G-Cloud: Opportunities and Security Challenges for Burkina Faso

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Abstract. In this paper, we try to clearly outline the opportunities of cloud computing in the context of developing countries, while helping stakeholders grasp the challenges ahead. In particular, we consider the case of the G-Cloud project engaged by the government of Burkina Faso to boost the ICT economy, improve administration-citizen relations, and strengthen the education system. Through this article, we try to show the actors, that the G-Cloud to be a vector of opportunities and sustainable development for Burkina Faso, pre-conditions and challenges are facing particularly in terms of security in the cloud environment and the challenge on the supply in sufficient quantity and quality of electric power.

Keywords: G-Cloud · Opportunities · Security chalenges · Developing countries

1 Introduction

Around the globe, we are witnessing the momentum of cloud computing technology, which allows providers to make both hardware and software infrastructure available on demand as services via the Internet. In an era where resources must be intelligently managed and expenses reduction has become a priority, cloud computing has been positioned as a powerful vector of the economy. Indeed it provides opportunities in various sectors of development, contributing in a rational management of economic, human and infrastructural resources. For developing countries such as Burkina Faso, with embryonic economies where citizens and governments face diverse overlapping priorities, cloud computing can be leveraged as a concrete opportunity for sustainable development based on an efficient exploitation of IT infrastructures. Nevertheless, given the context of developing countries where technological challenges are immense, cloud computing projects must check the capability of stakeholders to ensure the availability, reliability and security of the infrastructure of the hosted applications and of stored data.

This paper is an effort from the academic community to clearly outline the opportunities of cloud computing in the context of developing countries, while

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helping stakeholders grasp the challenges ahead. In particular, we consider the case of the G-Cloud project engaged by the government of Burkina Faso to boost the ICT economy, improve administration-citizen relations, and strengthen the education system [2,3].

The remainder of this paper is structured as follows: Sect. 2 discusses related works. Section 3 enumerates the opportunities that the G-Cloud project will help realize if/when fully implemented. In Sect. 4, we will detail challenges, in particular security challenges, that arise in the design and implementation of the G-Cloud project in the context of a developing country. We provide discussions on the impacts of security issues as well as propositions on mechanisms to secure the cloud. We conclude this work in Sect. 5.

2 Related Works

The emergence of cloud computing as a technological advance of the 21^{st} century, several studies highlighted the opportunities that such a model of service can offer to developing countries. In [5], Mathias and Baldreck highlight the benefits of cloud computing for small and medium-sized enterprises of developing countries. The authors discuss the potential of cloud computing in Africa and the challenges associated with the use of the services offered. In [6], Juster by analyzing the benefits of cloud computing for developing countries, shows that Cloud Computing can bridge the gap in development between the developed and developing.

Hong-Linh [7] focuses on the opportunities of cloud computing to the field of education and research in developing countries. Needs infrastructure and software for countries with weak economies related to cloud computing profits overshadow not however challenges in terms of security applications and data especially for less advanced nations economically, technically and where the legislation on the protection of personal data is not yet in the beautiful fixed. Because of its operation, Cloud computing has both of legal risk for the customer and technical and operational risks due to the loss of control of the client on its own data processing. It also introduces new risks, whether for the sharing of responsibilities, the location of the data or sharing.

3 G-Cloud: Opportunities for Burkina Faso

Cloud computing is a major technological shift from traditional computing. It leverages virtualization on remote servers and distributed pooling of storage resources to provide remote (i.e., users can be geographically distant from servers) data processing and application computing. This yields substantial savings in various resources (including energy, storage, human resources, etc.) and thus, an economy of scale particularly for countries under development. Based on a new economic model that is to provide services and applications available online through network (e.g., in a web service mode) based on an on-demand policy and billing to the use, cloud computing has now turned into an obvious

opportunity for the information and communication technology sector and also for the sector of entrepreneurship in developing countries. The main services offered by Cloud Computing can be summarized as follows [15]:

- The infrastructure as a Service (IaaS): it provides the entire infrastructure stack that delivers the computer infrastructure and it leverages significant technology, services, and data center investments to deliver IT as a service to customers. It delivers hardware such as servers, Server virtualized and application, data center virtualized, memory, flexible storage and application, CPUs, disk space, network connectivity, flexible local area networks (LANs), firewalls, security services, etc.
- The platform as a Service (PaaS): it provides the development environment and delivers operating systems and associated services over the internet without the need to download or installs applications on end-user computers.
- The software as a Service (SaaS): Software-as-a-Service is a software distribution model in which applications are hosted by a vendor or service provider and made available to customers over a network, typically the internet. This may relate to business applications, customer relationship support (CRM), Finance (ERP), online payment, electronic marketplace (for the TPE/PME), etc. (Fig. 1).

Apart from these main service delivery models a number of variations exists, namely [5]:

- The communication as a Service (CaaS): based on SaaS, it delivers audio/video communication, collaborative services, unified communications, e-mail, instant messaging sharing data (web conferencing).
- The network as a Service (NaaS): based on IaaS, it provides Internet managed (warranty of throughput, availability, etc.), virtualized networks, Virtual Private Network (VPN) combined with Cloud Computing, flexible bandwidth services and demand.

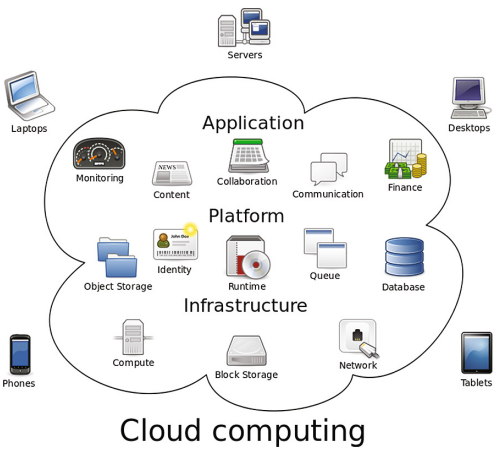

Fig. 1. Cloud computing delivers services

In the light of the services offered by cloud computing, there emerge a number of opportunities for countries with weak economies and in all sectors of activity. We will focus on cloud computing opportunities in three areas of development for the developing countries: education and research sector, sector of the technologies of the information and communication, sector of entrepreneurship.

3.1 G-Cloud: Opportunities for Education and Research in Burkina Faso

Education and research in developing countries are generally characterized by several challenges related mainly to the access to resources (teaching and related work material), and to the lack of qualified teachers [7]. Given the inadequacy of budget allocations for addressing these challenges, cloud computing may be suitable for alleviating several difficulties.

Indeed, leveraging cloud computing services, education and research stakeholders can quickly implement e-Learning, e-science and e-research platforms while establishing strategic networking within the scientific and academic communities. Another advantage of cloud computing for education and research is that it will allow mobility and emulate ubiquity. As a result, work initiated in a given location can be continued in another in another location via the cloud, without any need to duplicate or synchronize the supporting documents.

To face the shortcomings in budget, savings can be made at certain levels including the purchase of terminals. Storage and computing capabilities are deported into remote servers, and thus personal computers require less CPU and hard drive capacity. Furthermore, cloud computing adoption can limit the installation of a slew of software on personal computers, a hazard for spreading viruses and pumping energy to supporting redundant task processing. One can finally compensate for the accidental loss of data on personal terminals by saving documents in the cloud.

In Burkina Faso, the implementation phase of the 'G-Cloud' platform can be a springboard for the establishment of a Virtual University, which will facilitate online courses and researcher mobility, thus addressing the needs of an ever-growing university community. In response to the limited financial resources (including material and human resources in the field of education and research of the countries developing), cloud computing is a source of enormous to exploit opportunities. In addition to the educational field, cloud computing offers opportunities for the sector of information and communication technologies.

3.2 G-Cloud: Opportunities for Sector of ICT in Burkina Faso

The context of the ICT sector in developing countries is characterized by a very rapid development of mobile networks, while these countries attempt to find solutions to catch up in the deployment of fixed infrastructure and broadband networks. A main prerequisite however for the deployment of cloud computing in developing countries is to accelerate the development of such infrastructures. Other prerequisites for deployment are the constant availability of sources of

stable energy and water, in quantity and quality, for cooling of servers which must remain constantly active. Unfortunately, these conditions are not always met in these countries.

Cloud computing investments are therefore an opportunity for developing countries in the sense that efforts to satisfy the conditions necessary to its deployment will contribute to reduce the digital gap between developed and developing countries. The physical proximity of Cloud resources with the end user will have the immediate impact of the budget earmarked for the bandwidth savings and will guarantee some level of access speed to resources in the cloud.

Opportunities to gain immediate access to the latest innovations and for an organization to move from heavy investment in ICT infrastructure, in particular, in data centers, are a godsend for the reduction of the digital gap. As an illustration, in the context of implementation of the G-Cloud, the government of Burkina Faso undertook the creation of a national, 5740 km-long, backbone, and will have to improve connectivity and communications in a country that lacks basic digital infrastructure. Also, the realization of a technology park of 80 ha with a virtual point landing and an internet exchange point is considered in the South of Ouagadougou, the capital city [3,4].

The G-Cloud project participates in the reduction of the digital gap with the deployment of 513 km of optical fiber, and connecting more than 800 public buildings in the capitals of the thirteen regions of the country, as well as the establishment of an e-Government platform [1].

3.3 G-Cloud: Opportunities for Youth Entrepreneurship in Burkina Faso

In Burkina Faso, entrepreneurship and self-employment are essential vectors in the fight against unemployment of young people, and an engine for sustainable development. Unfortunately, entrepreneurship of youth in Burkina Faso faces several factors, mainly the lack of capital. The advent of cloud computing can contribute inexorably to boost entrepreneurship in countries with weak economy.

There is an increasing, and often unbalanced, competition between firms from developed countries and those of developing countries. To reduce operating costs, streamline investment, improve productivity and boost innovation, cloud computing can be leveraged by lower-economy companies to reduce investment costs in ICT infrastructure. With cloud computing, organizations, institutions and businesses will no longer have the need to invest heavily in computing resources, and requiring a heavy and costly internal management.

The availability of online services gives also the possibility to access more appropriate computer equipment in a pay-per-use model which is suitable in an economic environment where businesses seek to maximize investment and reduce operating costs while reaching competitiveness and performance for businesses.

Despite the benefits that come with cloud computing, its adoption and implementation in developing economies is confronted by a variety of challenges. One can find several arguments against cloud services in developing countries. However, the most critical one remains the security challenges. Indeed, an essential

concern of cloud computing setups in countries where the technological challenges are immense, remains to guarantee the security of the cloud infrastructure, applications, and data.

4 G-Cloud: Security Challenges for Burkina Faso

Lose control of its data and entrusted to a third party in a cloud computing environment can create specific problems due to the geographical dispersion of data in multiple treatment centers.

This new context calls for lawyers to include provisions to better protect the interests of each and other. It should therefore be made in contracts in an environment Cloud Computing of the provisions strengthened in terms of security and data availability.

Indeed, in an outsourced computing environment, such as the Cloud, the end-user must obtain guarantees on levels of service for solutions to which he subscribes. The provider must be able to justify the levels of service on which he has committed, through a service contract, and provide clients with the means and tools to track these service levels over time.

In addition, at least the following aspects should be addressed [10,11,17]:

- The securisation of network connections: int the order to avoid attack methods such as phishing, fraud, and exploitation of software vulnerabilities. Avoid attackers to access critical areas of deployed cloud computing services, allowing them to compromise the confidentiality, integrity and availability of those services.
- The authentication of persons accessing the data: the security and availability of general cloud services is dependent upon the security of software interfaces or APIs that customers use to manage and interact with cloud services. These interfaces must be designed to protect against both accidental and malicious attempts to circumvent policy.
- The encryption of data: Data protection is the most important security issue in Cloud computing and encryption is a key technology for data security. In the service provider's data center, protecting data privacy and managing compliance are critical by using encrypting and managing encryption keys of data in transfer to the cloud.
- The data access controllability: the possibility to the data owner to perform the selective restriction of access to his data outsourced to cloud and denied the access to persons without permissions.
- The backup of data: the ability to retrieve data when an undesirable operations corrupt or delete them.
- Traceability of access and actions on data.
- The certification of organization and security procedures of the Cloud Computing provider.
- The duty of information reinforced the claimant on security incidents.
- The establishment of regular testing of procedures for the recovery of data and procedures in the event of discontinuance of the service.

- The level of quality of service: the customer must have a right to look at the quality of the services and the level of performance of the service, with a contractual commitment on the part of the contractor;
- The location of data: Cloud has no borders, one must have a commitment on the places of storage of data, and ensure that the regulations of the countries are in compliance with the regulations to which the client is subject or that it wishes to have.
- The conditions for termination of contracts including the reversibility of the service: in the event of breach of contract or change of supplier, the customer must ensure the recovery and destruction of its data on provider infrastructure after his migration.

4.1 The Legal Framework of the G-Cloud

A regulatory environment meets the international requirements in terms of protection of personal data and security of data exchange is the first pillar for a successful development of Cloud Computing.

Since geographic dispersion of data is an important factor associated with cost and performance of the cloud, an issue that deserves mention relates to regulatory arbitrage, which means that cloud vendors can take advantage of loopholes in regulatory systems of certain jurisdictions to reduce risks. Economies worldwide vary greatly in the legal systems. Experts expect that, at least for the short run, countries are likely to update their laws individually rather than acting in a multilateral fashion [9,10].

Due to the newness, jurisdictional arbitrage is higher for the cloud compared to the IT industry in general. In this regard critics are concerned that cloud providers may store sensitive information in jurisdictions that have weak laws related to privacy, protection and availability of data [12,16]. Given the cloud's significance to economic competitiveness and national security, policy makers need to look at developments in cloud-related institutions in other countries and take proactive measures to enact and enforce laws for developing the cloud industry.

In implementing data center according to the rules of the art offering the guarantees of continuity of service, rapid accessibility and secure backup of data according to international standards is another pillar of the G-Cloud.

4.2 The Energy Challenge for Security, Performance, and Availability

The security, performance, and availability are essential pillars in the cloud environment. Availability without fault and the guarantee of continuity of service require a constant availability of electricity to power data centers and a mechanism for cooling without fault. Landlocked climate Sudano-Sahelian, Burkina Faso knows country an energy deficit estimated in 2016 to 110 kwh/day [18] and water resource deficiency [19].

One of the challenges for Burkina Faso to ensure proper security for the G-Cloud is the challenge on the supply in sufficient quantity and quality of electric power in accordance with the need for power and stability required by the hardware. The distribution and consumption of electrical energy by computer equipment off a lot of heat and generally, the temperature quickly exceeds the thresholds recommended for the proper functioning of the equipment. A cooling device is therefore necessary. It is mainly based on the cooling of equipment, directed by forced cold air with forced convection or/and cooling water. Availability is an index that is measured by the ratio between the time during which the service is available and the total time required use either the sum 'uptime + downtime'.

Availability = uptime service/(time uptime + downtime of the service)

The energy efficiency index or PUE (Power Usage Effectiveness) is used to determine the energy actually available for computing resources. It allows to measure the efficiency of a data center and its ecological footprint.

With appropriate levels of security, trust and governance, service providers can provide a secure environment for company data and applications. For this, in the context of G-Cloud, it will ensure an adequate (quantity and quality) supply of electric power in accordance with the need for power and stability required by the hardware.

5 Conclusion

Cloud computing technology is increasingly used and it gives promising approaches for the government, public and private sectors of education and research, ICT, entrepreneurship, etc.

However, customers are also very concerned about the risks of Cloud Computing if not properly secured, and the loss of direct control over systems for which they are nonetheless accountable.

In developing countries, several arguments against cloud services can be discussed. The most critical one remains the security challenges. Cloud providers need to guarantee some aspects of security, performance, and availability for organizations to be more comfortable in service consumption.

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