BP)
		Strategic Planning (SP)
		Sourcing (SRC)

C. Requirement for a Detailed Micro-Level Organizational Framework for Cloud Implementation and Management

A review of the literature illustrates there to be a number of approaches to cloud migration available, however many

serve to provide a high-level structure [18][20], as opposed to a more micro-level of prescription or guidance that can be executed at a practitioner level. In effect, what is missing is an independent holistic management framework that allows an organization to consider all aspects of cloud from a technical, people and process perspective.

Conway and Curry's original Executive Level Management Framework [4] provides a potential solution, however although organizations have used this framework successfully, they observe that significantly greater detail is required, to adequately address the problems posed by cloud. This paper attempts to address this requirement through the development of a framework at a detailed micro-level to support the migration to and management of a cloud environment.

The structure of the paper is as follows; Section 1 introduced and provided justification for the development of a cloud framework at the micro-level of prescription; Section 2 outlines the methodological research approach adopted; Section 3 presents the detailed micro-level cloud implementation and management framework; Section 4 discusses and provides an overview of the key conclusions.

II. RESEARCH METHODOLOGY

Firstly, and closely mirroring the approach taken by Conway and Curry [4], the IT-CMF was mapped to the Cloud Lifecycle to establish the key capabilities an organization should consider in order to successfully migrate to, and manage a cloud environment (Figure 2). See [27] for a detailed explanation of the IT-CMF capabilities.

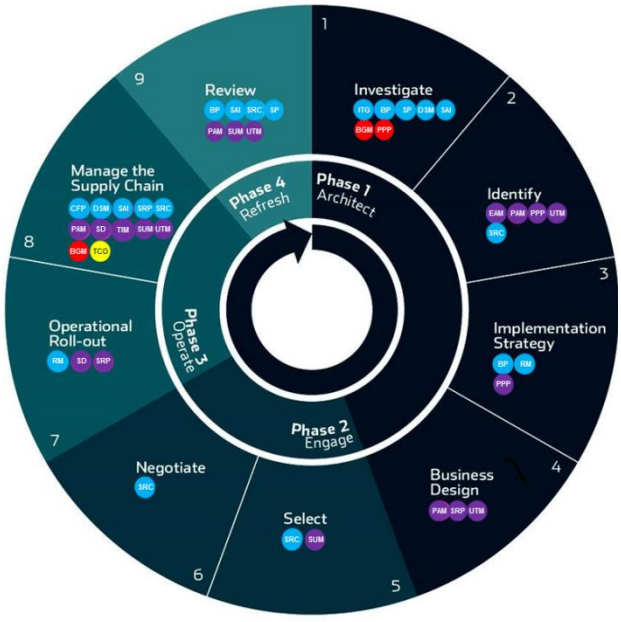

Figure 2. Detailed micro-level cloud framework

Secondly, a qualitative approach was taken to the framework development process (using both a workgroup and semi-structured interviews with key stakeholders). The workshop/workgroup approach was undertaken in conjunction with the Innovation Value Institute (IVI) consortium comprising of leading organizations from industry (including: Microsoft, Intel, SAP, Chevron, Cisco, The Boston Consulting Group, Ernst & Young, and Fujitsu) and academia. The consortium adopted an open innovation model of collaboration that engages academia and industry in scholarly work to amalgamate leading academic theory with corporate thought leadership in order to advance practices for managing IT for business value and innovation. This workgroup followed a design process with defined review stages and development activities that were based on Design Science Research (DSR) guidelines [23]. A cloud workgroup of ten subject matter experts, comprising researchers, industry practitioners and academics drawn from this consortium was established to develop the framework for systematically managing cloud projects. In addition to incorporating the insights of workgroup members throughout the framework development process, a qualitative approach to empirical data collection was adopted. Semi-structured interviews with cloud stakeholders across 11 organizations were conducted in order to capture the views of key domain experts and to understand current practice and barriers to managing cloud projects. These included organizations that had both successfully delivered, and that had failed to deliver, cloud-based projects. The interview approach enabled depth, nuance and complexity to be captured [24], and the insights gathered were used to inform and revise the framework's development.

III. DEVELOPMENT OF A DETAILED MICRO LEVEL FRAMEWORK TO IMPLEMENT AND MANAGE A CLOUD COMPUTING ENVIRONMENT

In the original Executive level framework, Conway and Curry [4] identified 11 critical capabilities (Table 3) to provide an executive high-level maturity assessment comprising 24 questions, so that organizations could rapidly understand their ability to migrate and manage their cloud environment. Based on the feedback from organizations that used the Executive level framework, a new detailed micro-level framework was developed as shown in Figure 2 and Table 4. This micro-level framework provides organizations with an in-depth maturity assessment based on an expanded list of 18 critical capabilities (Table 4) that encompasses 169 maturity questions.

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TABLE 4. CLOUD LIFECYCLE CAPABILITIES (DETAILED LEVEL)

Phase	***Step***	***Capability***
Architect	*Investigate*	IT Leadership and Governance (ITG)
		Budget Management (BGM)
		Business Planning (BP)
		Demand and Supply Management (DSM)
		Portfolio Planning and Prioritization (PPP)
		Service Analytics and Intelligence (SAI)
		Strategic Planning (SP)
	Identify	Enterprise Architecture Management (EAM)
		People Asset Management (PAM)
		Portfolio Planning and Prioritization (PPP)
		Sourcing (SRC)
		User Training Management (UTM)
	Implementation Strategy	Business Planning (BP)
		Portfolio Planning and Prioritization (PPP)
		Risk Management (RM)
	Design	People Asset Management (PAM)
		Service Provisioning (SRP)
		User Training Management (UTM)
Engage	*Select*	Sourcing (SRC)
		Supplier Management (SUM)
	Negotiate	Sourcing (SRC)
Operate	*Roll-out*	Risk Management (RM)
		Service Provisioning (SRP)
		Solution Delivery (SD)
Operate	*Manage the Supply Chain*	Budget Management (BGM)
		Capacity Forecasting and Planning (CFP)
		Demand and Supply Management (DSM)
		People Asset Management (PAM)
		Service Analytics and Intelligence (SAI)
		Service Provisioning (SRP)
		Solution Delivery (SD)
		Sourcing (SRC)
		Supplier Management (SUM)
		Technical Infrastructure Management (TIM)
		Total Cost of Ownership (TCO)
		User Training Management (UTM)
Refresh	*Review*	Business Planning (BP)
		Service Analytics and Intelligence (SAI)
		Sourcing (SRC)
		Strategic Planning (SP)

The micro-level framework is designed for three different use case scenarios as follows:

- A complete assessment using all 18 capabilities.
- An assessment based on specific phases or steps of the cloud life cycle: e.g., limit the assessment to the negotiate step (where the preferred service providers are selected and contracts finalized).
- An assessment based on one specific cloud issue: e.g., security.

Each of these use case scenarios provides the following:

- It supports an organization in understanding its current maturity using IVI's maturity model.
- It identifies an organization's future target maturity level.
- It determines the importance the organization places on each capability in the context of the cloud lifecycle.

The output from an assessment highlights areas of low maturity, and the gap between current and target maturity relative to its importance to the organization's needs. This supports prioritizing those capabilities that will benefit from short, medium, and long-term development. The detailed micro-level assessment also provides an organization with an improvement roadmap, detailing the actions necessary to drive improvement across the areas under investigation. This is achieved by providing guidance on the practices typical at each maturity level, the value-oriented outcomes resulting from effective implementation of these practices, and a series of metrics to monitor progress and performance of these practices over time.

IV. DISCUSSION AND CONCLUSION

As highlighted in the literature, there are various cloud approaches that can be utilized in the organizational context; however it is acknowledged that these frameworks do not offer a holistic approach to managing the transition to or management of the cloud environment. Consequently, this paper presents a detailed micro-level conceptual framework developed by key academics and industry practitioners using a Design Science approach to address this gap. Engagement with these subject matter experts was key in the framework's development and refinement. For example, one key insight was that the framework needed to provide organizations with the flexibility to use it where and when it was needed, and to allow it to be tailored to an organization's specific requirements. This was incorporated into the framework by:

- Allowing it to be consumed in its entirety or tailored for use at a particular stage, e.g., the Identify stage.
- Linking each capability to a specific cloud issue thereby allowing an organization to tailor the framework to address a specific area, e.g., security.

This framework provides organizations with a management tool to enable them to better understand their enterprise IT capability maturity to position, evaluate, introduce and manage cloud services, and their associated strengths and weaknesses in these areas. The framework further provides organizations with practical improvement roadmaps for cloud migration and management which are grounded in industry best practice at a detailed level of prescription. Whilst the framework does not claim to address

all of the issues faced by an organization when implementing and managing cloud, it is proposed as a good starting point in the transition and subsequent management of the cloud environment. Limitations of the study are its small sample and its focus on large multinational organizations. Future studies could address these limitations by increasing the sample size or by undertaking further research with Small and Medium-sized Enterprises (SMEs). The study and the resultant conceptual framework adds value to academics, as it provides new insights into an area where there is currently a research deficit, specifically in the transition to a cloud computing environment. This paper may assist policy makers in this area through highlighting the key challenges facing firms in cloud adoption. Finally, from an industry perspective it is hoped that researchers in this area may utilize this framework and provide further validation and refinement through its use.

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