Proposing a Capability Maturity Model Toward Adopting Cloud Services

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Abstract— Cloud is increasingly becoming the most sought-after method of service delivery for its ability to provide a rich amount of services that aid businesses in countless ways. From data sharing, data storage, and online applications, the possibilities of the cloud are almost endless. However, a significant number of small and medium enterprises (SME) have not made the jump to the cloud, fearing valid risks like security, privacy, and quality. In this paper, after careful consideration of risks, it was concluded that SMEs need a systematic approach to implementing cloud services as well as a method to assess and improve the implementation. Moreover, the paper looked over a few IT approaches and solutions that aid in deducing a possibly better method of acquiring cloud services. Lastly, a model was proposed which is based on the outsourcing lifecycle model and the capability maturity model integration approach. This model is referred to as cloud capability maturity model integration or CS- CMMI.

Index Terms— Cloud Computing (CC), Cloud Lifecycle, Capability Maturity Model Integration (CMMI), Cloud Services (CS), Cloud Services – Capability Maturity Model Integration (CS-CMMI), Small and Medium Enterprises (SME), Cloud Outsourcing Lifecycle.

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1 INTRODUCTION

Cloud computing (CC) has grown to be one of the most IT services demanded by enterprises, because of its ability to provide an online platform where large sets of services can be easily delivered, supervised and performed with relatively increased efficiency compared to a localized platform [1]. Those services can be referred to as cloud services (CS) and in simple terms, they are means to implement an OnDemand network access to applications and data. Moreover, CS frees employees from doing repetitive tedious tasks, allowing them to focus on more pressing matters, in effort to ultimately increase productivity and efficacy in the workplace [2]. However, a large number of small business enterprises (SME) are hesitant to adopt CS into their business infrastructure due to concerns about the quality of service, security, and cost. As mentioned above, cloud computing involves combining a lot of services into one platform, and that's where the issue of quality presents itself. To have an optimized working cloud service platform, it is imperative for services to be integrated together and to work harmoniously in conjunction with one another. As for security, the problem stems from the fact that CC requires a large amount of personal and work data to exist on the internet, a platform that it is generally believed to be insecure and lacking privacy [3]. Lastly, SMEs may unknowingly try to implement low-cost cloud services solutions in their businesses without having a reliable method to measure the risk level of said implementation, which leads to unplanned unnecessary costs. After consideration of these issues and concerns, it is logical to conclude that the primary problem of adopting cloud services for SMEs is the lack of a framework of activities or a guideline for enterprises to follow while implementing cloud. Moreover, a systematic criteria to judge the progression of process implementation is needed to ensure the quality of implementation. This paper will review the approach of capability maturity model integration (CMMI) along with the concept of outsourcing lifecycle in order to propose a model that serves as a solution to the stated problem above. The revised model is called cloud service capability maturity model integration, abbreviated as CS-CMMI

2 LITERATURE REVIEW

2.1 Cloud Computing and Cloud Services:

As mentioned above, Cloud computing involves the development and management of a lot of computing services such as storage, software's, and networks in an online platform. However, according to Lindner "all of these services can be categorized into three groups of services under CC [4]:
-Software as a service or SaaS, which involves running applications on the cloud and providing remote access to applications from different user devices. That access is usually achieved via a simple user-friendly interface. For example, a file storage application like "Google Drive" is considered to be SaaS.
-Platform as a service or PaaS allows programmers to create and optimize applications on a cloud platform that houses the needed programming languages and tools.
-Infrastructure as a service or IaaS is about building a platform where users can benefit from a number of essential rudimentary computing resources like data processing or networking, in order to install and use their own software. For example, Firewalls are considered to be one of the networking services that developers can run in IaaS.

2.2 Capability Maturity Model Integration (CMMI)

It is customary in the field of IT to focus on processes when trying to implement and support an IT system. In the case of cloud service, developers must keep close attention to reinforcing their services while simultaneously simplifying it to suit average users [5]. Another issue to consider is the fact that cloud service is the collection of improvised services that are most probably provided by a number of different developers [4]. Therefore, a process focused guideline like CMMI that aims to optimize organizational growth and software implementation might be the most effective approach to implement cloud services.

In general, CMMI consists of five maturity levels and six capability levels that are used as a framework to aid developers in evaluating and guiding their software development. Moreover, CMMI suggests key process areas (PA) which are governed by sets of generic and specific goals, those goals are achieved by performing generic and specific practices [6].

2.3 Capability Levels and Maturity Levels

Capability levels are considered to be the continuous yet more concentrated portrayal of CMMI which focuses on a specified process area. It offers a structure of steps to follow when improving the process area in question. On the other hand, maturity levels is a collective approach that is used to give an overall status review of the implementation level the enterprise is currently on regarding a number of process areas as a whole [2]. The following is a description of their levels in more detail.

2.4 Maturity Levels:

Maturity levels are composed of an established collection of process areas where the level of maturity is defined by accomplishing a set of generic and specific goals that are related to the established collection of process areas. The following text sheds light on each maturity level [6]:

ML 1 - Initial:

- Processes are yet to be defined and seem to be improvised and not in order.
- Organizational positive results depend solely on the efforts of the organization members and staff.
- Some processes might be completed, however not without errors, faults and time delays.

ML 2 – Managed:

- All current practices of the organization are managed according to a plan and are durable enough to survive sudden change.
- Results of services are guaranteed to satisfy its objectives and can be evaluated at any time.

ML 3 – Defined:

- Processes being defined, comprehended and kept in line with standard procedure.
- Processes are heavily elaborated and are more aggressively managed through previously attained knowledge about consistent processes activities.

ML 4 - Quantitatively managed:

- Subprocesses are created to increase general performance.
- Quantitative objectives are set to satisfy the requirements of average users, stakeholders and process implementers alike.
- Process performance quality is constantly being studied and measured to determine variations and its sources.

ML 5 – Optimizing:

- The primary function of this level is to apply incremental and creative technological advancement to regularly enhance process performance.

- Enterprises lay out a set of quantitative process improvement objectives which can be occasionally modified to suit changeable business objectives.

2.5 Capability Levels

A capability level can be described as a heavily detailed developmental podium where enterprises can determine their own capability level to a specific process area. It houses a number of specific and generic practices that fall under a particular process area. Those practices, when followed properly, will improve the enterprise's processes that are related to the process area which involves such practices [6].

CL 0 – incomplete:

- A process in this level is one that has not been implemented or was implemented incorrectly due to an inability to achieve all the specific goals related to the said process.

CL 1 – Preformed:

- The process was performed successfully and with no error.
- Although the performance was unsteady, works are being done.
- Ready to be monitored and modified in the future.

CL 2 – Managed:

- A managed process is one that had its performance controlled by the enterprise to achieve a specific preset objective.
- Results have been reviewed and metrics are being recorded for future improvement.

CL 3 – Defined:

- Once modified and improved, a managed process is considered a defined process.
- Information about a defined process performance can be used as a standard for measuring other processes performances.

CL 4 - Quantitatively managed:

- Quantitative and statistical management approaches have been taken by the enterprise in controlling and measuring a defined process.
- The result is a process that performs according to the enterprises set of quantitative objectives.
- The statistical recordings of the process performance are used to identify variations in its cycle.

CL 5 – Optimizing:

- Based on the variations identified in the above level, the process is constantly being optimized and modified to reach better results.

2.6 Process Areas (PA)

A number of associated practices grouped together in one area are referred to as a process area. A series of important specific goals must be achieved to result in a considerable advancement in that area, which in turn will lead to a successful implementation of the PA as a whole. In essence, process areas are a 'what to do list' for developers, or the

building blocks of each level of CL and ML. For example, in order for an enterprise to move from ML1 (initial) to ML2 (managed), it must fully implement the process areas of ML2 first to be ready and able to start working on moving up to ML3 (defined). Process areas are classified into four types, which are process management, project management, engineering, and support. Furthermore, each process area has two categories of goals, generic goals which are a part of every process area and specific goals which concern a particular process area [6].

2.7 Outsourcing

Wither for IT development or other business activities, enterprises may need to outsource activities due to their lake of ability to perform those activities and in order to lower risks. Briefly, outsourcing is the act of delegating tasks to external sources, freeing enterprises to concentrate efforts on core tasks rather than functions that cannot be executed perfectly [7].

2.8 Outsourcing Lifecycle

This lifecycle was proposed by [8] and he concluded that it has four phases and nine building blocks, where each phase contains at least one building block and each block consists of several key activities. It exists in order for enterprises to have a standard method when managing their outsourcing. Following this method, which divides the outsourcing process into small easy achieved acts, will significantly improve the decision making of the enterprise regarding the outsourcing to ultimately reach the desired results.
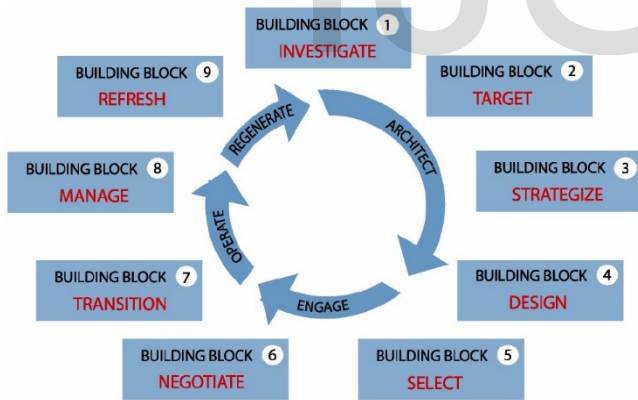

Figure 1: The Outsourcing Lifecycle Model: Phases and Building Blocks [8]

2.9 Cloud Outsourcing Lifecycle

Lindner [4] suggested a cloud lifecycle that is built upon the outsourcing lifecycle design by Cullen [8]. The model consists of four phases and nine steps which concentrates on migrating IT services to the cloud. Its primary function is to help enterprises in managing the migration of services to the cloud while concurrently limiting errors. It does that through breaking down migration tasks to reasonably attainable steps for the enterprises to work on. However, the model does not serve the need for systematic criteria for assessing the implementation of the cloud. Although it contributes to

performance improvements, it does not specify how to perform those improvements or what specific area to focus on.
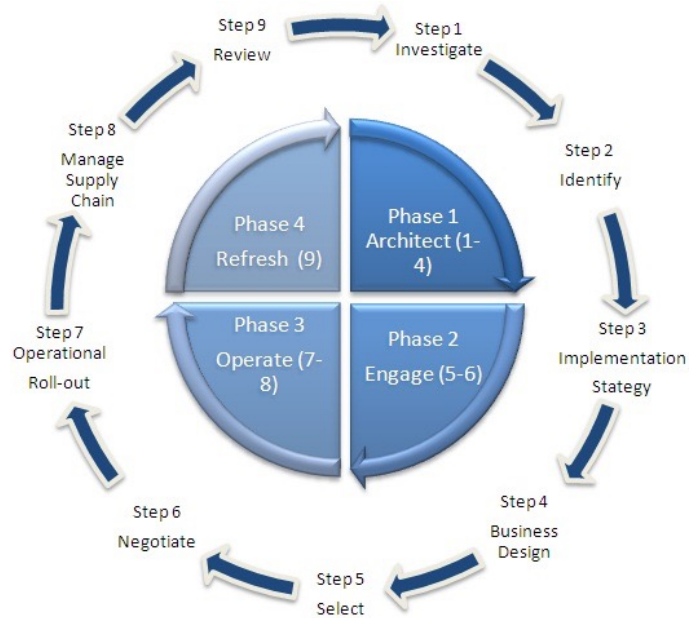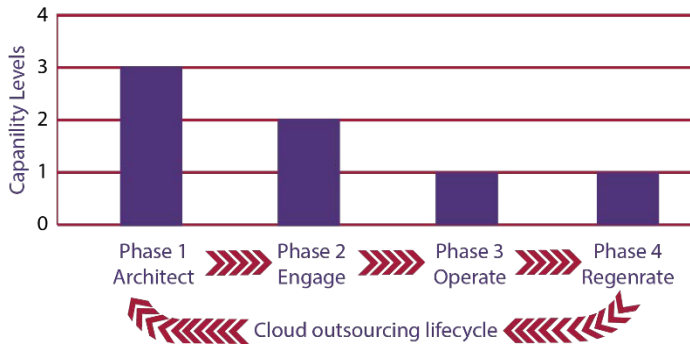

Figure 2: Cloud Outsourcing Lifecycle [4]

3 CLOUD SERVICE CAPABILITY MATURITY MODEL (CS-CMMI)

The proposed model is mentioned in detail within this section of the paper. The outsourcing lifecycle is used as a base for the model where CMMI (specifically the continuous approach of capability) was built up upon. Those two elements helped in identifying the steps needed to be taken in order to implement the cloud (Cloud Outsourcing lifecycle) and the means of performing/improving these steps (CMMI). After studying the concept of phases and building blocks in the lifecycle, a modification was made where the phases were replaced by process areas and the building blocks were considered to be specific practices, under which there are a set of activities that can be referred to as sup practices. To achieve this, the activities of the building blocks that serve the implementation of the cloud were selected along with new activities created to enforce the migration to the cloud. The result is a set of activities that act as the sup practices, or in other words, the tasks to perform each specific practice. As mentioned above, this provides the overall steps of integrating cloud, as a what to do list, but to know how to do it and improve it, one must apply the continuous approach to processes improvement, i.e., the capability levels of CMMI. Hinging on the rotating repetitive nature for the outsourcing lifecycle and the generic goals of the CMMI model, the four phases were placed on a capability leveling model in order to demonstrate and assess their performance during each cycle and to apply improvement when needed. Figure 3 is an example of this.

Figure 3: Assessment results example

Furthermore, specific practices contribute to a specific goal that set for each process area. For example, in phase 1 (architect) of the outsourcing lifecycle, a process area was set as (Plan cloud project), and its goal was identified as (Gather knowledge about SME), as for the specific practices, it was concluded to investigate, target, strategies, and design. Under each one of those specific practices, there are a set of activities related to said specific practice. Thus, in order to move to phase two (engage), one must perform all the activities under each specific practice, when all four sets of activities have been done i.e. all four specific practices have been performed then the specific goal of the process area (building the cloud) have
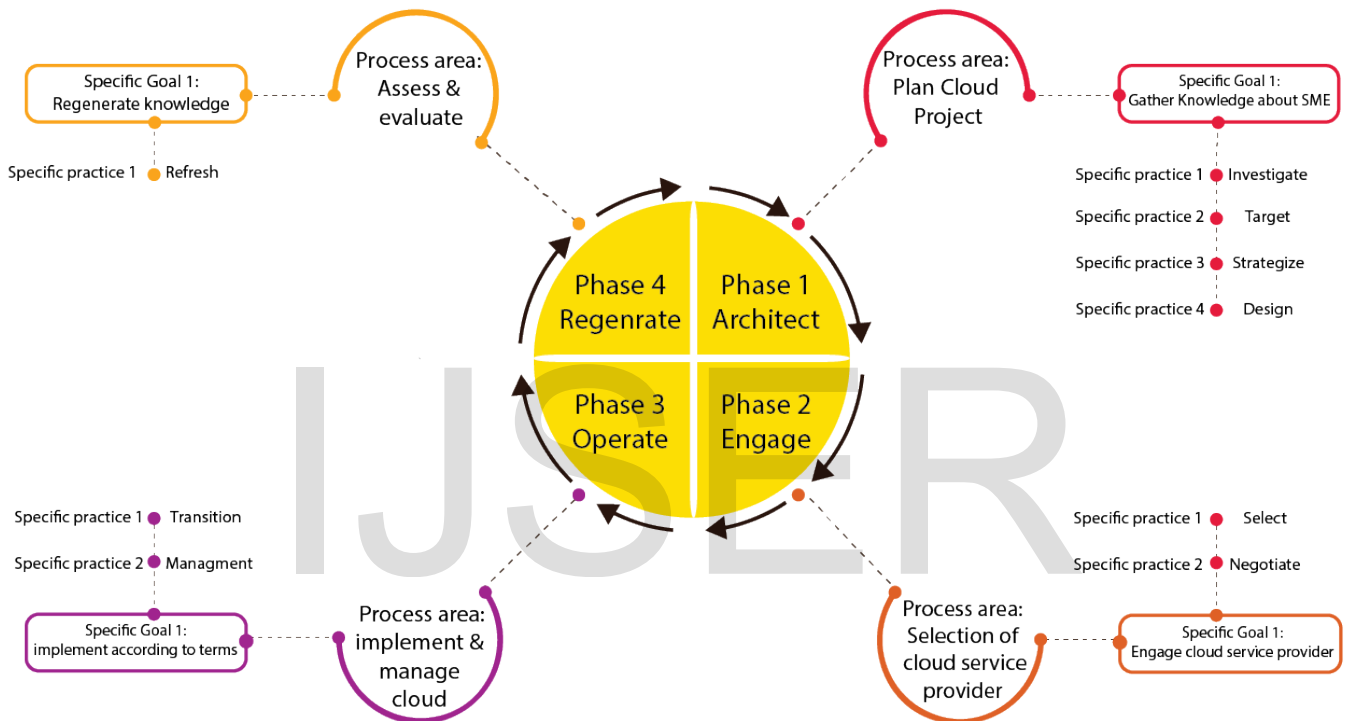

Figure 4: Proposed Cloud Lifecycle with Process Areas

4 METHODOLOGY

To demonstrate the usage of the proposed CS -CMMI model, the paper will offer a hypothetical SME (company x), which is attempting to obtain cloud services. Due to lack of internal resources, company x choose to benefit from the public cloud and is planning to acquire an online platform to start corresponding through the use of their official business email service, which will be their first obtained cloud service. The following defines the process areas, their specific goals and their specific practices which will, in turn, illustrates how company x can procure their desired email cloud service with an improved evaluated performance by taking advantage of the cyclic nature of the proposed model. It is important to note that after finishing the cycle of implementing cloud email service, company x can determine the capability level of the process areas according to their performance in said cycle.

been achieved and the enterprise can move to phase two (engage) and begin working on its process area. Figure 4 illustrates the proposed model as a whole.

4.1 Phase 1, Architect

Process area: plan cloud service
In this phase, company x must effectively architect the implementation of the cloud email service while focusing mostly on their own specific needs of the service.

Specific Goal 1 - Gather knowledge about SME:
Company x must gain sufficient knowledge about itself in order to identify their needs of the service and plan the implementation accordingly. In the case of cloud email services, company x must possess enough knowledge to accurately identify enquires like, the number of staff members who need emails, the amount of online storage needed for the service, and how much should be allocated to each email.

Specific practice 1 - Investigate:

Company x must develop insight about itself and cloud service providers that are able to provide the needed service according to the SME requirements. Next, company x will have to dictate and convey their goals or expectations of the service to potential providers. When sufficient knowledge is collected, company x will be able to make an informed decision when it comes to choosing the right provider.

Specific practice 2 - Target
Using the goals identified in the last practice as objective criteria, company x can start targeting the most suitable service provider, who's cloud email service model matches the set criteria.

Specific practice 3 - Strategize
The aim of this practice is to give company x the opportunity to plan the next phases of the lifecycle carefully, in order to primitively counter any sudden expensive changes in the future. A strategy must consider how the service will be rolled out, its rules/regulations, the staff needed for implementation of service, who to communicate with and most impotently the possible risks and effects of acquiring the service.

Specific practice 4 - Design
All the work done in the previous practices leads to the fulfillment of this specific practice. It allows company x to design or set the layout of acquiring the cloud email service. In other words, this practice documents the contract terms with the desired service provider. Those terms must at least determine how long is the service going to be provided, what method of payment is used, who is going to monitor the delivery of the service.

4.2 Phase 2, Engage
Process area: Selection of cloud service provider
Based on the information gathered in the previous phase, one or more cloud email service providers are selected and approached for negotiations over contract terms set by company x. It is worth noting that both phase 1 and phase 2 aim to give the SME as much time and opportunity to gather as well as study information to make decisive decisions regarding the implementation of the cloud service.

Specific Goal: Select, engage, then negotiate the deal
While approaching potential providers, company x should consider things like the market situation, the standard capabilities of cloud service providers and price ranges.

Specific practice: Select
Based on the monetary resources available, company x will have to select the most suitable service provider, one that meets all company x requirements regarding the cloud email service.

Specific practices: Negotiate
Administer effective negotiations methods while prioritizing important terms of the contract.

4.3 Phase 3, Operate
Process area: Implement and manage cloud service
This is where actual integration of the cloud service gets provided by the service provider and tested by the SME. In the proposed hypothetical, if company x has reached this part of the cycle successfully then it is safe to assume that the selected cloud email service provider has transitioned or delivered the service to company x according to contract terms, and staff members started to yield benefits from having a cloud email service. Thus, the aim of this process area is for company x to assess the transition of service and manage its performance. In simpler words, company x role here is to try the service for future evaluation.

Specific Goal: Implement according to terms
Company x are advised to follow up with the provider and supervise the transition of cloud email service, to ensure implementation of the service according to contract terms.

Specific practice: transition
This practice consists of finalizing all plans, providing needed resources for the transition, updating workflow and performing post-implementation testing.

Specific practice: Manage
The results of all the work done so far represent themselves in this practice. Benefits and problems of the service can be identified now and an on the spot plan of improvement can be applied to allow for better outcomes. This is done by conducting worthwhile analytic reports, managing risks and rectifying variations.

4.4 Phase 4, Regenerate
Process area: Assess and evaluate
Going through this process area, the SME is more experienced in decision making. The outcome of the previous phase governs future decisions regarding the implementation of other cloud services. Moreover, options and plans for the next cycle are discussed in this phase based on an evaluation of the currently implemented service. In the case of company x, if the cloud email service evaluation is favorable and the transition of service went smoothly according to contract terms, then company x might decide to deal with the same cloud service provider again and if for any given reason that is not possible, it will have informative knowledge when it comes to choosing a new provider.

Specific Goal: Regenerate knowledge
Refers to regathering information on the needs of the SME and cloud service provider's capabilities in order to make an informed decision regarding the next cloud service needed.

Specific practice: Refresh
Involves refreshing cloud service implementation strategy to create a more definite approach in the next cycle. Here, the SME must take into consideration the implementation outcome and heed the lessons provided by the whole

experience. The reason or the primary benefit of the rotating cyclic nature of this model comes in fruition at this stage of the cycle. Form the point of view of company x for example, the decision makers will definitely have a diminished uncertainty towards cloud services, if they did it once then they can do it again, only better.

Furthermore, having gone through the cycle once, company x can assess the progress of all phases according to the capability levels of CMMI. With the implementation of the cloud email service being successful, company x can conclude that all phases i.e. all the process areas have reached capability level 1 - performed. Going further means that the SME needs to prepare itself to manage the process areas in the next cycle (the implementation of the next cloud service) more closely in order to raise the process areas capability levels to managed and so forth.

5 CONCLUSION

As it was established earlier, cloud services can provide a large set of services that will definitely benefit enterprises in many ways. However, Enterprises and SMEs in specific need for a systematic approach when implementing cloud. Through research, only one approach was found that serves the needs for migrating to the cloud, which is the cloud outsourcing lifecycle, developed by [4]. Unfortunately, one might consider it to be incomplete or lacking on the side of assessment and improvement, yes it can be used to migrate to the cloud, but it may not be able to measure its performance compared to the enterprise's objectives. Thus, this paper theorized a new cloud migration model, one that is based on the outsourcing lifecycle and governed by the concepts of capability maturity model integration. Not only does this proposed model suggests the right steps to implement cloud i.e. what to do, it also demonstrates how to assess, improve and modify to ensure the quality of cloud services with minimum costs.

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