SURVEY ON SENEGALESE'S CORPORATE INFORMATION AND TECHNOLOGY INFRASTRUCTURE TRANSFORMATION ON SERVICES *CLOUD: CHALLENGES AND OPPORTUNITIES*

FALL Momar Aly Dom PhD student Department of Mathematics & Computer Science University Cheikh Anta Diop, UCAD Dakar, Senegal, momarfa@hotmail.com	Dr KARIM Konate, Professor and Lecture Department of Mathematics & Computer Science University Cheikh Anta Diop, UCAD Dakar, Senegal, kkonate911@yahoo.fr

1 INTRODUCTION

According to a study by the McKinsey firm in 2012, the Internet could contribute to the annual GDP of the African continent by 300 billion dollars by 2025.

In Senegal, the Internet would contribute 3.3% to GDP, a proportion higher than that of France, Canada or Germany. Telecommunications, which contributes 10.6% of gross domestic product (GDP), generated 60,000 jobs, according to Dr. Raul Katz, Research Director at the Columbia Institute for Tele-Information in USA, an impact study Economic growth of telecommunications in Senegal carried out in October 2013.

This article provides a scientific contribution to:

- better understanding of the opportunities offered by the Cloud Computing;
- better understand the day-to-day challenges faced by Senegalese companies in: improving the efficiency of their information technology (IT) infrastructure; changing the investment mode from capital expenses (CAPEX) to operational expenses (OPEX); improving the security of their information systems; speed up the application development process; improve the reliability, security of their information systems and improve the interoperability of different systems;
- know the state of the IT infrastructure of Senegalese companies by presenting the results of the survey carried out;
- know the opportunities to transform the IT infrastructure of Senegalese companies into IT Services;
- develop a migration guide to the Cloud.

2 DEFINITION OF CLOUD COMPUTING ACCORDING TO NATIONAL INFORMATION OF STANDARDS AND TECHNOLOGY (NIST)

The Cloud computing is a ubiquitous, convenient, on-demand networking model of a configurable set of computing resources (network, servers, storage, applications, and services) that can be provisioned and commissioned with minimal management effort or interaction with the service provider. It consists of five essential features, three service models and four deployment models. To facilitate understanding, the Cloud computing could be considered a toll highway that is used on demand and pays according to the distance traveled.

2.1 Essential characteristics

2.1.1 Free demand for services

The User may unilaterally make available to him / her computer capacities such as the duration of use of servers, the size of data storage, the computing power, automatically according to his needs without needing to request the intervention of resources for each of the providers.

2.1.2 Access to telecommunication networks

Telecommunication resources and capabilities are available and accessible through mechanisms standardized by different types of clients (desktop, laptop, tablet, Smartphone).

2.1.3 Pooling IT resources

Service providers computing resources are consolidated to serve multiple consumers using a multi-tenant model, with dynamic physical and virtual resources assigned and re-assigned based on consumer demand.
Quick elasticity Technical capacities can be made available elastically and in some cases automatically released in relation to demand.

2.1.4 Measured services systems

The resources used by Cloud Computing Clients can be monitored in real time.

2.2 Service Models

2.2.1 Software as a Service (SaaS)

In the SaaS model, users use software applications that run on a cloud infrastructure provided by an application provider from thin clients, such as a web

browser that runs on a variety of devices (desktop, laptop, Tablet or Smartphone).

2.2.2 Platform as a Service (PaaS)

Clients use an infrastructure, which includes software languages, libraries, services and tools supported by the vendor, to develop applications and use software.

2.2.3 Infrastructure as a Service (IaaS)

A company no longer needs to purchase a set of computer and telecommunications equipments to install and configure its IT infrastructure. It will simply lease this infrastructure and use it as it sees fit.

2.2.4 Deployment methods

The four deployment models are:

- Private Cloud: used exclusively by a single organization
- Community Cloud: Used by a community of organizations with common characteristics: University Cloud, Government Cloud, etc.;
- Public cloud: for public use;
- Hybrid Cloud: is a combination of multiple cloud infrastructure models (private, community, or public).

To facilitate its understanding of the Cloud, one can compare the electricity service provider with the National Electricity Company of Senegal, SENELEC, which produces and sells electrical energy to consumers according to their needs and means.
Indeed, the Client only pays for the Cloud services used.

3 PROBLEM STATEMENT

3.1 Improving the efficiency of the use of IT infrastructures

Companies are investing a lot of money to set up Datacenters that include all the servers on which the company's systems and data are installed, all telecommunications and energy equipments.
A Datacenter that complies with security standards also requires investments in:

- physical security, with the development of a room built according to construction standards, protection against fire, flooding and natural hazards such as earthquakes .
- access security, which includes: biometric control to authenticate those who have the right to enter, surveillance cameras for remote monitoring and identification badges for authorized persons, require significant investment and much human resources.

On the energy front, Senegal faces the challenges of energy self-sufficiency and energy quality. To ensure the energy autonomy of Datacenters, institutions invest heavily on generators, fuel, inverters and energy storage batteries connected to a system of photovoltaic panels for the most ecological institutions. To complete the whole, a large army of managers, engineers and technicians in : IT maintenance, network and telecommunication, electrician, cold specialists, is needed to keep a Datacenter working properly 24 hours /7 days .

Richard Talaber's study "USING VIRTUALIZATION TO IMPROVE DATA CENTER EFFICIENCY" from VMWARE, carried out in 2009 with a thousand international companies, shows that 75% of the 300,000 servers analyzed are used at a maximum of 5%. A server used at 10% consumes 173 watts, while a 20% increase in workload increases power consumption by 9%, from 173 watts to 189 watts. In other words, an increase in workload does not mean a linear increase in electricity consumption.
Senegalese data centers are no exception with very low-use computing resources (processors, disk size, memory).

3.2 Capital Expenses (CAPEX) / Operational Expenses (OPEX) paradigm

Institutions invest to buy their IT infrastructure: servers, routers, storage arrays, etc., to operate and maintain their information systems in proprietary Datacenter. However, with the Cloud Computing, they will have to change their investment paradigm by sharing an IT infrastructure that is available to them and which may not be localized on their premises or even their geographical area.

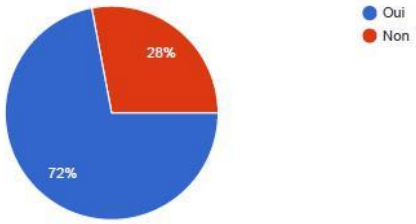


Figure 1 IT CAPEX Budget

The study shows that, 72% of companies have an IT CAPEX budget. The financial constraints: access to bank credit and credit high cost with an average of interest rate at 13%, are blocking factors for new investments in information technologies within companies.

3.3 Improve security

As of Tuesday, April 8, 2014, Microsoft has ceased its support and security updates for computers running Windows XP, its most widely used operating system in the world, to focus on newer versions: Windows 8 or Windows 10.

In 2016, it appears that ATMs of Senegalese's financial institutions display the Windows XP logo at startup. More surprisingly, some large companies in the field still use computers running Windows XP to perform very critical tasks.

Approximately 65% of branded computers (HP, DELL, IBM, LENOVO etc.) are purchased in uncertified marketing channels commonly referred to as the black market, according to a study conducted by the International Data Corporation (IDC) and commissioned by Microsoft. The IDC study "The Dangerous World of Counterfeit and Pirated Software" was released in March 2014 on the "Play It Safe" initiative launched by Microsoft to educate consumers and businesses about the dangers of Internet software piracy. Most of these computers use pirated software that exposes their users and their institutions to the risks of cybercrime.

As the icing on the cake, extended support for Windows 2003 Server ended on July 14, 2015. As a result, Microsoft no longer releases security updates for any version of Windows Server 2003 and recommends migrating all servers to Windows Server 2012 R2, Microsoft Azure, to protect their infrastructure and Datacenters.

3.4 Accelerate the application development process

Applications, used by companies to manage human resources, manage inventory or customer relationships, which are increasingly demanding, have increasingly complex business logics. Their very complex development is carried out with specific software: increasingly complex programming languages (PHP, Java, C++, etc.), relational databases (Mysql, Oracle, MS SQL) or Object oriented databases software and business process modeling software, which require scalable platforms and IT human resources.

3.5 Improve the reliability and security of the information system

Business Continuity is a strategic and critical objective that many companies must meet to ensure their survival in the face of major risks.
The Business Continuity Plan (BCP) will be responsible for the majority of the risks: Hacking (unauthorized access that can lead to destruction or theft of data); Computer virus infection; Natural hazards (floods, earthquakes, riots, fire, etc.). The study shows that only 34,6% have a business continuity plan.

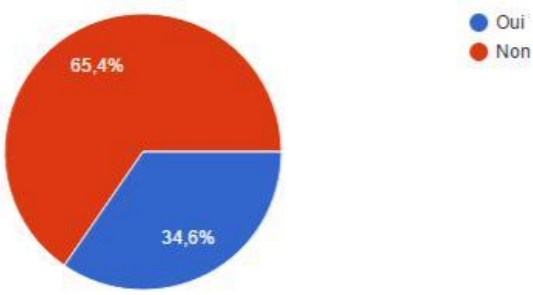


Figure 2 Business Continuity Plan existence

• Interoperability of systems

Many systems from many vendors make up the enterprise information system and each software has its technical specifications in terms of operating system, (Linux, windows server, IBM Iseries etc.). The multiplicity of user codes and passwords to carry out its work, causes frustrations to Users who must be more productive for more competitiveness.

4 RESEARCH METHODOLOGY

4.1 Survey

This survey focuses on the challenges and opportunities provided by the digital transformation of IT infrastructures of Senegalese companies in Services using Cloud Computing.

4.2 Approach

The main steps in the methodology used for data collection are:

- Development of a digital questionnaire;
- Identification of about 100 private enterprises;
- Collection of quantitative and qualitative data from eighty-seven (87) companies from March 2015 to December 2016;
- Conducting interviews with targeted Corporate Directors;

5 RESULTS

5.1 Optimize the management

The results of the survey show that information systems play a strategic role in the management of institutions. 57.7% of respondents adopted an organization in the form of an Information System Directorate (ISD) for the management of activities related to their information system. However, 26.9% of companies have their information system organized and managed in the form of a business unit, which is most often attached to an Administrative Directorate or Finance Directorate. Moreover, the survey showed that only 15.4% of Senegalese institutions do not have a particular

administrative organization that controls their IT activities.

5.2 Influence of the Chief Information Officer (CIO)

We note that 53.8% of Information System Officer are not part of the company's Management Committee, while 57.7% of companies have an Information Systems Department.
The top management committee is a functional body composed of the Chief Executive Officer and Directors, who usually meet once a week to evaluate, guide, validate and prioritize the company's activities. It is the place and the moment where the strategic decisions are taken.

5.3 Computer Master Plan

The survey shows that half of the companies have a sight-driven information system, without rigorous planning. Indeed, only 50% of companies have a Computing Master Plan (CMP) or Informatics Master Plan (IMP) up to date with projects identified, validated, budgeted and planned.

5.4 Information System Management Budget

The survey showed that 76.9% of companies have a budget for the management of the information system. To budgetize a Cloud migration project, CIO must conduct a financial analyzes of the positive impacts.
Whereas in a structure where the costs of managing the information system are embedded in the overall operating budget of the company or drowned in the budget of another Directorate, such as the Directorate of Finance or the Administrative Directorate, the CIO will have more difficulty measuring the impact of its project.

5.5 Project management expertise

The survey showed that half (50%) of Information Technology Managers or Decision Makers have certification equivalent to that of the Project Management Professional (PMP) of the renowned Project Management Institute in the United States, while 38,5% received equivalent training.
According to the Gartner Group, 70% of planned and budgeted projects fail due to an overrun of the budget initially planned and validated, a delayed delivery compared to the expected date or a poor quality with a product that does not meet the needs and quality requirements initially validated by users.

5.6 Use of Software Packages

The survey shows that all companies use licensed software packages purchased from international vendors like Microsoft, SAP, Oracle, and Cisco.
As a result, these vendors face a variety of software asset management issues of the companies with licensing and versioning management.

- The different modes of software licensing

A software license is a right to use a given software, not a right of ownership of the software itself. There are essentially 3 types of licenses: boxed licenses for personal use, OEM licenses and volume licenses for businesses.

- Asset management

It is a set of infrastructure and processes necessary to effectively manage, control and protect software in an organization at all stages of its life cycle (source: ITIL Best Practice Software Asset Management).
Companies that do not have good asset management take several risks including asset management risks, technical and security risks, legal, image and financial risks.
In addition to the legal risks, there are technical problems, which can cause loss of data or the computer system to shut down, due to the absence of maintenance contracts related mainly to the absence of a license acquisition contract.

- Management of CLOUD assets

The Cloud provides companies with Software as a Service (SAAS) services to be used from the Internet. Among the most commonly used are: Salesforce, Microsoft Office 365, Google Apps, and NetSuite. As a result, the software asset management issues, known to CIOs, disappear with SAAS.
Moreover, the CIO will still have to put in place a SAAS licensing policy.

5.7 Use of internally developed software

Approximately 61.5% of companies use in-house developed software to meet specific business needs. Indeed, all the services of the company (Human resources, finance, IT) need applications to facilitate the automation of the tasks, the collaboration between the employees and the partners, and the communication with the Clients. Sometimes those applications even make these interactions faster and boost productivity.

5.8 Software Development Team (Programmer, Analyst, Database Administrator)

To respond to the growing needs for software, mobile and internet solutions to improve productivity, profitability and above all satisfy the needs of increasingly demanding Clients, 57.7% of companies have a multidisciplinary development team.

5.9 Appliances in use

Servers and desktop computers are widely used. Tablets and smart mobile phones are emerging with 42.3% in the IT environment of Senegalese companies. Indeed, the need to connect remotely to company data has become a priority for workers who are under pressure to be more productive.

5.10 Operating Systems in use

In Senegalese companies, many computers still work under Windows XP, in which is installed software that perform critical functions. In addition, Windows XP is found in all sectors of activity (banking, ATM, police, health, government, etc.).
We note that 92.3% of companies use the Micorosoft Windows XP operating system for their desktops and 76.9% use Microsoft Windows Server 2003 as their operating system for servers.

5.11 Size of It infrastructure

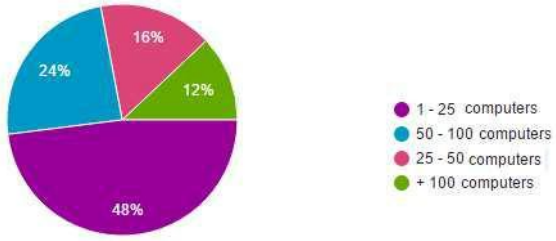


Figure 3 Size of IT infrastructure

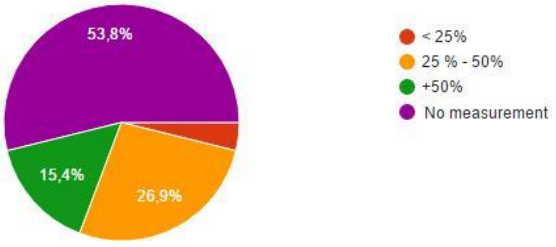
The results of the survey show that only 12% of companies have a computer park with more than 100 computers, and that 24% of companies have a computer network of up to 50 computers.
However, it is important to note that half of the companies, 48%, have a computer park of 25 computers at the most.

5.12 A dedicated computer room (Datacenter)

38.5% of the interviewed companies do not have a technical room devoted to computer and telecommunications equipment, despite the strong penetration of the IT tool within companies. However, more than the majority of companies (61.5%) have a dedicated computer room that ensures the smooth operation of the information system 7 days a week.

5.13 Rate of utilization of equipment (servers, storage array)

Of the 68.5% of companies that own a data center, we find that 53.8% of companies do not know the rate of use of computer equipment and at the most 15.4% of the companies measured the utilization rate of computer equipment that exceeds 50%.



5.14 High availability and quality of energy

According to the Director General of the National Electricity Company (SENELEC), the average number of hours of outage has decreased from 900 hours in 2011 to 60 hours in 2016.
Despite this, to ensure good quality of power supply with good protection against power surges and outages, 92.3% of companies use inverters and 50% use voltage regulators. The generators are heavily used (73.1%) to ensure a high quality of power supply. Interestingly, there is a breakthrough of green energy with solar energy installations to reduce the energy bill.

5.15 Cooling system

Up to 80.8% of the computer rooms are cooled with split air conditioners, 42.3% with air conditioners and only 19.2% of Datacenters are equipped with central cooling cabinets.

5.16 Types of telecommunication links in use

Fiber optics is occupying a growing part of the market, with 36%, because it offers more capacity, yet its cost is a blocking factor, while 92% of companies use wired connections and 36% install private telecommunication networks using wireless technology, in a local radio loop.

5.17 Types of Internet connection in use

The most widely used Internet connectivity in companies is broadband ADSL with 76.9%. However, there is a progression of broadband connectivity by mobile phone with 3G Internet packages offered by all telephony operators at attractive costs.

5.18 Usage of dedicated software development environment

The majority of institutions that participated in this study, 85.7%, use a dedicated software development, which is good practice. While 14.3% of institutions use software developed in a non-dedicated environment.

5.19 Lack of dedicated test environment

The survey showed that 28.6% of institutions do not have dedicated test environments. This non-compliant practice in software engineering does not guarantee quality, performance and the proper functioning of the software in the production environment.

5.20 Usage of production environment

According to the results of the study, only 42.9% of institutions have a dedicated and secure production environment running critical software applications.

6 DISCUSSION

6.1 Organizational management

The use of ICT is no longer a luxury for business. The implementation of a migration project to Cloud Computing is a strategic decision, which requires a solid internal organization. Indeed, it is essential to establish an Information System Directorate, autonomous with an information systems management budget, which is a member of the Steering Committee.

The Chief Information System should have a management profile with strong training, at least a Master degree in the field of information system management, to play a strategic role at the level of the Management Committee. He/she must preferably have a certification in project management, from an internationally recognized organization or at least at national level.

Project management is a weak link in national and international companies. Consequently, the Chief Information Officer should have a strong capacity to manage the portfolio of projects that it has validated beforehand by the Management Committee.

In addition to a Directorate of the Information System, managed by an experienced Chief Information Officer, the company must have an IT blueprint, composed of projects with budgets validated by the General Management team, in which there will be a digital transformation project with migration to Cloud Computing.

6.2 IT Infrastructure optimization

With 53.8% of companies that do not know the utilization rate of their IT and telecommunication equipments, it becomes urgent for companies to start an audit project to:

- measure the utilization rate of their computer and telecommunication equipment in their Data Center;
- conduct a compliance audit of all their licensed software and quantify the annual cost of licensing;
- measure the cost of the energy bill for the operation of the equipment in their Data Center and the cooling of the latter;
- measure the telecommunication bill for the interconnection of the various sites and employees.

The results of these studies will be used as input data to measure the ownership costs of their IT infrastructure and to define a migration project to the Cloud computing with keys performance indicators (KPI) such as energy cost control, telecommunication costs reduction, compliance with the use of licensed software and above all a better use of investment in equipment.

6.3 Software Development

National market specificities and international competition push companies to develop technological solutions adapted to their needs and realities. Indeed, the ISD will have to seriously consider the use of SaaS, PaaS, and IaaS solutions available, for the implementation of software development projects, while respecting the modern standards of software development.

In addition, all vendors of software development tools offer SaaS, PaaS and IaaS solutions. This is the case of Microsoft Azure, which allows all ISDs to start and conduct a complex software development project easily with all the tools available on the cloud of Microsoft Azure and especially with payment facilities based on usage.

In addition to the time savings achieved in the execution of the project, thanks to the rapid and unlimited implementation of the various development environments, integration tests, performance and production tests, significant savings will be realized in the capital budget. This budget will shift from CAPEX to OPEX, which will have a strategic impact that will allow the company to better focus on its core business, innovation and last but not least, product and services quality improvement.

On the security front, developers will no longer be able to use non-compliant software. Cloud Computing has become the standard for software development.

6.4 Business Continuity Plan (BCP)

On a strategic level and to ensure the survival of his company, a Chief Executive Officer will have to ask himself : *how will my company resist the loss of data from his inventory management software, following a fire of servers in a data center?*

With only 34.6% of companies with a BCP, the situation is very critical for Senegalese companies. A BCP is not a superfluous document, it is as essential as the seat belt is essential to ensure the safety of the driver in a car.

Admittedly, setting up a BCP is a complex project, requiring a great deal of expertise, human, material and financial resources. However, a migration to Cloud computing will provide excellent opportunities for companies to implement a BCP without having to invest in setting up a secondary datacenter with complex real-time data replication systems and a real-time failover system in the event of a disaster.

For example, by choosing IBM Bluemix IaaS solutions, the CIO entrusts this strategic project to a qualified and recognized resiliency provider, and frees up time to better handle the alignment of digital transformation and innovation within his company.

7 MIGRATION GUIDE TO THE CLOUD

To migrate to the Cloud and transform their IT infrastructure into Services, we offer companies a 5 step pragmatic methodology, presented in Figure 5.

7.1.1 Stat of play

During this stage, the Director of the Information System must make an inventory of its entire IT infrastructure and measure the rate of use of each equipment (telecommunications, server, computer, etc.) and component. In addition, it will have to perform a compliance audit of the software used and its cost in license.
The analysis of this information will allow identifying a pilot project or even defining a portfolio of projects to migrate to the cloud using Pareto's law. This law consists of investing 20% effort to solve 80% of the problems. For example, migrating desktop software to cloud solutions such as Microsoft Office 360 will address compliance issues, reduce software management costs, and control licensing costs.

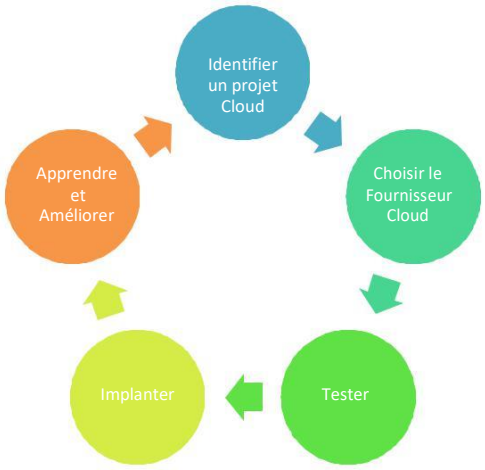


Figure 5 Cloud migration guide

7.1.2 Identify a Cloud pilot project

An iterative "step by step" approach will provide short-term results with better management of changes. For example, migrating desktop applications to Cloud solutions are less risky and can allow stakeholders to quickly appreciate the benefits of cloud computing.

7.1.3 Set up a dedicated project team

To ensure the success of a project, it is very important to set up a dedicated project team.

7.1.4 Choose your Cloud Provider

At the national level, and even in sub-Saharan Africa, we have not identified any cloud service providers with operational African datacenters. Apart from IBM, which has a Datacenter in South Africa, the world leaders, listed below, have their Datacenters operational in Asia, Europe or the Americas. However, Cloud Computing exceeds geographical considerations, it is a service.
The main Cloud players are available through the Internet and any company could start a cloud project rapidly with just a credit card or a Paypal[1] account:

- Amazon Web Services, a subsidiary of Amazon, established in 2006, which offers a range of Web-based IT infrastructure services called Amazon Web Services (AWS) based on a Cloud Computing platform;
- Google Cloud Platform, a cloud computing platform that provides hosting and provides developers with products to build a range of programs from simple websites to complex applications;
- IBM Bluemix / Softlayer: IBM Bluemix is a platform-based Cloud Computing (IaaS) tool developed by IBM. It allows using several programming language, is based on IBM-specific technologies, and runs on SoftLayer, an IBM division responsible for IaaS;
- Microsoft Azure, an open, flexible, enterprise-class Cloud Computing platform that provides developers and IT professionals with a number of tools to create and manage applications in the cloud.

7.1.5 Learning and improving

This very important and often neglected step will allow the project Cloud team to learn from previous experiences and to optimize the future migrations towards the Cloud.

8 CONCLUSION

This article presents the partial results of a survey carried out among eighty-seven (87) Senegalese companies on the digital transformation of IT infrastructures in Services with the Cloud Computing.

The analysis of the results showed that migration to the Cloud is more than a necessity to stimulate creativity and consolidate leadership in a global economy that is becoming more and more digital.

Indeed, customers who are over-equipped with mobile phones and tablets connected to the Internet, are better informed and more demanding.

To improve its services and products offered to Clients, a company will have to develop a Cloud strategy, to reduce

---

1 **PayPal** is a popular and easy online payment service.

its costs, improve its agility, its security, its resilience and its innovation capacity.

This article does not discuss the results of the security survey and the legal aspects of the Cloud, which may be the subject of further research and publications.

9 REFERENCES

1. B. S. Alliance, « 2016 BSA Global Cloud Computing Scorecard », *2016 BSA Global Cloud Computing Scorecard*. http://cloudscorecard.bsa.org/2016.
2. SO, Candice, « Cloud computing not widely adopted by SMEs: study », *IT Business*, 24-dec-2013. .
3. GALLAGHER, Patrick D., Under Secretary of Commerce for Standards and Technology and Director , Joint Task Force Transformation Initiative, « Security and Privacy Controls for Federal Information Systems and Organizations », National Institute of Standards and Technology, NIST SP 800-53r4, apr. 2013.
4. MELLET, Peter et GRANCE, Timothy, « The NIST Defintion of Cloud Computing », Special Publication 800-145, sept. 2011.
5. HORTON, Jerry, Chief Information Officer (CIO), United States Agency for, International Development, et Jerry Horton, « UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT INFORMATION TECHNOLOGY STRATEGIC PLAN FISCAL YEARS 2011-2015 », apr. 2013.
6. RADACK, Shirley, Editor, Computer Security Division, Information Technology Laboratory, National Institute of Standards and Technology, et Department of Commerce, « CLOUD COMPUTING: A REVIEW OF FEATURES, BENEFITS, AND RISKS, AND RECOMMENDATIONS FOR SECURE, EFFICIENT IMPLEMENTATIONS », ITL BULLETIN, Juin 2012.
7. VivekKundra U.S. Chief Information Officer, « FEDERAL CLOUD COMPUTING STRATEGY », FEVRIER 2011.
8. IBM Global Technology Services, « Get more out of Cloud with a structured workload analysis », White paper, oct. 2011.
9. STUART Williams, Director, TBR Software Practice. « IBM Cloud Services Balancing compute options: How IBM SmartCloud can be a catalyst for IT transformation, Spring 2011
10. SANOU, Brahima, ITU, Director Telecommunication Development Bureau (BDT), CLOUD COMPUTING IN AFRICA: SITUATION AND PERSPECTIVES, http://www.itu.int/ITU-D/treg/publications/Cloud_Computing_Afrique-e.pdf, April 2012