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# AN ANALYSIS OF THE ADVANTAGES, CHALLENGES AND OBSTACLES OF CLOUD COMPUTING ADOPTION TO AN ACADEMIC CONTROL SYSTEM

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**Abstract.** The evolution of cloud computing (CC) over the past few years is certainly one of the greatest advancements in the history of computing. However, for this technology to reach its potential there must be a clear understanding of the issues involved in its adoption. The purpose of this exploratory case study is to build an evaluation model that takes into account aspects such as the advantages, challenges and obstacles of adopting CC. To assess the feasibility and usefulness of such model, an Academic Control System (ACS) from an International School was analyzed. Such analysis enabled the development of recommendations, the provision of inputs and the suggestion of actions necessary to launch the ACS as a cloud service. The model revealed challenges regarding governance, human resources (HR) management, project management and organizational culture to deal with innovations and changes. Such challenges shall be taken into account in the cloud strategy. Also, security issues, business models, technical capacity, performance, service level agreements (SLA) are obstacles that organizations willing to provide such services must face. According to the model, the recommendations to overcome such challenges and obstacles include HR management good practices, risk management processes and well-defined decision making instances.

**Keywords:** Cloud Computing, Software as a Service, Product Management

## 1 Introduction

Considered one of the greatest developments in the history of computing [1], Cloud Computing (CC) has been gaining ground as a successful model as it promises economic savings, easiness of use and greater flexibility in the control of resource use, anytime and anywhere, while delivering the required computing power. The model's value proposition is that resources are no longer idle, as they almost used to the fullest (with lower unit costs) [2]. However, for this technology to reach its potential there

must be a clear understanding of the various issues involved in its adoption, from the point of view of both providers and customers [2].

The purpose of this research is to investigate the applicability and usefulness of an evaluation model for the CC adoption, built under the scope of the study. The model considers aspects such challenges, obstacles and advantages of CC. Supported by the literature, these aspects were unfolded into issues involving governance, people management, project management, risk management and forms of investments, as well as into other topics related to design, development and marketing of software products to be offered with a service, within this new paradigm of computing.

Having started its operation in 2003, an International Education institution began modernizing its Information Technology (IT) area in 2009. As its growth exceeded 100% per year, the department, initially directed to academic needs, started meeting business requirements through the adoption of specific ERP modules and development of an Academic Control System (ACS), aiming at improving organizational processes and controls.

In light of the challenges to maintain the hardware and software infrastructure updated and secure and with the required availability, IT management currently rethinks the way in which these computing resources are acquired, developed and used, studying the feasibility of the adoption of CC.

IT managers believe that the internally developed ACS, as part of efforts to improve processes and controls, could become a product to meet common needs of international schools. As with the IT infrastructure, the International School is assessing the possibility of using CC. The ACS would open a new business opportunity for the organization, currently focused exclusively on the education segment, possibly with the setting up of a company with this specific purpose. Thus, this new product would be developed for the cloud, and it would be necessary to assess the issues inherent to this decision.

The main motivation of this case study was to examine the robustness of the proposed evaluation model, as well as to assist the International School in making decisions regarding the release of the ACS, seeking to identify the key advantages and potential obstacles for the adoption of CC, so that organizations can offer competitive, updated and effective products, with the most efficient use of its resources.

## 2 Literature Review

To achieve the proposed objective to work (construction of an evaluation model for the adoption of CC, investigating its applicability and its usefulness for the launch of the ACS as a cloud service), the authors searched the literature that examine major issues concerning the subject, as follow.

**Definition of Cloud Computing.** Although many formal definitions have been proposed by academia and industry [3,4,5,6], the definition provided by NIST (National Institute of Standards and Technology) [7] includes the main concepts commonly used in the CC community. According to 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.”

**Table 1.** Advantages of Cloud Computing.

ADVANTAGES	DESCRIPTION
A1	<b>Lower cost of customers' capital:</b> Customers do not buy software or infrastructure (hardware and operating system, for example) in advance, but they pay for the access to those services over time [1].
A2	<b>Lower cost of providers' capital:</b> CC can provide an almost immediate access to hardware resources with no upfront investments to its users, reducing the “time to market” for products from many companies [1].
A3	<b>Reduces deployment cycle:</b> since applications are already deployed in <i>SaaS</i> vendors' sites. The SaaS model also allows cost savings in the large-scale operation of standardized business components [9].
A4	<b>Reduces cost of entry into new business:</b> significantly reduces the cost of entry for small companies that can benefit from the business applications, previously available only to large corporations [1].
A5	<b>Reduces cost of business expansion or entry into new markets:</b> CC makes it easier for businesses to expand their services according to customers' demands, since computing resources can be deployed very quickly and in accordance with needs [1].
A6	<b>Easier maintenance:</b> the IS provider has greater flexibility to correct, improve or add new features as it has greater control of the application's configuration [10].

**Table 2.** Challenges of Cloud Computing adapted from [12].

CHALLENGES	DESCRIPTION
C1	<b>Human Resources:</b> in practice, the recruitment and retention of a high quality team, albeit small, is one of the biggest challenges of HR management. In general, there is a lot of demand for staff skilled to work with CC resources, requiring organizations to pay them slightly more than competitors, within a career plan, keeping them always challenged and stimulated.
C2	<b>Changes in culture, values, guiding principles, beliefs:</b> CC allows a change in the vision of the IT function. Traditionally, IT departments spend 60% to 80% of their efforts to keep their infrastructure running, resulting in little time to focus on business needs. With CC, IT can be quicker to respond to changing needs in business requirements. This challenge is enabling the change in the current situation of organizations, to achieve the skills to meet the business needs and the functions of architects and experts in CC.
C3	<b>Project Management:</b> it must be a core skill of the organization and not just the maintenance of a business resource. Candidates for the role of project manager are most likely found among relationship builders and technology evangelists. The creators of business systems, leaders, architects and specialized buyers must have an active role in projects with a strong technology or component of CC.
C4	<b>Innovation:</b> IT areas shall be designed to handle dynamic business contexts, which, among other tasks, are designed to innovate. Organizations still need to make big changes if they want to take advantage of the great innovations of technology/service providers in the cloud. Fundamental practices such as support the effective collaborative innovation and deepen the collaboration between areas of the organization can offer not only an operational IT but also business process and strategic innovations.
C5	<b>Cloud evolution:</b> IT executives need to focus on the reality of technical expertise and services, while ensuring that business managers have the correct perception of the necessary improvements to IT performance. Capacities to plan architecture, correct technical errors and facilitate contract management are particularly important. A greater proactivity in the delivery of strategic technologies for business and increased focus on needs are required.

**Cloud computing services.** Also according to NIST [7], the definition of CC includes three different service models: Infrastructure as a Service (*IaaS*), Platform as a Service (*PaaS*), and Software as a Service (*SaaS*). In the *IaaS* model, customers are allocated computing resources in order to run virtual machines consisting of operating systems and applications [8]. In the *PaaS*, consumers are allowed to write applications that run on the service provider's environment. The third model, *SaaS*, provide consumers with typical software applications running over the Internet. *Google Apps Engine* and *Google Docs* are, respectively, examples of *PaaS* and *SaaS* [3]. The paradigm of cloud computing reinforces the assertion of Delone [11], which to measure the overall success of IT, the service quality is more important than the quality of the information or the quality of the systems themselves.

**Table 3.** Obstacles for Cloud Computing adoption.

OBSTACLES	DESCRIPTION
O1	<b>Strategic feasibility of procurement or provision of services:</b> organizations may believe that certain information systems, depending on their criticality to the business and on the need to maintain them under their control, cannot be hired or offered in the cloud. This may occur when the system business rules can offer a competitive business advantage for that organization within the segment in which it operates. [15].
O2	<b>Lack of technical capacity:</b> implementing a CC environment is a major technical challenge. Complex software solutions have to be developed and available 24x7 [13].
O3	<b>Business model deficiencies:</b> the economic viability of provider, its ability to thrive and continue in the activity may inhibit customers' willingness to use cloud products [13].
O4	<b>Security issues:</b> Migration to any of CC models presents many security risks. In addition to physical security and to the security of organizations' data, there are technical, legal and policy issues [16]. The risk model must cover all aspects of security requirements, including physical security, data security and policy, technical and legal issues [16].
O5	<b>Behavioral Tradition - Abandoning the traditional IT model:</b> There is an important cultural obstacle, which can generate mistrusts and uncertainties. This obstacle can be represented by customers' need to abandon the traditional IT model, in which physical and logical IT resources to support business organizations are more tangible [13].
O6	<b>Availability:</b> services require an internet connection constantly available. Otherwise, these connection failures may result in the application unavailability [10] [13].
O7	<b>Performance:</b> applications may not work well with low-speed connections: which will result in the downtime or slowdown of the application or of some of its resources due to possible latency in the target analysis application data transfers [10] [13].
O8	<b>Governance:</b> As a result of technical and contractual complexity, consumers fear that unheard-of situations and consequent short time of maturations, providers are not prepared to deal with them satisfactorily, causing difficulties in the relationship [14].
O9	<b>Service level agreements (SLAs) and quality:</b> these refer to providers' ability to ensure availability and have the resources to meet contingencies. They are provided for in the SLA, where compliance standards and penalties are defined [14].
O10	<b>Reliability:</b> consumers expect CC environments to be reliable and that the availability of services and resources offered fully meet their needs, especially those related to critical business aspects. Thus, CC crucially depends on reliability; if consumers feel the system is not fully reliable, they become reluctant to use this service model [14].

**Advantages, challenges and obstacles to the adoption of CC.** Marston [1] considers that CC, by enabling the convergence to an environment where information can be accessed, notwithstanding the device used and the location, represents a major shift in computing and can offer significant advantages to adopting organizations. **Table 1**

shown the main advantages of CC, identified as A1 to A6, to facilitate the understanding of the recommendations presented in 4.

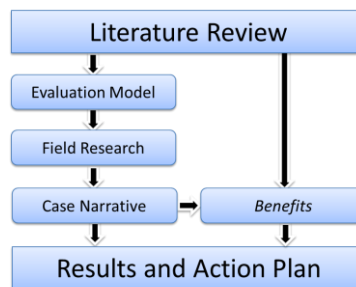
According to Willcocks *et al.* [12], there are five major challenges that must be faced by those who currently use the traditional IT infrastructure model and who want to switch to CC. Challenges were identified as C1 to C5 in **Table 2**, in order to facilitate the understanding of the recommendations presented in 4.

The literature on CC offers studies [13,14,15] which mention the difficulties to its adoption, represented by obstacles inherent to the computing model. The main obstacles, listed from O1 to O10, are shown in **Table 3**.

### 3 Research methodology

**Research method.** The research consisted of an exploratory case study. Based on the literature review, was identified advantages, challenges and obstacles relevant to the development of an evaluation model for the adoption of CC. These aspects are the basis for building the model, in which challenges and obstacles were grouped into four correlated action foci: organization, business model, human resources and security. These action foci grouped the recommendations of the action plan (**Table 5**), facilitating the understanding and its unfolding in the actions themselves.

Questionnaires were used to implement the analysis model. They were designed to investigate the qualitative aspects (advantages, challenges and obstacles) of the evaluation model. The result of these questionnaires applying, called Case Narrative (**Fig. 1**), were analyzed using knowledge of literature bounded by the model. The result of the analysis is a set of recommendations, which unfolds in the proposed action plan.



**Fig. 1.** Schematic diagram of the construction of results.

**Characterization of the target organization.** The unit of analysis is an International School that started its activities in 2003 with just over 70 students and a few staff, and grows exponentially since then. It currently has about 1,000 students, approximately 250 employees and its revenue is of approximately R\$ 48 million/year.

In addition, the organization and its IT environment (personnel, systems, processes, etc.) have the relevant characteristics to enable the study. Following the definition of issues and research project, interviews were held with people who hold the following

positions: IT manager, process and authorship engineer (manager), development coordinator (manager) and development analyst (coordinator).

**Description of the target application.** The IT infrastructure currently has ERP (Financial - billing) systems and the Academic Control System (ACS), which becomes, every day, more important in the operation of the organization. The application that will be the object of analysis is the ACS (candidate to move to the cloud).

## 4 Results and Action Plan

The construction of the Case Narrative (**Fig. 1**) resulted from the application of questionnaires to investigate the relevant topics of the target organization and the target application. **Table 4** presents the advantages of using the CC found in the literature and adapted by the author based on what can be extracted from the Field Research and recorded in the Case Narrative.

**Table 4.** Recommendations for taking advantages of CC.

ADVANTAGES	RECOMMENDATIONS
A1 & A3	<b>Lower customer capital:</b> ACS provider shall promote its product to customers in the SaaS model, arguing that they will not need to purchase software or infrastructure, but will pay for access to services over time. This will result in reduced cost of fixed capital, dilution of service costs over time, allowing a quicker return on investment, and potentially, bringing significant cost savings.
A2	<b>Lower providers' capital cost:</b> CC, by providing almost immediate access to hardware resources with no initial investment for ASC provider, improving its "time to market". As it is an operating expense, it also helps drastically reducing the necessary investments to product launching.
A3	<b>Reduces deployment cycle:</b> ACS provider shall promote its product arguing that it is already deployed under the SaaS delivery model, reducing deployment time, parameterization and system "tuning" (ACS).
A4	<b>Cost of entry into new business:</b> ACS provider shall promote its product arguing that customers can drastically reduce the cost of entry into the market for international schools that benefit from the knowledge of existing ACS business rules.
A5	<b>Cost of business expansion or entry into new markets:</b> ACS provider shall promote its product arguing that CC makes it easier for customers to expand their services for purposes of business expansion or entry into new markets according to their strategic plan. This is because computational resources can be deployed very quickly, according to new needs, scaling them up or down dynamically, depending on customer's load, with minimal interaction with service providers (self-service).
A6	<b>Easy maintenance:</b> ACS provider has greater flexibility to correct, improve or include new features, as it has a greater control on the distribution and management of its applications, enabling agility in meeting the business needs of customers.

The recommendations were grouped in into four foci of correlated actions summarized in a preliminary action plan (**Table 5**) for further detail, with the definition of responsible parties, timeframes and indicators for monitoring and control.

## 5 Conclusions

The analysis model proved to be robust enough to capture the peculiarities (and desires) of the organization and compare them with literature. Its application enabled the formulation of recommendations, giving subsidies and presenting an action plan for the International School to be able to guide and implement its decisions, regarding the development and marketing of ACS as an application for CC.

**Table 5.** Action Plan to implement recommendations.

ACTION FOCUS	ASPECT	ACTION TO BE PLANNED
<b>Organization</b>	<b>C2, C4, C5 &amp; O8</b>	<ul style="list-style-type: none"> <li>- Share organizational values, such as, for example, keeping channels of communication that promote improvements, seeking greater efficiency and effectiveness.</li> <li>- Practice effective <b>collaborative innovation</b> between different areas involved with CC, such as development, marketing, human resources and interfaces with providers.</li> <li>- Demonstrate the commitment to develop, implement and improve the ability to offer ACS as a service, within the organization's business context and customers' needs.</li> <li>- Inform customers of sustainable strategies through decisions (medium and long terms) involving CC.</li> </ul>
<b>Business Model</b>	<b>C5, O1, O3 &amp; O5</b>	<ul style="list-style-type: none"> <li>- Improve processes for the selection of providers based on technical and commercial criteria.</li> <li>- Rely on outside legal assistance for the preparation of procurement contracts and offering of services associated with ACS.</li> <li>- Solidly rely on technology partners and infrastructure providers, which shall preferably be large organizations, well known in the market, to be presented to business plan partners for the development and commercialization of the product.</li> </ul>
<b>(HR) Human Resources</b>	<b>C1 &amp; O2</b>	<ul style="list-style-type: none"> <li>- Promote measures to reduce turnover of highly skilled people in CC.</li> <li>- Promote training in CC key technologies.</li> </ul>
<b>Product Development</b>	<b>C3, C4, C5, O7, O9 &amp; O10</b>	<ul style="list-style-type: none"> <li>- Define processes, records and documentation of projects.</li> <li>- Plan, design and implement activities directly focused on the performance of ACS.</li> <li>- Establish metrics (indicators) to monitor and control the expected performance.</li> <li>- Develop a plan to identify and mitigate risks inherent to the selected service model (own or outsourced infrastructure under the <i>PaaS</i> model).</li> </ul>
<b>Security</b>	<b>C5 &amp; O4</b>	<ul style="list-style-type: none"> <li>- Deploy an IT risk management through a set of processes, policies and structures, providing an insight into the organization of all risks involved in the service provision.</li> </ul>

Although CC is a relatively new model for the delivery of IT resources, based on its proposal and use, is possible to see that the main issues addressed are the same of the traditional IT model found in organizations. Issues such as organizational strategy, governance, technical and legal training, information security, personnel management, project management, contract management are present and are the same as the vastly used IT model, although here seen from the perspective of CC.

The model identified good management practices, such as establishing communication channels between the hierarchical levels and owners, promoting innovation through collaboration between areas, establishing strategic and long-term partnerships with providers, establishing payment policies to retain people, setting processes and



metrics for the development and performance of the product and treatment of risks as a structured process with clearly defined responsibilities and methods. These aspects should be taken into account by organizations wishing to offer cloud services.

Difficulties encountered in applying the model result from the different nature of the issues involved (for ex., governance, HR, security, etc.). Thus, applicator must have specific knowledge of these aspects, so that, when raised and analyzed, they produce the appropriate result.

Any generalization is limited since the study's focus is on a single application in a single organization. Aiming to generalize the findings of this work, further study of the model can be performed in different countries and with software vendors or service providers willing to use the cloud to offer their applications.

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