

Applying effective cloud computing maturity model (CCMM)

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Abstract. Cloud computing has evolved become important computing paradigm for all organizations around the world. Cloud computing emerges to address the limitations of organizational resources in deploying IT services. Due to its advantages, there are still many debates about how to apply cloud computing effectively. Many organisations have reported that embracing the cloud computing is not an easy task and surrounded with many complexities. The use of cloud computing depends heavily on the ability of the organization to adapt with cloud computing paradigm. In order to maximize the benefits of cloud application, each organisation needs to develop a systematic, broad, holistic, and pragmatic approach. Cloud computing maturity model (CCMM) is initiated to provide easy tool for assessing current conditions and improve service capabilities related to cloud computing. Measurements the implementation of cloud computing however, is challenging task since it needs to address certain factors in both business and technical perspectives. The article applies the popular framework initiated by the Open Data Center Alliances (ODCA) cloud computing maturity model (CCMM) as essential reference to guide applying cloud environment.

1. Introduction

Over the past few years, cloud computing has emerged as a phenomenon that is potentially transforming businesses in information technology, suggesting huge profits for IT professionals. Many IT professionals use the paradigm of cloud computing with a variety of benefits includes a reduction in IT infrastructure and operating costs, increased flexibility and ease and speed of data access [1]. Existing resources in cloud computing can be dynamically used to match variable loads, allowing for optimal resource utilization [2]. Cloud computing is typically run on a pay-per-use basis, in which the warranty offered by the infrastructure provider conforms to the service level agreement (SLA) [3].

Etro [4] suggested the firms to start adopting cloud computing from the simplest application and move into a more relevant direction. For instance, one of Italy's leading hospitals, Children's Hospital of Bambin Gesù in Rome, recently switched to an online solution for 2500 employee email services (taking place in 2010) in less than four months, creating substantial cost savings and directing IT specialists to focus on other more relevant tasks for the hospital). In news reports that are highlighting the vulnerability of cloud computing growth; A recent survey of 613 done by Poneman institute to IT security practitioners had reported that 66 percent of respondents believe that the use of cloud computing resources enable to reduce the ability of an organization to protect confidential or sensitive information [5]. Furthermore, Poneman institute addressed that 63 percent of

respondents believe there is a lack of awareness in auditing or assessment of cloud computing services and 64 percent believe cloud computing service providers are not fully compliant with privacy and data security regulations.

Oracle defined a cloud computing approach with the use of cloud computing maturity model (CCMM). CCMM is developed based on deep experience and best practices with the aim to accelerate the adoption of cloud computing and is expected to dramatically reduce the risks associated with the transformation needed in cloud computing (6). The article applies the framework of Open Data Center Alliance's (ODCA) CCMM, with the aim to enable the organizations to implement effective cloud strategy, assessing current capabilities and paving the way for continuous improvement of an organization's capabilities.

2. Theoretical Foundation

Cloud computing according to NIST is defined as a method to utilize the availability of computing resources from providers based on demand by a customer using a computer connected to the network (usually the internet) [7]. Cloud computing refers to a computing, software, data access, and storage service that does not require end-user knowledge of the physical location and system configurations to provide services. Cloud computing enables to take over the operating servers and applications elsewhere, offering an alternative to businesses by providing on-demand computing power over the internet, with quick implementation, little local maintenance and few IT staff (8).

Armbrust defined the cloud computing has characteristics as follows [9]: (1) on-demand self-service; (2) broad network access; (3) resource pooling; (4) rapid elasticity; and (5) measured service. Cloud computing has three major types of services such as (7): Infrastructure as a Service (IaaS), Platform as a Services (PaaS), Software as a Service (SaaS). Based on the use, the cloud computing is summarized as: (1) public cloud (2) private cloud (3) community cloud; and (4) hybrid cloud.

Rajaraman examined the advantages of cloud computing comprised of [10]: (1) reduction of the organization's capital burden because they do not need to invest in large computer infrastructure and repeatedly invest so the computer will become obsolete; (2) availability of number of software systems by paying what; (3) elastic and scalable computing infrastructure in accordance with available demand. An organization may request more computing power and, when necessary with the limitations of processor and storage power; (4) organizations can use cloud infrastructure to automatically backup their important data; this will allow quick recovery if data is corrupted; (5) a cloud service can be designed to be 'self-healing'. In other words, if the server where the application is running fails, the system enables to move the application automatically to another server. Ashari and Setiawan addressed the disadvantages of cloud computing needs to be addressed such as [11]: (1) internet connection, it needs adequate bandwidth and stable for cloud computing running well; (2) companies that rent services from cloud computing do not have direct access to resources. So, it all depends on the condition of the vendor / service provider cloud computing; (3) if server provider of the service is damaged or have a bad backup service, then the company will suffer huge losses.

Sharma suggested to use CCMM as prediction tools to examine the results that most likely to be expected from subsequent projects that enables organization to perform better tasks [12]. To apply capability maturity effectively, companies can start from addressing the key characteristics such as: business strategy, governance, procurement methods, applications,

information and information security. In addition to CCMM use, the repair process guidelines are introduced to assist two main methods to improve cloud services such as: (1) improvements through the cloud service maturity level; and (2) improvements through process issues in terms of cloud service capability level [13]. Chen et. al. further addressed the formation of the CCMM to provide a framework for successful implementation. There is a gradual approach to CCMM, encompasses five key components: consolidation, virtualization, automation, functionality, and cloud computing. CCMM contributes to demonstrating the need for improvements and cloud computing management tools to the established CMM to fill gaps (1).



Figure 1.Cloud Computing Maturity Model

Holger et.al. stated that CCMM can be used as a tool for managing cloud computing and it comprised of a 5 level of maturity capacity to be done (see Fig.1). CCMM also can act as an indicator for improvement whenever it did not reach the predetermined indicator (1). Kaur et.al. addressed that CMM can be used for evaluating capability with the aim to provide a way for assessing the software process capabilities of an organization and the assessment of the software process with the aim of selecting a service provider or enhancing its process capability based on key characteristics. It comprised of: business strategy, governance, applications, information and information security [12]. Rittinghouse and Ransome [14] proposed a CCMM phased approach consisting of consolidation, virtualization, automation, utilization and computation as a strategy to reduce costs, management of personnel and computational problems. Chen et.al. [13] suggested to address the knowledge of implementation and guidance of the cloud service into CCMM, as an essential roadmap to develop superior service quality and institutionalization design to maintain the results of cloud computing implementation.

3. Theoretical Model

The article examines the literature studies from databases from IEEE and Association Computing Machinery (ACM) starting from year 2012-2017, and Google Scholar with keyword “Cloud Computing Maturity Model (CCMM)”. We found out that common CCMM works are based on the work of Open Data Center Alliance Inc. (ODCA). Currently, the recent version of 2.5 has been proposed to be used in the industry. The recent version provides new breakthrough to understand the maturity level of cloud based application in the industry. It covers wide range of area such as: business, technology and service perspectives. ODCA recommended to accelerate migration to cloud computing through improving ecosystems built on openness and interoperability (15). ODCA examined the importance of CCMM should consist of two main perspectives: business skills and technological capabilities and mapping the level of maturity for individual cloud computing services models: SaaS, PaaS, IaaS, and Information as Service (16)(17).

Perspective of CMM business capabilities can be defined as a comprehensive view of the stage of maturity model through the view of business use of cloud computing. The

perspective includes a mixed model of cloud computing services, cloud computing deployment model, and cloud computing capabilities in four business categories: (1) business strategy, (2) organization and skills, (3) governance, (4) projects, portfolios and services (17). Overall the business perspective capability of CCMM should contain five levels such as: (1) Business strategy; (2) Organization and skills; (3) Governance; and (4) Projects, portfolios, and services, contains in the capabilities associated with the planning and development of cloud computing services, and the management of service portfolios.

The summary description of each level of maturity of the CCMM is shown in the table 1 below:

Table 1. Description of Cloud Computing Maturity Level Model (16)(17).

CMM 0 (No existing)	Applications on Dedicated Infrastructure. No cloud computing approach is taken. No cloud computing element is being implemented.
CMM 1 (Initiative)	Analysis of the current environmental preparedness of cloud computing. Mapping and analyzing the potential of cloud computing for existing systems and services. Awareness of cloud computing was established and several groups began to apply the elements of cloud computing. No cloud computing plan is clearly followed.
CMM 2 (Opportunities)	The process for cloud computing is adopted, defined. An approach has been decided and opportunities are applied. This approach is not widely accepted and excessive or overlapping approach exists. Perhaps informally defined or if documented, may exist primarily as "self-awareness" (Benefits of Capability).
CMM 3 (Defined Systems)	Equipment and integration for automatic use of cloud computing. This approach has been reviewed and accepted by the affected parties. There is a documented purchasing approach and an always (or almost always) followed approach. (Gain Efficiency)
CMM 4 (Measurable)	The federation guides. Cloud computing applications are deployed according to business needs in public, private, and hybrid platforms. Measurability and quantitative are managed through several types of governance structures. The size approach is being collected and reported. (Increase in speed and quality).
CMM 5 (Optimize)	Federal, interoperability and open cloud computing. Sizes are consistently collected and used to gradually improve capability. Assets are proactively maintained to ensure relevance and truth. Potential market mechanisms that will be used to improve inter-cloud computing operations have been built. (Proactive enabling business strategy)

The CCMM of technological perspective capability comprised of five levels shown in Fig. 2 such as: (1) operations, administration, and governance; (2) information; (3) Infrastructure; and (4) architecture; while the CCMM service model addressed the service delivery such as: (1) infrastructure as a service (IaaS), (2) platform as a service (PaaS), (3) software as a service (SaaS), (4) information as a service (IaaS).

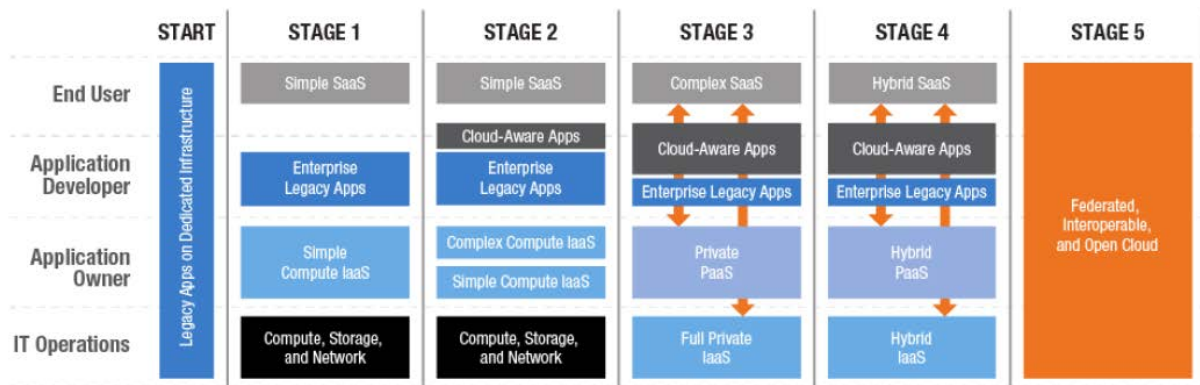


Figure 2.CCMM of Technological Perspective Capability (16)(17) .

The CCMM adoption enables to provide an end-to-end visualization for the technical use of cloud computing technology in the company evolves over time. As a technical implementation of maturity, the use of cloud computing becomes more sophisticated, comprehensive, and optimal. Based on ODCA industry experience, many large advanced companies have adopted the same overall trajectory but at different adoption rates (18).

4. Discussion

The CCMM leveling provides valuable steps of implementation for cloud designer to apply cloud application. Current fast adoption of cloud paradigm provides advantages along with its disadvantages. Cloud designer faces common problems such as addressing the gap of knowledge from the users to apply the cloud framework. Users in general do not have enough best practices or framework to guide them to maximize the utilization of IT technology (19). Therefore, they experience difficulties to extend the scale of cloud applications for future use. Although everyone is aware of the cloud based application in enterprise setting, nevertheless, there is only very few can take advantage of it. The revision 2.5 of CCMM enables to fill the designer's expectation, by providing new trend and reference for organization to take advantage of it. The recent CCMM version provides systematic thinking that allows the cloud designer to analyze the organization's needs and deliver the maximum benefits, reduce unnecessary costs and maximize the use of resources (20).

In order to apply the CCMM effectively, it requires the support of the top management, effort of the IT department, and an excellent promotion to make sure that wide acceptance within the organization (21). The CCMM requires organizations to achieve cloud computing environment, interoperability, and open to deliver expected benefits. This in turn will enable the business's expected value that cloud computing services should represent the organization's achievements of capabilities, efficiency improvements, quality advantages, increased flexibility, and speed gains, ultimately resulting in strong business strategy empowerment (22).

5. Conclusion

Cloud based applications have emerged as essential application for all enterprises. Due to its advance growths, cloud computing suffers lack of adequate reference to gain its maximum results. The article examines the recent maturity level articles from IEEE and ACM databases, and addresses the popular maturity level version 2.5 frameworks that suits with needs of modern enterprises. The article selects the work from the Open Data Center Alliance (ODCA) that has been referred by the industry. The formulation of CCMM framework is essential to enable organizations to implement effective cloud strategy, assessing current capabilities and paving the way for continuous improvement of an organization's capabilities. ODCA summarized the CCMM should comprise of two main perspectives such as: business skills (business use) and technological capabilities (comprehensive for the organization). The business perspective capabilities comprised of five levels of maturity of cloud computing through four business capabilities such as: (1) business strategy; (2) organization and skills; (3) governance; (4) projects, portfolios, and Services. The technological perspective capability of CCMM Open Data Center Alliance (ODCA) defines the CCMM is essential framework to provide stages of cloud implementation that comprised of five levels: (1) operation, administration, and governance; (2) information; (3) infrastructure; and (4) architecture. The maturity level for the cloud computing service model are defined as: information as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS). Each organization has different interest to utilize type of cloud service, and it depends on the needs of business, problems to be solved, level of organization maturity, regulatory design and strategic considerations.

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