Do Cloud Computing Tools Support the Needs of Virtual Enterprises?

Andre F. Ruaro, Ricardo J. Rabelo

Do Cloud Computing Tools Support the Needs of Virtual Enterprises ?

Andre F. Ruaro, Ricardo J. Rabelo

Department of Automation and Systems Engineering
Federal University of Santa Catarina, Florianopolis (SC), Brazil
andrefruaro@gmail.com, ricardo.rabelo@ufsc.br

Abstract. Virtual Enterprise (VE) is a prominent strategy for leveraging new sustainable models to SMEs. A VE is as temporary network of enterprises that collaborate via the Internet towards achieving common goals, sharing assets, costs, risks and benefits. However, VE members do not use to share ICT assets and infrastructures in the collaboration. Cloud computing has emerged as option for that. Research works have developed prototypes and cloud-based environments to support very specific issues within given VE scenarios. However, it is important that SME managers have a broader perception about at which extent commercial cloud computing tools can indeed support the usual VE needs. This is the essential goal of this paper. The needs of VEs and performance indicators to evaluate cloud tools have been identified, and two commercial SaaS, PaaS and IaaS tools have been evaluated. Conclusions are provided in the end.

Keywords: Cloud Computing; Virtual Enterprises; SME.

1 Introduction

SMEs (Small and Medium sized Enterprises) have gradually looked for establishing network-centric and collaborative-based strategic alliances as a means to leverage new sustainable models that allow them to more effectively cope with the increasingly and variable market demands [1].

Collaborative Networks (CN) basically is represented by a group of autonomous and heterogeneous organizations that have the willingness to collaborate with each other towards reaching common goals [2]. There are different types of CN. This paper focuses on the type Virtual Enterprise (VE). A VE is a temporary and dynamically CN formed by a group of enterprises that join competences, capacities and resources with the aim of sharing risks, costs and benefits when coping with given demands [2].

One of the most basic requirements for the realization of the VE concept is that the communication among its members should fundamentally be carried out via computer networks and proper ICT tools [2].

During the VE *life cycle* [3], VE members have different needs regarding the many types of business processes to support. On one hand, this demands adopting proper ICTs by the VE members. On the other hand, this demands investments in such ICTs, including in people to maintain them. This may become a problem as ICT is usually not part of the SMEs' core businesses and they are very limited in terms of financial and human resources [4]. Regarding that VE concept involves *per se* sharing of assets, it is relevant to extend collaboration at the ICT level so as to provide SMEs with more rational use of the general ICT infrastructure [3].

In this direction, Cloud computing technology [5] has increasingly been adopted by SMEs as a strategy to outsource ICT, under the on-demand and pay-per-use modes [6]. Some research have been done developing cloud-based prototypes for VEs looking at engineering solutions for very specific problems, including its use as an "integration middleware" among VE members and their systems (e.g. [7]). Regarding the impact the shift to cloud computing can represent to companies, it is important for SME managers to have a broader perception about at which degree the commercial cloud computing tools can indeed support VE requirements.

This represents the main objective of this paper. It shows results of an evaluation of some SaaS, IaaS and PaaS cloud tools available in the market, mostly from the end user (company) point of view. This experimental work has also provided elements for better understanding these tools' features and limitations regarding VE needs.

This paper is organized as follows. Section 1 has introduced the problem and the paper's goal. Section 2 briefly presents the research methodology. Section 3 summarizes the main foundations used in this work. Section 4 gives an outline of the literature related to the research methodology. Section 5 presents the evaluation results with the selected cloud tools. Section 6 presents some conclusions and next steps.

2 General Research Methodology and Delimitation

This work does not propose a model. Instead, it corresponds to a descriptive and applied research carried out to evaluate the phenomenon related to cloud tools, mainly in terms of their deployment and further execution. It has been focused on the *SaaS, IaaS* and *PaaS* type of cloud tools regarding the usual need of companies' processes. The tools were analyzed fundamentally considering the VE needs in the *Operation* phase of the VE life cycle [2].

This research was carried out in some steps considering the paper's goal. The *Systematic Literature Review* (SLR) methodology was applied in different steps of this research. First, the ICT requirements to support the transactions among VE members were compiled from a number of papers and further generalized. Second, performance indicators to evaluate cloud computing tools against such requirements were investigated and elicited (the results of these two steps are showed in Section 4).

Given the large number of commercial cloud computing tools available in the market, only two tools of SaaS, PaaS and IaaS were evaluated in the first phase of this research. Actually, a preliminary subset of tools was initially and roughly evaluated. For SaaS: *OneDrive, Google Drive, DropBox, Office 365, Google Apps,* and *Google Apps for Work*. For PaaS: *Google App Engine, Microsoft Azure Platform,* and *AWS Elastic Beanstalk*. For IaaS: *Amazon EC2, Google Compute Engine,* and *Microsoft Azure Platform.*

The final tools selection tried to consider the SMEs' reality and their usual behavior when selecting ICT tools: i) *free* or *low-cost tools*: most of SMEs are financially very limited, which is a problem due to ICT-related costs (software and hardware acquisition, training, maintenance, updating, etc.); ii) *well-known tools*: they use to be more robust, consolidated, documented, and easier to find training programs as well as experienced people on that; iii) *open tools*: they are less difficult to integrate and interoperate with enterprises' systems as well as with other systems at the VE level (which in turn can also be deployed in a cloud). Open tools can save integration costs and time as well as mitigate the problem of technology lock-in.

Once selected, the cloud tools were evaluated in a transversal way, executing the experiments in a single moment. The tools were deployed and executed in a controlled environment so as to systematically observe them regarding the elicited VE requirements against the selected performance indicators. The results were annotated and analyzed in way to respond to pre-established purposes, i.e. if cloud computing tools could support the VE needs.

3 Basic Foundations

3.1 Cloud Computing

Cloud computing can be defined as a set of resources with processing power, storage, connectivity, platforms, applications and services that are available over the Internet. Its main characteristics are: on-demand self-services, resource pooling, broad network access, rapid elasticity and measured services [5,8]. There are four basic cloud models [5,8]: *private cloud*, *public cloud*, *community cloud*, and *hybrid cloud*.

The main cloud models are [8]:

- SaaS (*Software as a Service*) – on-demand access to application software, usually under a pay-per-use basis. Cloud providers manage the infrastructure and platforms that run the applications.
- PaaS (*Platform as a Service*) – offering of development and deployment environments and interfaces to developers of (usually SaaS) applications.
- IaaS (*Infrastructure as a Service*) – availability of infrastructure services for using computing resources, scaling, security, backup, among others.

An important element in cloud is the SLA (Service Level Agreement). It refers a guarantee, in the form of contracts, which are provided by the services providers to its consumers defining access conditions and quality levels of the provided services [8].

In the context of networked organizations, there are some issues about cloud computing that are considered as more sensitive to de treated than in single enterprises, like governance, integration/interoperability, security, data privacy, compliance, trust and dependability, at different levels of the global systems architecture [9,10,11].

3.2 Collaborative Networks

CN encompasses strategic alliances that are focused on the intense and fluid collaboration among autonomous organizations. The vision relies on allowing organizations to keep focused on their core skills, aggregating competencies and sharing resources with each other in order to better meet market requirements [2].

A VE can be characterized as a temporary alliance formed by autonomous and heterogeneous organizations that join their complementary core-competencies and resources to satisfy given demands, dismantling itself after all legal obligations have been met. VEs are classically originated from a VBE (Virtual organization Breeding Environment). A VBE can be defined as a long-term association of organizations which have the willingness and enough pre-conditions to collaborate towards creating VEs with the most adequate partners in a more agile and trustful way [2].

The collaboration within a VE is carried out along a lifecycle [2]: *Creation* (the VE is enacted, partners are selected and the network is configured); *Operation* (when the VE effectively runs, executing and managing the required activities and partners towards reaching its goals); *Evolution* (performed when problems take place during the *Operation* and that can jeopardize the VE's success); *Dissolution* (the VE is ended. This can either happen when the VE goals are achieved successfully or due to severe problems along its execution which lead it to abandon its business goal).

Each of such stages imposes different requirements from cloud computing tools. A wide scope of activities have to be supported, like information requests from one enterprise to another, services invocations, VE project management, distributed and cooperative (re)planning/(re)scheduling; discussions among distributed partners and decision-making, execution supervision, product development, among many others.

4 Summary of Literature Review

4.1 VE Requirements

According to the performed SLR (see section 2), nine general requirements were considered as the main ones to be provided by cloud tools to support VE needs. They were elicited based on a careful generalization of fourteen papers taken as a reference for that ([6,9,10,11,12,13,14,15,16,17,18,19,20,21]):

- *Standards and Functionalities*: support for standard specifications, advanced features, and aspects related to ownership.
- *Multi-tenancy*: support for data privacy, user access control, access management and multi-user architecture.
- *Scalability and elasticity*: support for dynamic scalability and transparent load balancing and clustering.
- *Extensibility and openness*: licensing and rights support, modular architecture, access to documentation, forums, communities and training.
- *Security and reliability*: support for users authenticating, SLAs and reliability aspects.
- *Access control*: support for QoS management, measurement mechanisms, and billing.
- *Development tools*: support for developers, including *plugins*.
- *Management and operation*: access to management interfaces and APIs.
- *Interoperability*: supporting business process interoperability, web services, common and configured adapters, and messaging mechanisms.

These requirements are, however, generic as they do not consider the different VE needs in respect to SaaS, PaaS and IaaS types of tools. Taking those fourteen papers once again as a basis, a set of “business cases” were extracted and generalized in order to have a more concrete idea about which “VE situations” would be more representative to be observed when evaluating the cloud tools:

- *SaaS tools*: office and storage functionalities, involving the creation and sharing of documents in different formats, as contracts, budget spreadsheets, materials lists, list of VE members, working schedules, engineering projects, engineering projects, governance model and other VE configuration-related information, photos and videos. This also includes the access to systems - when offered under a SaaS model - like ERP modules and CRM.
- *IaaS tools*: supporting functionalities to deploy a web server allowing hosting an application and a database, including a virtual machine and regarding different operating systems. This also includes the request for extra memory to run enterprises’ applications (like ERP modules and CRM) or to store their data.
- *PaaS tools*: supporting functionalities to develop and host applications (including databases), e.g. applications for control and VE monitoring. From a more end-user perspective (focus of this paper), PaaS seems to be the less important type of cloud tool and even not necessary for some companies. It might be important, for example, in the case a third part is hired to develop some specific software to support the achievement of the VE’s goals.

4.2 Performance Indicators for Cloud Computing Tools

A second SLR was performed to identify which indicators use to be adopted when evaluating cloud tools. Among many found works, two of them [22, 23] were taken as the reference for this research, generating a list of 27 indicators. Due to space restrictions, these indicators are shown directly via the tables that present the evaluation of the selected tools (e.g. Tables 2-3-4).

The next step of the work involved the mapping of every single business case (previous section) of each type of cloud tool against each indicator, i.e. which VE need a given indicator will measure.

For example, for *SaaS*, the indicators ‘data privacy’, ‘storage capacity’, ‘management interfaces’ and ‘general and personalized adapters’ were the ones considered as suitable to be applied to evaluate the VE need ‘creation and sharing of documents in different formats’. This example means evaluating a given SaaS tool in terms of e.g. how good it is when dealing with the ‘sharing of documents’ need from the ‘data privacy’ point of view / indicator. Actually a subset of those nine basic VE requirements was considered to evaluate each business case. In this example, for instance, ‘data privacy’ is related to the ‘multi-tenancy’ requirement, ‘storage capacity’ to ‘scalability and elasticity’, ‘management interfaces’ to ‘management and operation’, and ‘general and personalized adapters’ to ‘interoperability’.

For *PaaS*, for instance, the indicators ‘modular architecture’, ‘storage capacity’ and ‘plugins IDE’ were the ones considered as suitable to evaluate e.g. the VE need of ‘the creation and execution of applications’.

For *IaaS*, for instance, the indicators ‘modular architecture’, ‘storage capacity’, ‘processing capacity’, ‘memory capacity’, ‘management interfaces’ and ‘plugins IDE’ were the ones chosen to evaluate e.g. the VE need of ‘deploying a web server allowing hosting an application and a database’.

This mapping was done empirically, considering the authors’ experience with cloud computing and VEs. Besides that, the more precise meaning of indicator varies a bit depending on the type of tool and hence to be contextualized during the evaluation task.

5 Experiments and Results

A local controlled computing environment was deployed to test the tools, emulating and instantiating all the mentioned business cases in each type of cloud tool.

A *weight* dimension was added in the analysis and had two objectives. The first one refers to the fact that the elicited 27 performance indicators for cloud tools are generic. Therefore, they had to be somehow “filtered”, i.e. weighted about its importance or applicability according to the type of tool (SaaS, PaaS and IaaS). The second one refers to a greater focus on the VE *operation* phase regarding the research delimitation (see section 2). This means a *subjective* qualification of importance (weight) of each indicator in the context of that VE phase. In the tables, ‘✹’ indicates that the given criterion (the performance indicator) is very important to be considered; ‘✹’ that it is barely important; and ‘✪’ that it is few important or not applicable.

Inspired in [23], still *qualitatively* and *subjectively*, each indicator has received a number of stars in terms of its general performance evaluation when coping with the given VE need: *excellent* (5 stars); *good* (4 stars); *regular* (3 stars); *bad* (2 stars); *very bad* (1 star), and zero star when the given VE tool *does not support* or offer elements to evaluate it from the given indicator, or this indicator is *not applicable*.

Complementarily and also inspired in [23], but now *quantitatively*, stars were also assigned to indicators according to the following parameters (Table 1):

Table 1. Classification of Quantitative Indicators

Classification	Value	Storage capacity (TB)	CPU capacity (Un)	Memory capacity (GB)	Level of cryptography (Key size)
Excellent	★★★★★	100-1000	24-32	100-1000	265
Good	★★★★☆	10-100	12-24	10-100	192
Regular	★★★☆☆	0-10	0-12	0-10	128
Not support	☆☆☆☆☆	No support or no means to measure it			

As explained in the section 2, two cloud tools of each type were selected out of a number of existing ones. They are the tools provided by *Google* and *Microsoft*:

- SaaS: *Google Drive* and *Google Docs* from Google [24], and *OneDrive* and *Office 365* from Microsoft [25];
- PaaS: *Google App Engine* from Google [24], and *Windows Azure* (App Web) from Microsoft [25];
- IaaS: *Google Compute Engine* from Google [24], and *Windows Azure* (VM) from Microsoft [25].

Tables 2-3-4 show the evaluation of such tools. Due to space restrictions, the analysis of each tool is just generally presented instead of per indicator, individually.

Table 2. SaaS tools evaluation

Performance Indicator	Weight	*Google Drive & Google Docs*	*OneDrive & Office 365*
Patterns & specifications	◐	★★★★☆	★★★★☆
Advanced functionalities	◐	★★★★★	★★★★★
Tool's ownership	◐	★★☆☆☆	★★☆☆☆
Data privacy	●	★★★★☆	★★★★☆
Management of users' access	◐	★★★★☆	★★★★☆
Multi-user architecture	●	★★★★☆	★★★★☆
Dynamic scalability	◐	★★★★☆	★★★★☆
Transparent scalability	◐	★★★☆☆	★★★☆☆
Load balancing & clustering	○	☆☆☆☆☆	☆☆☆☆☆
Storage capacity	●	★★★★★	★★★☆☆
Processing capacity	○	☆☆☆☆☆	☆☆☆☆☆
Memory capacity	○	☆☆☆☆☆	☆☆☆☆☆
Tool's licensing	◐	★★★☆☆	★★★☆☆
Modular architecture	○	★★★★☆	★★★★☆
Documentation, forums and training	●	★★★☆☆	★★★★★
Users' authentication	●	★★★★☆	★★★★☆
SLA	●	★★★★☆	★★★★☆
Dependability	●	★★★★☆	★★★★☆
Cryptography & security	●	★★★★★	★★★★★
QoS control	◐	☆☆☆☆☆	☆☆☆☆☆
Billing mechanisms	◐	★★★★☆	★★★★☆
Support to developers	○	★★★☆☆	★★★☆☆
Plugins IDE	◐	★★★★★	★★★★★
Management interfaces	◐	★★★★☆	★★★★★
Master API	◐	★★★☆☆	★★★★☆
Interoperability	●	★★★★☆	★★★★☆
Customized adapters	◐	★★★★★	★★★★★

As it can be observed, both tools are in general equivalent. Some advantages of one to another also depend on the weights assigned to indicators. However, some pros are important to mention. In the Microsoft tools, to highlight the quality of the documentation (written in many different idioms), their master API, and the general management interface. The integration with other storage-related functionalities is intuitive and integrated with the Microsoft's desktop tools. Google tools provide a much larger storage capacity besides an interface with voice recognition capabilities.

Table 3. PaaS tools evaluation

Performance Indicator	Weight	*Google App Engine*	*Windows Azure* (App Web)
Patterns & specifications	○	★★★☆☆	★★★★★
Advanced functionalities	○	★★★★★	★★★★★
Tool's ownership	○	★★☆☆☆	★★☆☆☆
Data privacy	●	★★★★☆	★★★★☆
Management of users' access	○	★★★★☆	★★★★☆
Multi-user architecture	●	★★★★☆	★★★★☆
Dynamic scalability	●	★★★★☆	★★★★☆
Transparent scalability	○	★★★☆☆	★★★☆☆
Load balancing & clustering	○	★★★★☆	★★★★☆
Storage capacity	●	★★★☆☆	★★★☆☆
Processing capacity	○	☆☆☆☆☆	★★★☆☆
Memory capacity	○	☆☆☆☆☆	★★★★☆
Tool's licensing	○	★★★☆☆	★★★☆☆
Modular architecture	○	★★★★☆	★★★★★
Documentation, forums and training	●	★★★★☆	★★★★★
Users' authentication	●	★★★★☆	★★★★☆
SLA	●	★★★★☆	★★★★☆
Dependability	●	★★★★☆	★★★★☆
Cryptography & security	●	★★★★★	★★★★★
QoS control	○	★★★★☆	★★★★☆
Billing mechanisms	○	★★★★★	★★★★★
Support to developers	●	★★★☆☆	★★★☆☆
Plugins IDE	●	★★★☆☆	★★★★☆
Management interfaces	○	★★★★☆	★★★★★
Master API	○	★★★☆☆	★★★★☆
Interoperability	●	★★★★☆	★★★★☆
Customized adapters	○	★★☆☆☆	★★★★☆

Although with some degree of subjectivity, Microsoft's PaaS tools presented clearer advantages against Google in some indicators, besides providing more powerful and intuitive equivalent functionalities. To highlight the several customized adapters, a better hardware configuration for storage, memory and processing, the possibility of using plugins IDE other than *Visual Studio* (Google only supports *Eclipse*), on-line files synchronization (Google does that manually), among other advantages.

Table 4. IaaS tools evaluation

Performance Indicator	Weight	*Google Compute Engine*	*Windows Azure* (VM)
Patterns & specifications	✧	★★★★☆	★★★★★
Advanced functionalities	✧	★★★★★	★★★★★
Tool's ownership	✧	★★☆☆☆	★★☆☆☆
Data privacy	✸	★★★★☆	★★★★☆
Management of users' access	✧	★★★★☆	★★★★☆
Multi-user architecture	✸	★★★★☆	★★★★☆
Dynamic scalability	✸	★★★★☆	★★★★☆
Transparent scalability	✧	★★★☆☆	★★★☆☆
Load balancing & clustering	✧	★★★☆☆	★★★☆☆
Storage capacity	✸	★★★★☆	★★★★☆
Processing capacity	✸	★★★★★	★★★★★
Memory capacity	✸	★★★★★	★★★★★
Tool's licensing	✧	★★★☆☆	★★★☆☆
Modular architecture	✧	★★★★☆	★★★★★
Documentation, forums and training	✸	★★★★☆	★★★★★
Users' authentication	✸	★★★★☆	★★★★☆
SLA	✸	★★★★☆	★★★★☆
Dependability	✸	★★★★☆	★★★★☆
Cryptography & security	✸	★★★★★	★★★★★
QoS control	✧	★★★★☆	★★★★☆
Billing mechanisms	✧	★★★★★	★★★★★
Support to developers	✧	★★☆☆☆	★★☆☆☆
Plugins IDE	✸	★★★★☆	★★★★★
Management interfaces	✧	★★★★★	★★★★★
Master API	✸	★★★★☆	★★★★☆
Interoperability	✸	★★★★☆	★★★★☆
Customized adapters	✧	★★★☆☆	★★★☆☆

IaaS tools from Microsoft and Google can also be considered as equivalent at a general level. However, Microsoft tools showed sound advantages in some indicators. Microsoft tools offer much more possibilities and customizations to instantiate, configure and execute the tools, including many plugins IDE. While Microsoft offers more than 3 thousand supporting software, Google offers few more than 140. By default, Microsoft offers 448GB of memory against 208GB of Google. Yet, Microsoft allows execution also via the *Visual Studio* environment, whereas Google does that only via a browser.

After all this analysis of SaaS, PaaS and IaaS tools, the impression is that while Microsoft tools seem to be designed for enterprises usage and their integration with back-end systems (and users, of course), Google's seems to focus more on ordinary Internet end-users.

6 Conclusions

This paper has presented an experimental work with some SaaS, PaaS and IaaS cloud tools aiming at evaluating at which extent they fit the requirements of Virtual Enterprises (VE). A literature review has been made to ground the elicitation of the VE needs and performance indicators to be adopted upon cloud tools.

Given the relatively large number of tools available in the market, a number of tools were pre-evaluated. The tools from *Google* and *Microsoft* were selected and more deeply evaluated for VE purposes. This selection tried to consider the reality of SMEs, given the tools' costs, wider acceptance and openness.

The evaluation of the tools provided a more comprehensive understanding about the features, possibilities and limitations of the tools, even though considering some subjective analysis in the some cases. Due to the controlled testing environment and considering that the performance measurement was carried out in single moments, some indicators could not be properly evaluated. An example of this is the tools' resilience capability, both during their normal operation and when an intensive and transparent scalability is required. Moreover, billing issues were evaluated based on the tools' documentations available at their official sites.

As the general conclusion, it was observed that the selected cloud tools available in the market support the VE needs in the elicited representative "daily" situations. Besides their functionalities themselves, they in general present good usability and are not so complex from the user point of view. Therefore, cloud computing approach seems a technically feasible approach to be adopted by SMEs in the context of VEs. Thus SMEs might invest resources and efforts in their core areas instead of in ICT.

The access to enterprise applications (like ERP, CRM, etc.) that can be offered as-a-service is included in those situations. However, the general quality of such applications (their processes/services) and respective cloud providers could not be evaluated in this work as this varies from vendor to vendor.

One can point out that part of the tools evaluation work was carried out with some level of subjectivity. Although it was tried to consider representative VE situations and authors' experience when filling out the evaluation tables, they should not be taken literally, but rather as a general reference. Therefore, more particular analyses should be performed by each company regarding its business profile.

It was also noticed that the general VE needs for cloud-based tools are basically the same than individual “non-VE” enterprises. Therefore, it seems to be more about how sensitive and often enterprises’ collaborative-related operations should be executed over the net and hence to get dependent on the general quality and security of cloud tools. Related to this matter, some aspects are important to highlight. For example, depending on the enterprises’ sector, the data volume and size of ‘packages’ can be very large, as happens in engineering firms that intensively exchange CAD models using collaborative tools. This can overload the network and can then require very robust local network infrastructures, which can sometimes be not available at all locally or to be too expensive for a SME to support.

It is also important to stress that a VE scenario implies a very dynamic integration among enterprises, many of them by the first time. So, whenever a VE is created, the appropriate systems of the involved enterprises have to be rapidly integrated to the selected cloud tools (and then with the enterprises’ systems themselves), generating a complex demand in terms of e.g. interoperability, standardization, governance and security. In addition, the work of setting up the VE’s business environment should be performed whenever new VEs are created, changed and dissolved, which also demands good usability and agility from the cloud tools’ environments and interfaces.

Next step of this research includes the evaluation of more cloud tools, a separated tools’ evaluation for each phase of the VE life cycle, and the elaboration of a kind of tools’ benchmarking for SMEs when they look at working in a VE scenario.

References

1. Myers, J. Future Value Systems: Next Generation Economic Growth Engines & Manufacturing, in IMS Vision Forum 2006, IMS International, Seoul, pp. 30-47 (2006).
2. Camarinha-Matos, LM; Afsarmanesh, H. Collaborative networks: A new scientific discipline, in Journal of Intelligent Manufacturing. V 16 (4-5), pp. 439-452 (2005).
3. Cancian, M. H.; Rabelo, R.J.; Wangenheim, C.: Supporting Processes for Collaborative SaaS. Proc. 14th IFIP Working Conf. on Virtual Enterprises, Springer, pp. 183-190 (2013).
4. Westphal, I; Thoben, KD; Seifert, M.: Managing Collaboration Performance to Govern Virtual Organizations. Journal of Intelligent Manufacturing, 21-3, pp. 311-320 (2010).
5. Erl, T.: Cloud Computing - Concepts, Technology & Architecture, Prentice Hall (2014).
6. Jingjing, C; Haitao, S.: Industrial clusters information based on SaaS model. Proc. Int. Conference on Business Management and Electronic Information, pp. 28-31 (2011).
7. Hyvonen, T; Jarvinen, J; Pellinen, J.: A virtual integration - the management control system in a multinational enterprise. Management Accounting Research, Vol 19, pp. 45–61 (2008).
8. NIST (National Institute of Standards and Technology). US Cloud Computing Technology Roadmap, http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.500-293.pdf (2014).
9. Zhang, K; Ma, B; Dong, P.; Tang, B.: Research on producer service innovation in home-textile industrial cluster based on cloud computing platform. Proc. 2010 IEEE International Conference on Service Operations and Logistics and Informatics, pp. 155-160 (2010).
10. Li, J; Li, B; Du, Z.: CloudVO: Building a Secure Virtual Organization for Multiple Clouds Collaboration. Proc. 11th ACIS Int. Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing, pp. 181-186 (2010).
11. Gao, J; Ma, J; Zhang, X.: Cloud computing based logistics resource dynamic integration and collaboration. Proc. IEEE 16th Int. Conference on CSCW, pp. 939-943 (2012).

12. Mvelase, P; Dlodlo, N; Williams, Q; Adigun, M.: Virtual enterprise model for enabling cloud computing for SMEs. Proc. 2011 International Conference on Intelligent Semantic Web-Services and Applications (paper n. 13) (2011).
13. Lai, IKW; Tam, SKT; Chan, MFS. Knowledge cloud system for network collaboration: A case study in medical service industry in China. Expert Systems with Applications, 39 (15), pp. 12205–12212 (2012).
14. Jiang, N; Xu, L; Vrieze, P; Lim, M.: A Cloud Based Data Integration Framework. Proc. 13th IFIP Working Conference on Virtual Enterprises, Springer, pp. 177-185 (2012).
15. Kourtesis, D; Bratanis, K; Bibikas, D; Paraskakis, I. Software Co-development in the Era of Cloud Application Platforms and Ecosystems: The Case of CAST. Proc. 13th IFIP Working Conference on Virtual Enterprises, Springer, pp. 196-204 (2012).
16. Munch, T; Buchmann, R; Pfeffer, J; Ortiz, P; Christl, C.: An Innovative Virtual Enterprise Approach to Agile Micro and SME-Based Collaboration Networks. Proc. 14th IFIP Working Conference on Virtual Enterprises, Springer, pp. 121-128 (2013).
17. Mvelase, P; Sibiya, G; Dlodlo, N; Oladosu, J; Adigun, M. A comparative analysis of pricing models for enterprise cloud platforms. Proc. AFRICON 2013, pp.1-7 (2013).
18. Bandinelli, R; D'Avllio, E; Rinaldi, R.: Assessing the maturity of collaborative networks: a case study analysis in the Italian fashion SMEs. 20th IEEE Int. Conference on Engineering, Technology and Innovation, pp. 1-9 (2014).
19. Camarinha-Matos, LM; Afsarmanesh, H; Oliveira, A.: Cloud-based Collaborative Business Services Provision. Enterprise Information Systems. Springer. pp. 366-384 (2014).
20. Mezgar, I; Rauschecker, U.: The challenge of networked enterprises for cloud computing interoperability. Computers in Industry, Vol 65, pp. 657-674 (2014).
21. Gueye, A D; Sanogo, I; Ouya, S; Saliah-Hassane, H; Lishou, C.: Proposal for a Cloud Computing solution and application in a pedagogical virtual organization. Proc. International Conference on Information Technology, INEER, pp. 349-359 (2014).
22. Binz, T.; Exertier, F.; Krebs, R.; Le Jeune, G.; Pelletier, B.; Rodero-Merino, L.; Niemoller, J.: 4CaaST - Building the PaaS Cloud of the Future. Immigrant PaaS Technologies: Scientific and Technical Report. European Union's Seventh Framework Programme (2011).
23. Veloudis, S; Paraskakis, I; Petsos, C. Cloud Service Brokerage: Strengthening Service Resilience in Cloud-Based Virtual Enterprises. Proc. 16th IFIP Working Conference on Virtual Enterprises, Springer, pp. 122-135 (2015).
24. Google, Inc. Google Cloud Platform. In <http:// cloud.google.com/>
25. Microsoft, Inc. Microsoft Corporation. In http://www.microsoft.com/pt-br/