Chapter

10

Open Perspectives on the Adoption of Cloud Computing: Challenges in the Brazilian Scenario

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Abstract

Cloud computing is a paradigm shift in computing that has changed the way Information System users deal with and perceive computing. This scenario has created opportunities for companies that have manifested a perceived inclination toward cloud computing and the benefits reaped by them such as low start-up cost, pay only for services used, up-to-date resources/features, and rapid deployment. However, there are challenges in the adoption of Cloud Computing, especially in the Brazilian scenario. Switching to the cloud means giving up incumbent information systems practices and facing the initial perception of losing control of data that previously had been stored in local servers. Moreover, potential adopters of Cloud Computing must face challenges related to identifying the appropriate profile of cloud services that match their needs, considering both the development of a new application or migrating a legacy system to the cloud.

10.1. Introduction

Cloud computing (CC) is a promising technology for software development, changing the way customers interact with data and applications [Di Martino et al. 2015]. Cloud computing has been as disruptive to the technology landscape as Internet was in the 1990's[1]. It has changed the way technology supports companies to deliver their services and how information is consumed. The rapid development of applications, fast response to market changes and possibilities to pay for a service on demand have boosted the adoption of cloud computing where customers only pay for what they consume. The concepts of Capital Expense (CapEx) and Operating Expense (OpEx) are important in explaining this scenario. Capital Expense (CapEx) is

[1]http://www.enterpriseinnovation.net/article/hp-research-enterprises-need-holistic-approach-cloudmanagement

a term used in accounting and means spending money on a physical resource that needs to be amortized, typically 3-5 years. On the other hand, OpEx is an upfront investment that allows a business to make payments on goods or services [2]. Leasing services and resources through OpEx has become an attractive option rather than purchasing physical hardware and database and other types of software, thus preserving important capital reserves for appropriate CapEx. Companies have the option of not buying, storing, and maintaining expensive hardware infrastructure, which can significantly reduce the time and money involved in maintaining, updating, and repairing their own equipment [Di Martino et al. 2015]. This leading to the possible benefits such as low initial cost, paying only for services consumed, up-to-date resources/features, and rapid deployment [Buyya et al. 2009], [Li et al. 2013]. This scenario enables the company to focus on their respective core business. However, there are challenges for companies that plan to adopt the Cloud Computing paradigm, in the Brazilian scenario in particular.

Brazil has the largest computing services market in Latin America followed by Mexico, Chile and Argentina. As such, it has attracted the attention of vendors from across the world and become a very competitive environment. Seizing opportunities, vendors must contend with security concerns, connectivity shortfalls, high costs and a recessive economy recently. These make the Brazilian market a challenging, yet potentially rewarding one for companies with the resources and commitment to manage these issues [3].

According to Frost and Sullivan, Brazil's cloud computing market revenue was $217 million in 2012 and it is expected to reach $1.1 billion by 2017[4]. This represents a five-year compounding annual growth rate of almost 40 percent. By 2017, the firm expects the SaaS market to lead at $584.3 million in spending, while IaaS and PaaS will be worth $489.9 million and $39 million, respectively[5]. A survey conducted in 2014 by Capgemini found that nearly three out of four Brazilian IT decision-makers use a SaaS application for enterprise resource planning or customer relationship management. Smaller but still substantial numbers reported adopting IaaS (55 percent, largely for data backup purposes) and PaaS (39 percent); and the uptake rates of both (but especially IaaS) are expected to pick up in the next few years. Some of the key motivators cited by respondents include the desire to achieve cost savings, enable innovation and raise productivity[6]. Specialists identify unlimited opportunity in Brazil, especially for over one million small and mid-sized businesses. These range from restaurants and ice cream parlors to small farms and language schools. Cloud solutions for such businesses are an affordable way to manage processes, deal with finances, comply with regulations and offer their services to the market as they pay a monthly fee for services without having to invest in infrastructure[7]. This explains why major global cloud providers such as Amazon, IBM, Microsoft, Oracle and Verizon

[2] http://ecsnamagazine.arrow.com/whats-the-difference-between-capex-vs-opex-2/

[3] http://trade.gov/topmarkets/cloud-computing.asp

[4]http://www.slideshare.net/FrostandSullivan/frost-sullivan-analysis-of-the-brazilian-cloud-computingmarket

[5] ibid

[6]www.br.capgemini.com/resource-file-access/resource/pdf/business_cloud_in_brazil_20140827_v15.pdf

[7] http://www.news.sap.com/outpacing-rest-world-latin-american-business-soars-cloud/

maintain or have plans to introduce Brazilian based data centers to support their local cloud operations, while others such as Dell, Google, Rackspace and Salesforce at least market their services in the country [8] [9]. Other foreign providers such as the German cloud heavyweight SAP, the UK's BT Global Services Prominent and Japan's Fujitsu are also present[10].

Brazil also suffers from significant connectivity challenges. The cost of bandwidth is much higher than that in other countries with competitive cloud sectors and there are clear shortfalls in the reliable provision of service and infrastructure, especially regarding the critical last-mile of delivery [11] [12].

Other studies have also mentioned that the decision towards adopting Cloud Computing (CC) takes into account issues such as the range of opportunities for migration, the attractiveness of the cost-benefit relationship and the availability of service providers to offer what best fit their needs [Li et al. 2012a], [Li et al. 2012b]. However, to address these issues, practitioners need to face challenges as described as below.

10.2. Background

CC 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. The cloud model has five essential characteristics, three service models, and four deployment models, as can be seen in Figure 10.1 [Mell and Grance 2011].

- **On-demand Self Service.** A consumer can get services from the service provider without requiring human interaction with each service provider. [Mell and Grance 2011].
- **Broad Network Access.** The resources are available through the network and standard mechanisms that promote use of heterogeneous platforms (e.g. mobile phone, tablet and desktop) [Mell and Grance 2011].
- **Resource Pooling.** The resources of the service providers (e.g. storage, processing, memory and network bandwidth) are pooled to meet multiple consumers in a multi-tenant model with different physical and virtual resources dynamically assigned and reassigned according to demand. There is a sense of geographic location independence due to no control or knowledge of the exact location of the provided resources by the consumer. However, the consumer may be able to specify a location at the highest level of abstraction (e.g. country, state or datacenter) [Mell and Grance 2011].
- **Rapid Elasticity.** Resources can be elastically provisioned and released to increase or decrease according to demand stimulus. From the consumer perspective, the resources available for provisioning will often seem to be unlimited [Mell and Grance 2011].

[8] http://www.verizonenterprise.com/infrastructure/data-centers/latin-america/

[9] http://www.datacenterknowledge.com/archives/2014/06/05/microsoft-azure-clouds-brazil-southregion-goes-live/

[10] http://www.zdnet.com/article/sap-invests-in-brazil-cloud-facility/

[11] http://techpolis.com/its-taxing-cloud-computing-in-brazil/

[12] http://www.eubrazilcloudconnect.eu/sites/default/files/WhitePaper_Future_EUBrazil.pdf

- **Measured Service.** This refers to the capability to measure and quantify usage of resources. This is required for billing, access control, resource optimization, capacity planning, among other tasks [Mell and Grance 2011].

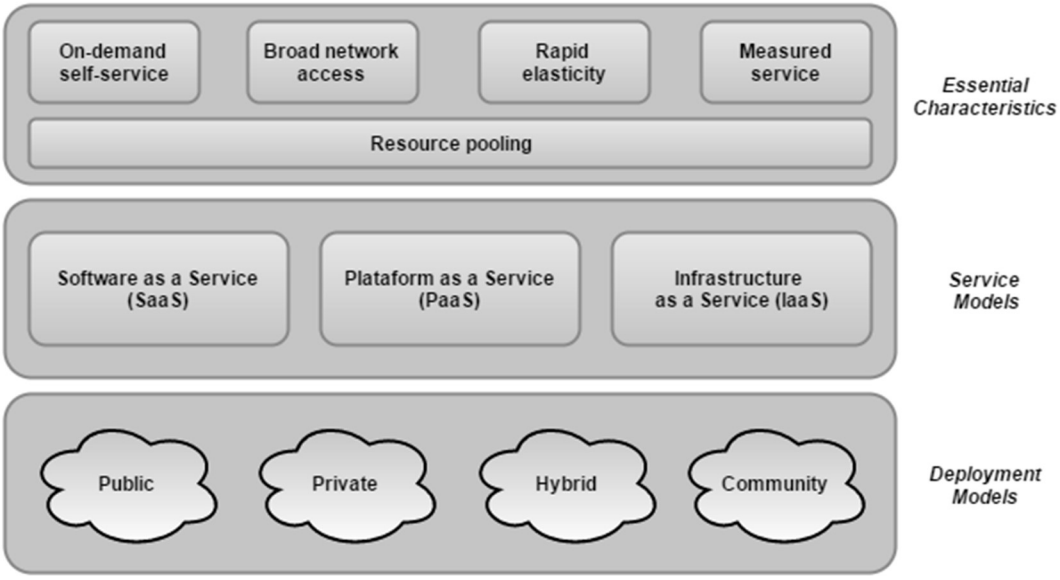

Figure 10.1. NIST Cloud Computing Model [Mell and Grance 2011]

10.2.1. Service Models

Cloud service providers usually offer service models at three levels as described in the following: software/application, platform or infrastructure (Figure 10.2).

- **Software as a Service (SaaS):** The applications running on a cloud infrastructure and can be accessed by various client devices using a web browser. In this model the service provider is responsible for providing the necessary software infrastructure, such as servers, network access and security. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings [Sadighi 2014], [Mell and Grance 2011].
- **Platform as a Service (PaaS):** Providers of this type of service allow developers to have access to different programming languages and tools without getting involved with hardware environments. PAAS providers provide platforms and operating systems for companies so that they can develop, test and deploy their applications [Sadighi 2014].
- **Infrastructure as a Service (IaaS):** This provides the highest level of user interaction with scalable hardware capabilities (such as storage capacity and servers). The service is usually provided through virtual machines, where the user has complete control of the machine and the software installed in it [Sadighi 2014].

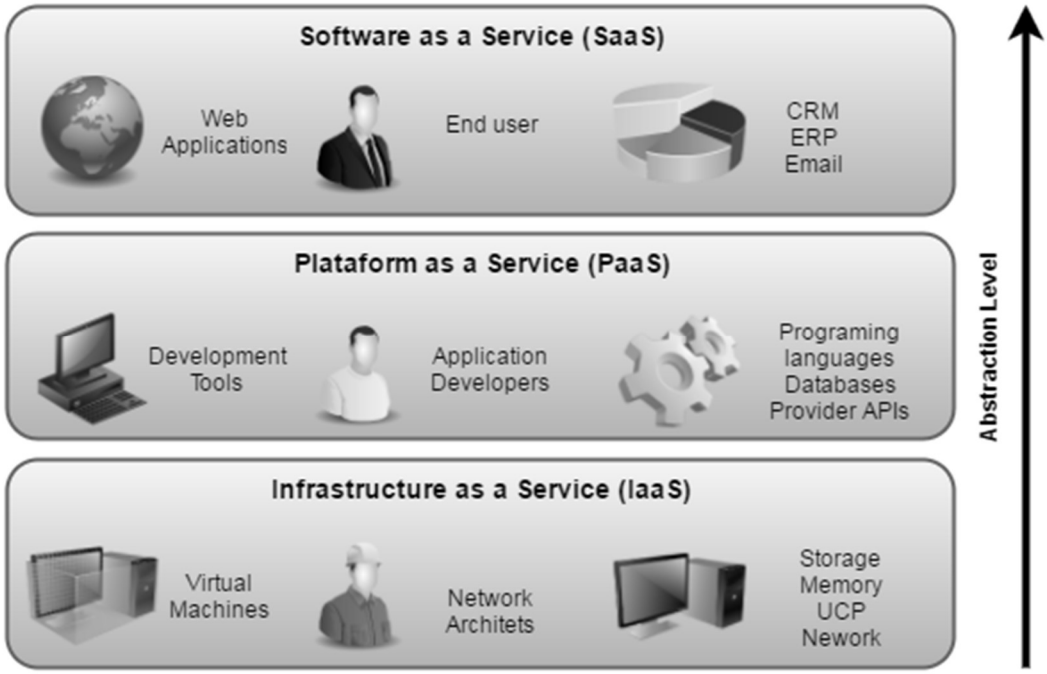

Figure 10.2. Service Model

10.2.2. Deployment Models

The deployment model is comprised of the following:

- **Private:** The cloud infrastructure is dedicated to a single organization. In this case, the infrastructure is maintained by the organization, a third party, or some combination of them. [da Costa and da Cruz 2012].
- **Public:** The cloud infrastructure is used by the general public. It is owned, managed, and operated by a cloud service provider [da Costa and da Cruz 2012].
- **Hybrid:** The hybrid cloud infrastructure is a combination of two or more distinct cloud infrastructures (private, public or community) that are bound together by standardized or proprietary technology. This technology should enable data and application portability (e.g. cloud bursting for load balancing between clouds) [da Costa and da Cruz 2012].
- **Community:** The cloud infrastructure is aimed at a specific community of consumers from organizations or groups with shared concerns. Their ownership, management and operation may be the responsibilities of one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises [da Costa and da Cruz 2012].

10.3. Challenges in the Brazilian Cloud Scenario

In this section, we present and discuss challenges considered relevant and facing practitioners in the Brazilian cloud scenario. The challenges were based on findings reported in a systematic literature review conducted by the authors [Paula and Carneiro 2016]. The authors also included information based on their experience in Cloud Computing activities in Brazil, in small and medium sized businesses in particular. The challenges discussed in this chapter focus on the adoption and migration to the cloud paradigm. **Challenge 1** is by far the most relevant due to its complexity and the need to face the other two challenges discussed in the chapter. For this

reason, part 1 of Figure 10.3 points to the other two parts corresponding to **Challenges 1** and **2**. In other words, companies need to identify their business goals that are met by cloud adoption and migration with respective deployment and service models. In **Challenge 2**, we discuss issues required to define the cost-benefit relationship towards the adoption. As can be seen in Figure 1.3, **Challenge 2** is considered a requirement for **Challenge 3**. In other words, this is the suggested order for a company dealing with these challenges.

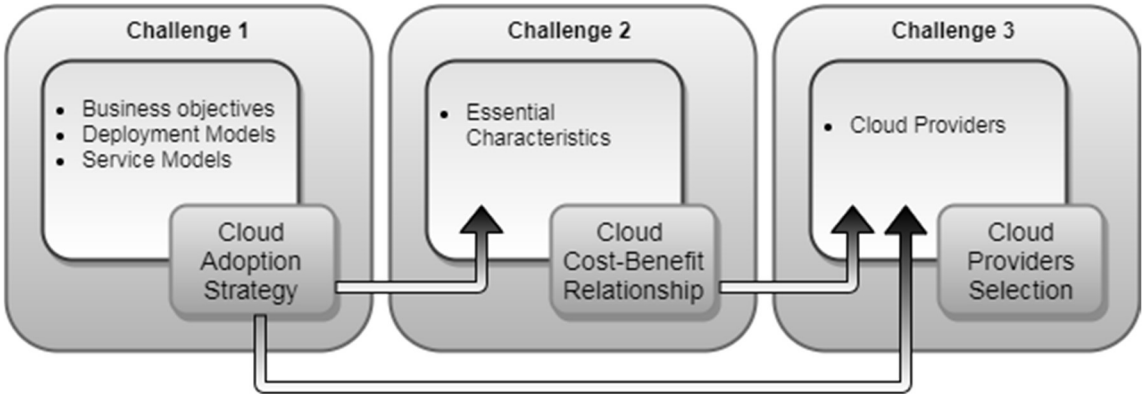

Figure 10.3. Challenges for Information System Practitioners in Brazil

Cloud Computing Challenge 1 for Information System Practitioners in Brazil: *Companies are not yet aware of effective strategies to adopt and migrate to CC.* Having access to strategies that support companies to define their goals in the CC paradigm and respective follow up to achieve them is by far the most important challenge for companies. Without effective guidelines on how to pursue it, the company cannot benefit fully from the advantages and functionalities of CC. We have previously identified a tendency for companies to adopt the IAAS model service [Paula and Carneiro 2016] to migrate their legacy systems to the cloud. In most cases, this happens because the migration process takes less effort required when supported by virtual machines that in this case represent the IAAS directly in the cloud. However, despite the lower estimated required effort, this solution through IAAS is not always the most appropriate for all migration scenarios and does not explore all the potential of the cloud resources. For many cases, PAAS would be a better choice, considering that it offers native cloud resources that can be configured to provide services of the application. On the other hand, studies have reported that the adoption of the PAAS model service poses the challenge of having to adapt the legacy system for the migration. This include the need to rewrite parts of the code, replace libraries and APIs that may not be compatible with the cloud provider environment. All these factors together contribute to greater migration effort and cost. Moreover, according to several companies, there is a lack of technical personnel qualified to perform these activities. Most of them are located in the Southeast Region of Brazil.

Suggested Strategy to Face Cloud Computing Challenge 1 for Information System Practitioners in Brazil. To deal with Challenge 1, we propose the development of an online guideline based on results of a Systematic Literature Review (SLR) focusing on this theme. This on-line guideline should be updated using crowdsourcing resources to obtain feedback from cloud practitioners regarding their experience in planning and performing the migration of their applications to the cloud. Considering the scenario of preference for the IAAS presented before, the guideline can present a set of criteria and evaluation of the cost-benefit relationship of both IAAS and PAAS

adoption. Initiatives have already been taken in this direction. An example is the role played by cloud brokers. Cloud users currently face the challenge of defining an strategy to satisfy their specific requirements. Using an intermediate cloud brokering service to this end is a way to meet their requirements [Naha and Othman 2016]. A cloud broker is a third-party individual or business that acts as an intermediary between the purchaser of a cloud computing service and the sellers of that service[13]. Another definition is that a cloud-based service broker entity is a mediator between the cloud consumer and multiple interoperable cloud providers, in order to support the former in selecting the provider, which better meets user requirements [Naha and Othman 2016].

Cloud Computing Challenge 2 for Information System Practitioners in Brazil. *Companies have difficulties assessing the cost-benefit relationship for the adoption and migration to the cloud computing.* The effective evaluation of the costs and benefits of migration to CC can be used as part of its planning and reference for the selection of cloud provider(s) or, depending on the case, a solution with private or hybrid cloud.

In the cost-benefit relationship assessment, the perception of cost reduction due to the reduction of Capital Expense (CapEx) and leasing services and resources through Operational Expenses (OpEx) should be taken into account. This can be explained by the absence of the requirement to tie-up capital, to deal with technological obsolescence, hardware maintenance, as well as purchasing software licenses and depreciation allowances. In the cloud paradigm, these issues are now the responsibility of the provider.

Suggested Strategy to Face Cloud Computing Challenge 2 for Information System Practitioners in Brazil. The same guideline proposed in Challenge 1 has a section dedicated to presenting illustrative scenarios of the cost-benefit relationship assessment and discussing issues that influence the cost-benefit relationship. These scenarios can include the comparison of maintaining a legacy system in traditional infrastructure and maintaining the same application in the cloud. The characteristics that stood out in the selected studies in [Paula and Carneiro 2016] were: cost, performance and security/privacy issues. The cost is by far the most influential characteristic in the adoption of CC. Companies that adopt CC are willing to pay for resources that can be allocated in a pay-as-you-go fashion. This can lead to representative overall cost reduction as a result of several factors including: reduction in maintenance costs, energy consumption, issues related to purchasing software licenses and depreciation allowances now the responsibility of the provider, just to mention a few. For example, performance and security/privacy characteristics are issues prioritized by companies. Considering problems related to security, providers usually update and patch all software regularly to limit possible access points (also known as vulnerability shielding). The use of encryption keys is also recommended to hamper unauthorized access to the company's data. Regarding performance issues, it is possible to allocate resources in the cloud by changing settings in the provider data center and thereby getting a quick response to business needs while increasing performance at times of peak processing. This is an important factor that lead to stability in the services provided by a company.

[13] http://www.gartner.com/it-glossary/cloud-services-brokerage-csb/

Of course, planning the cost of services offered by cloud providers is not a trivial task. For this reason, several providers offer cloud cost calculators (Amazon, Google, Azure, VMware, Ubuntu) to support companies calculating their costs according to services and respective conditions that may be contracted[14] [15] [16] [17] [18]. Moreover, there are also applications on the web that support companies to plan their costs comparing services offered by different providers[19]. The challenge of selecting one or more providers according to the company's need will be discussed below.

Cloud Computing Challenge 3 for Information System Practitioners in Brazil. The selection of service providers by companies according to their needs and profile is not a trivial task. Access to lessons learned and problems raised by inappropriate selection of CC providers provide organizations with more confidence in this task.

The selection of commercial cloud providers is challenging and depends on several factors. Among other reasons, cloud providers continually upgrade their hardware and software infrastructures as well as their commercial plans. This is the result of business competition among major players in the CC scenario [Li et al. 2013]. Studies have shown that successful migration to the cloud is usually driven by a set of criteria to select providers that best fit the company needs [Li et al. 2012b] [Li et al. 2010] [Garg et al. 2013]. For this reason, mapping needs to cloud services and conditions is a good way to select providers. This will be discussed further below.

Suggested Strategy to Face Cloud Computing Challenge 3 for Information System Practitioners in Brazil. The same guideline proposed in Challenge 1 will have a section dedicated to discussing issues related to the selection of CC service providers. The idea is to update this section of the guide continuously based on data collected directly from the site of the most used and relevant providers in order to allow companies and potential users to select services as a result of mapping their needs to service(s).

There are several sets of criteria proposed to select IAAS providers. We present two figures (Figure 10.4 and Figure 10.5) with a set of criteria from two different perspectives. The first was proposed by an independent consultant[20]. The second was proposed by Microsoft Azure in an attempt to support potential clients to move to the cloud. A step in this direction is the selection of providers[21]. The two selection criteria sets are presented below using the mental maps metaphor.

[14] https://calculator.s3.amazonaws.com/index.html

[15] https://azure.microsoft.com/en-us/pricing/calculator/

[16] https://cloud.google.com/products/calculator/

[17] http://vcloud.vmware.com/service-offering/pricing-calculator

[18] https://www.ubuntu.com/cloud/openstack/managed-cloud#calculator-form

[19] http://www.planforcloud.com/

[20] http://www.techrepublic.com/blog/the-enterprise-cloud/11-cloud-iaas-providers-compared/

[21] https://azure.microsoft.com/en-us/overview/choosing-a-cloud-service-provider/

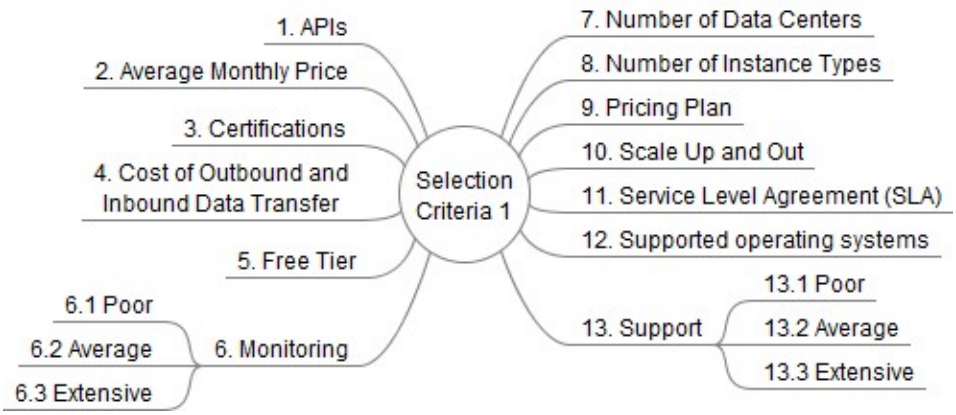

Figure 10.4. IAAS Providers Selection Criteria

The explanation of each criterion is as follows: **1. APIs:** Availability of APIs to interact remotely with the servers. **2. Average Monthly Price:** Estimated cost in US$ for a given server configuration. For example, an average Windows/Linux servers with 1 CPU, 2GB RAM cloud server (or the nearest best option), averaged over data centers for companies with location-based pricing. When available, hourly pricing should be used, based on 730-hour months. Otherwise, monthly pricing could be used. In all scenarios, data transfer costs should not be included. **3. Certifications:** Vendor compliance and security-related certifications. **4. Cost of Outbound and Inbound Data Transfer:** The cost, in US$, for each GB of outbound and inbound data sent from the server. Companies that offer a per second (Mbps) connection for free have costs listed as zero. **5. Free Tier:** Availability of a "free trial" tier for customers to test the service. **6. Monitoring:** This depends on the provider support to let customer monitor contracted services in real time fashion. The following three-level subjective scale can be used to evaluate the monitoring resources: **6.1 Poor:** Providers that have no monitoring/alert solutions integrated, requiring the deployment of third-party tools or that extra services be purchased; **6.2 Average:** Providers with very simple integrated monitoring tools (few indicators or no alerting); **6.3 Extensive:** Providers with very complete integrated monitoring tools offered for no additional cost. **7. Number of Data Centers:** The number of worldwide data centers available to deploy cloud servers. **8. Number of Instance Types:** The number of different server configurations available. Some providers offer fully customizable servers in terms of CPU, these are listed as "configurable". **9. Pricing Plan:** Providers offer pay-as-you-go (usually hourly) plans, monthly pricing plans, "membership" discounts (where the user receives a discount in usage rates in exchange for an extra yearly payment), or any combination thereof. The more options provided, the better, but the pay-as-you-go model is the most interesting stand-alone option as it makes more fine-grained usage possible. **10. Scale Up and Out:** Possibility of scaling up and out individual cloud server instances by adding/removing memory, extra CPUs or storage space or if it is possible to quickly deploy/exclude new/available server instances. **11. Service Level Agreement (SLA):** The uptime SLA offered (regardless of past performance), in percentage points. **12. Supported operating systems:** The number of supported operating systems, regardless of version, available as a pre-configured image. **13. Support:** Depending on the provider support for customer. The following three-level subjective scale can be used to evaluate this item: **13.1 Poor:** Companies that only offer on-line forums for free; any other support must be paid; **13.2 Average:** Companies that offer a single type of 24x7 support for free (either phone-based or on-line chat), in addition to forums; **13.3 Extensive:** Companies with

multiple support offerings included in the base price.

There is a tendency for cloud service providers to also suggest criteria for customers to evaluate themselves. For example, Microsoft Azzure has proposed the following criteria[22].

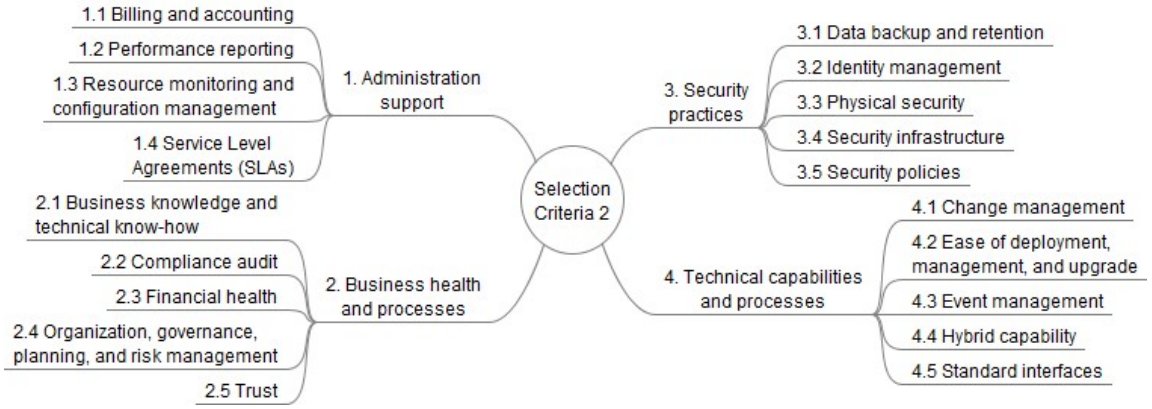

Figure 10.5. Provider Selection Criteria according to Microsoft Azure

The explanation of each criterion is as follows:

1. Administration support. 1.1 Billing and accounting: This should be automated so that customers can monitor resources and the corresponding costs. There should also be support for billing-related issues. **1.2 Performance reporting:** The provider should be able to issue performance reports. **1.3 Resource monitoring and configuration management:** There should be available controls for the provider to track and monitor services provided to customers and any changes made to their systems. **1.4 Service Level Agreements (SLAs):** The uptime SLA offered (regardless of past performance), in percentage points.

2. Business health and processes. 2.1 Business knowledge and technical know-how: The provider should understand the customer business and what the customer is looking for to be able to match it up with their technical expertise. **2.2 Compliance audit:** The provider should be able to validate compliance with customer requirements through a third-party audit. **2.3 Financial health:** The provider should have a track record of stability and be in a healthy financial position with sufficient capital to operate successfully over the long term. **2.4 Organization, governance, planning, and risk management:** The provider should have a formal management structure, established risk management policies, and a formal process for assessing third-party service providers and vendors. **2.5 Trust:** Customer should check the provider's reputation and see who its partners are and also their level of cloud experience.

3. Security practices. 3.1 Data backup and retention: Policies and procedures to ensure integrity of customer data should be in place and operational. **3.2 Identity management:** Changes to any application service or hardware component should be authorized on a personal or group role basis, and authentication should be required for anyone to change an application or data. **3.3 Physical security:** Controls ensuring physical security should be in place, including for access to co-located hardware. Also, data centers should have environmental safeguards to

[22] https://azure.microsoft.com/en-us/overview/choosing-a-cloud-service-provider/

protect equipment and data from disruptive events. There should be redundant networking and power and a documented disaster recovery and business continuity plan. **3.4 Security infrastructure:** There should be a comprehensive security infrastructure for all levels and types of cloud services. **3.5 Security policies:** There should be comprehensive security policies and procedures in place for controlling access to provider and customer systems.

4. Technical capabilities and processes. 4.1 Change management: The provider should have documented and formal processes for requesting, logging, approving, testing, and accepting changes. **4.2 Ease of deployment, management, and upgrade:** Make sure the provider has mechanisms that make it easy for you to deploy, manage, and upgrade your software and applications. **4.3 Event management:** The provider should have a formal system for event management that's integrated with its monitoring/management system. **4.4 Hybrid capability:** Even if the customer does not plan to use a hybrid cloud initially, it is worth making sure the provider can support this model. It has some advantages that the company may wish to exploit at a later time. **4.5 Standard interfaces.** The provider should use standard APIs and data transforms so that the company can easily build connections to the cloud.

10.4. Progress Evaluation

These three main challenges to the adoption of the CC in Brazil, especially for Small and Medium Enterprises (SMEs). These represent an opportunity for the Information System research community and practitioners to discuss issues related to each of them, propose strategies, as well as report and disseminate lessons learnt for companies. There is no doubt that relevant work can be performed to characterize these issues in the Brazilian scenario and therefore support the national software industry in the direction of the CC paradigm. To this end, there is room for a web portal to present and discuss the challenges mentioned in this chapter as well as others. For each challenge corresponding lessons learnt with both successful and unsuccessful scenarios can be described. Companies and providers will have access to the portal to contribute with information following a crowdsourcing model.

The authors will invite researchers from other universities to prepare a project proposal and also request national or international funding for the task. Considering that Brazil is a market with growth potential, cloud providers may be one of the interested players in this portal and be willing to disseminate their services to more SMEs Brazilian companies. Moreover, these providers will be invited to take part in webinars through the portal. The portal will then aggregate a community of stakeholders who play different roles in the cloud paradigm, including researchers, companies, customers and providers.

10.5. Final Remarks

In this chapter we discussed three main challenges faced by Brazilian companies when adopting the CC paradigm and migrating their services to it. Regardless of whether it is public, private or hybrid cloud adoption, companies need to share their experiences so that the community can discuss pros and cons regarding the cloud paradigm. They should therefore have access to the proposed web portal to provide data periodically reporting the way they have used cloud computing resources as well as potential benefits, challenges and business opportunities that this meant for their business. Data provided by these companies will also target performance issues of the services provided in the cloud. The goal is to provide a web portal to the community

where data related to experience reports of real scenarios could support the evaluation of CC usage by Brazilian companies. On the other hand, this same portal can be a source of information for researchers in the sense that improvement opportunities identified in the portal can be a reference for research projects to benefit and increase the adoption of CC services and infrastructure in Brazil.

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