Cloud Computing and Virtualization in Developing Countries

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Abstract. Cloud computing has emerged since almost a decade as a paradigm for hosting and delivering services over networks. A growing number of business owners and organizations worldwide has adopted Cloud computing as it enables users to access a scalable and elastic pool of data storage and computing resources, as and when required. To build cloud based architectures, virtualization should be ensured as well. It plays a key role for providing flexibility and consolidation of the underlying resources. Despite the cloud computing is witnessing a fast and wide spread across the globe, this technology is not as trendy for some other states, especially for developing countries. The purpose of this theoretical study is to explore a new way for developing countries to benefit from cloud computing use cases and to deal with its challenges and obstacles.

Keywords: Cloud computing · Virtualization · Developing countries · Cloud services · Cloud benefits · Cloud prerequisites

1 Introduction

People in developing countries are facing every day several challenges including poverty, hunger, health calamities and even wars. There is no better way to enhance life facilities than involving technologies in daily life, as it was the case in the developed world. Obviously, the advance of technologies cannot solve all these difficulties but it is worth to say that it should be part of the solution.

Cloud computing provides a relatively new business model and is one of the hippest buzzy word of the last decade. When we mention cloud, virtualization is often mentioned too. These technologies are not interchangeable but virtualization is fundamental for a better cloud usage. Developing world should have the urge to embrace these technologies as it will help them to increase flexibility, accessibility and cost effectiveness. However, due to all the instabilities that are hampering investment capacity in infrastructure, Cloud computing still only on its early stage in these countries.

This paper will start by introducing and differentiating both of virtualization and cloud computing concepts. Then, it will highlight the opportunities of cloud utilization for developing countries. In further sections, cloud infrastructure prerequisites will be detailed in order to boost developing world to challenge these adoption factors. Finally, this paper will close with a conclusion.

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2 Cloud Computing and Virtualization Concept

2.1 Cloud Computing

We can find several cloud computing definitions over the internet, but the most commonly used is the NIST[1] definition as it involves all the approved aspect of this technology. According to this institute, [1] "cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction". The NIST describes Cloud Computing as being based on:

- Five characteristics: On-demand self-service, broad network access, Resource pooling, rapid elasticity and measured service.
- three service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a service (SaaS)
- four deployment models: Private clouds, Community clouds, Public clouds, Hybrid clouds

2.2 Virtualization

Virtualization is a technique that provides a layer of abstraction on top of the underlying hardware or software and allows users to divide computer resources into multiple isolated execution environments. The main goal of using virtualization is running multiple operating systems or applications on the same physical server. Virtualization is ensured by a software called the Virtual Machine Monitor (VMM) also known as hypervisor. It is generally running on top of hardware to manage and allocate the required resources.

2.3 Virtualization Versus Cloud Computing

Many non-IT folks have issues to distinguish between virtualized data centers and cloud-based architecture. In fact, virtualization is a fundamental technique in cloud computing but it is not the cloud either. There is a weighty gap between these technologies capabilities.

The term Cloud computing refers to a business model using the paradigm as a service while virtualization only abstracts physical resources to create various dedicated ones. Although, virtualization provides a more efficient way to consume hardware resources, it stills always too far from the level of elasticity, self-service, and automation of cloud. Moreover, Virtualization offers multiple advantages and benefits that make it plays a key role in delivering a flexible, scalable, and cost effective cloud services, especially in computing service.

The first virtualization advantage is consolidation. It means that hardware resources usage will be optimized by running multiple virtual machines on the same physical

[1] NIST: National Institute of standards and technology.

server. Thus, not only hardware utilization percentage may reach 80% in each server instead of leaving it shiftless but also this practice reduces considerably hardware investments and energy consumption.

Besides, Virtualization offers a higher level of security by running each service in an isolated container on a single physical server. This method is known as "jailing of services".

Then, virtualization provides a greater flexibility by running several types of applications and operating systems on the same server. So it facilitates building testing environments and labs.

To summarize, Cloud and virtualization should not be confused but it does not mean that they could not be combined. And what about building cloud without virtualization? Let's say it is also possible but it will be with a lower level of efficiency.

3 Cloud Computing and Virtualization for Developing Countries

3.1 Actual State in Developing Countries

In developing countries, Cloud computing has already taken a major part in daily life. People often use a wide range of cloud provided applications such as Google Maps[2], Facebook[3], Microsoft's Hotmail[4], and so on…

In order to enhance the economic growth through cloud services, what is expected from these nations is almost adopting, exploiting and why not offering this technology in both of their own states and worldwide rather than a simple consumption of public cloud services. To do so, developing countries requires at least a bit of awareness of cloud computing impact in their economic models, and some expertise to plan for an adoption strategy.

According to a Gartner survey conducted among large enterprises in 2009, half of the respondents in emerging markets either had not heard of cloud computing or didn't know what it meant [2].

Otherwise, since then developing countries are more conscious of cloud computing benefits and consequently markets are getting wider every day.

3.2 Cloud Computing Impact in the Economic Model

– Increase the Economic Investment

Cloud computing is actually a weighty shift in both of business and economic model. One of its major impact in the economic model is to decrease business investment by acquiring a minimum amount of modern IT infrastructure, and then increase corporate profitability by serving maximum IT resources requests. Balancing these factors not only leads to a noticeable cost saving percentage in hardware resources but also drives investment through the reinvestment of retained profits.

[2] Google Maps. Find local businesses, view maps and get driving directions.
[3] Facebook. online social media and social networking service.
[4] Microsoft's Hotmail. free, personal email service from Microsoft.

When implemented properly [4], the cloud economic model can drastically reduce the operations and maintenance cost of IT infrastructures (Fig. 1).

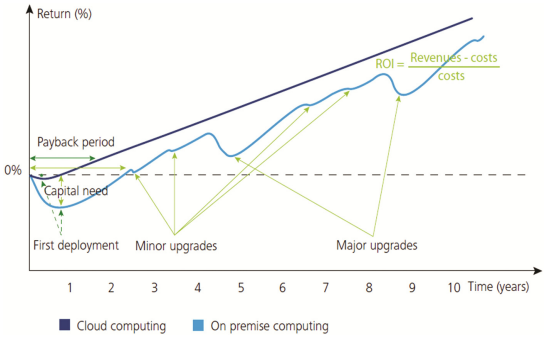

Fig. 1. A Deloitte (Deloitte is the brand under which tens of thousands of dedicated professionals in independent firms throughout the world collaborate to provide audit, consulting, financial advisory, risk management, tax, and related services to select customers) study confirms that cloud deployments delivered greater investment returns with a shorter payback period when compared to the traditional on premise delivery option [4]

– CapEx and OpEx Savings

Developing countries have the possibility to improve their economic evolution not only through private deployments but also within public cloud services. When public cloud model is used, it can play a key role for companies to transform IT expenses from CapEx[5] to OpEx[6] through purchasing the use of the service rather than having to own and manage the resources of that service. Thus, they can eliminate long-term investments in favor of pay-as-you-go costs.

Besides, the OpEx approach can also provide a suitable level of flexibility which allows companies to scale up or scale down depending on their needs and save up money for other investments.

– New Business Creation and Employment

Cloud computing is meant to increase and to have a relevant macroeconomic impact. This technology has changed the market structure of many sectors thanks to cost savings, reinvestment of profits and an improved level of competitiveness. This change in the market induces business expansion or creation and a re-allocation of jobs in developing countries.

[5] CapEx. Capital Expenditures creating future benefits. it is incurred when a business spends money either to buy fixed assets or to add the value of an existing asset with a useful life that expend beyond the tax year.

[6] OpEX. Operational Expenditures refers to expenses incurred in the course of ordinary business.

3.3 Benefit of Cloud Usage for Developing Countries

Rather than its economic and socio-economic advantages, cloud can offer other benefits like elasticity and multitenancy. This section will detail how developing nations can take profit from cloud computing environmental and technical advantages.

– Green IT

The traditional data centers running Web applications are often provisioned to handle sporadic peak Loads [8], which can result in low resource utilization and wastage of energy. Thanks to virtualization, Cloud datacenter can reduce the energy consumption through server consolidation. Thus, multiple workloads can use the same physical server and idle servers can be turned off. A recent research by Accenture [9] shows that moving business applications to Cloud can reduce carbon footprint of organizations.

Developing countries, suffer from pollution due to some local factors such as over-population. In this context, government should induce cloud utilization as it represents a green technology initiative which most businesses should adopt. Thus, Cloud computing and virtualization will reduce energy costs as well as it will offer a lower carbon emission.

– Scalability

Scalability is one of the most important advantage. In fact, in traditional on-premise IT infrastructure, consumers are always tied up to the physical constraints limitation such us hard-drive space, CPU, memory and bandwidth. But with [10] Cloud computing resources should look limitless and can be purchased at any time and in any quantity.

When Public Clouds are used by development countries, a pool of unrestricted resources is offered to simple consumers or business. This provide more flexibility and cost effective resources usage, reduce capital investment in business creation, decrease or even eliminate the need of hardware resources acquirement.

– Remote Access

With cloud computing, [11] instead of connecting to the network server, a mobile phone or device connects to the cloud service provider. All services are available from wherever we are, as long as there is a connection to the network. Armed with such portability and flexibility in the computing environment, businesses can reach their customers 24/7 anywhere in the world. Students can study online courses from anywhere in the world, and individuals can socialize on their mobile phones, SMS and do whatever they want from wherever they are, whenever they want [11].

– Improvement of Life Facilities

According to Kshetri's report (2010), cloud has several applications in daily life, such as E-health, E-education, E-commerce, E-business, and supply chain… If applied properly, people in developing countries could take a lot of profits from this technology even in daily life. It will not only build a new generation of skilled ICT professionals, but it will eliminate repetitive burdens in private or public establishment. The table below analyses the possible advantages in each application area (Table 1).

Table 1. Benefits of cloud computing application in different sectors in Developing Countries

Cloud applications	Examples
E-education	- Enable Academic Cloud based programs in engineering schools to enhance expertise level in developing countries - Provide unrestricted resources to students for development and testing purpose - Enables education for poorer country by offering remote courses
E-health	- Implement healthcare data-sharing and analytics technologies (example of china) - Develop insurance platform, to claim and follow up refund - Use cloud to build next generation medical research
E-commerce/ E-business/supply chains	- Offer local/worldwide shopping platform - Automating business processes - Improve performance and quality of Telecommunication, banking and IT hosting customer services
E-governance	- collaboration with industry and tertiary institutions to ensure the development of skilled and cloud-aware ICT professionals - Implementation of a cloud based platform to deliver more efficient government services - Delivering all the services on the web too in an easy fast and reliable way regardless to the distances and time - Reduce costs by reducing repetitive operations and increase the effective use of resources
E-environment	- Access powerful computer to analyze and predict climate changes
Telecommuting	- Build highly available call centers

3.4 Prerequisites and Limitations of Cloud Adoption in Developing Countries

Technical shortcomings and regulatory difficulties are inhibiting fast adoption of Cloud. This makes it imperative to comprehend the adoption barriers and to find ways to overcome them. Barriers can be divided into two main categories: internal and external barriers.

3.4.1 Internal Barriers

Internal barriers can be summarized in different attitudes towards cloud computing. In developing countries, there is no regulatory rules that ensure personal data protection and data transfer security in cloud environments.

That's why CEO's and decision makers are always anxious about their data privacy and security, the location of data and reliability of their services.

3.4.2 External Barriers

– Government Incentives and Regulations

As cloud adoption stills at a nascent stage in developing countries, governments should waste no time for defining new policies based on an assessment of cloud solutions and be rooted in a full understanding of existing ICT and cloud use within countries. Governments need to be aware of the diversity of cloud use cases and services, the huge number of cloud users.

To accelerate the adoption process, a governmental cloud strategy should be implemented in the general national development plan. Governments should ensure the execution of this strategy by continuous supervision and evaluation. Policy approaches should be then tailored to the circumstances of individual economies, and be consistent with the overall strategic framework for national economic development and for leveraging ICTs [13].

Among developing countries, let's take the example of Vietnam and China [2] which are notable examples of economies that have meaningful government interventions in the cloud sector. Cloud computing in Vietnam is driven fundamentally by the government's belief that this technology would help the country build a skilled workforce. A government agency uses the cloud to link the government, universities, private-sector research, startups, and other organizations [14].

– Inadequate Infrastructure

The feasibility of cloud computing depends to a great extent on the availability of reliable, affordable, high-quality communications networks. In practice, this means broadband networks that link all parties in the supply chains [13]. Developing countries suffer from limited or inadequate access to high-quality and affordable broadband infrastructure. Another important environmental factor for cloud adoption is reliable and redundant power suppliers. It is essential for maintaining large data centers and ensuring continuous service providing.

Multiple countries, like Tunisia have only one national power supplier which is insufficient since at least two distinct ones are mandatory in order to be compliant with the basic standards for cloud oriented data centers.

– Lack of Adequate Legal and Regulatory Frameworks for Electronic Commerce and Cybersecurity

Online transactions are the most important pillar to benefit from the pay as you go business model. Except that, there is a prerequisite for conducting commercial transactions online, including electronic payments, is that there is legal equivalence between paper-based and electronic forms of exchange, which is the goal of e-transactions laws. E-transactions laws have already been adopted by 143 countries, of which 102 are developing countries (UNCTAD, 2015). Another 23 have produced draft legislation in this area. That leaves nine developing countries with no e-transactions laws and 18 for which data are lacking. While four out of five countries in Asia and in Latin America and the Caribbean have adopted such laws, Eastern and Middle Africa countries are lagging behind the most [15].

Furthermore, laws may require the establishment of a national certification authority. However, due to the human and financial costs involved, certification authorities, especially in developing countries, have sometimes not been set up, or have been set up only after an extended period of time. In such cases, e-transactions may lack legal recognition when the intervention of the national certification authority is required to give legal validity to the transaction. In addition, a requirement to use cryptographic systems when conducting e-commerce or e-government operations can represent a barrier to online transactions [15].

4 Conclusion

Through this study we managed to detail factors and KPIs (key performance indicators) regarding cloud and virtualization adoption impact on the developing countries and show the actual state of this adoption is some of them.

Looking deeply in such experiences we managed to extract the main difficulties and breaks to such a change and we draw process draft that could by involving people, companies and governments overcome and accelerate such an adoption.

Even though the benefits are undeniable, meticulous planning and long term strategies are still key elements to successfully achieve the goals behind such a revolution along with a lot of change management.

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