# Accessing advanced computational resources in Africa through Cloud Computing

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## Abstract

*Low resources in many African locations do not allow many African scientists and physicians to access the latest advances in technology. This deficiency hinders the daily life of African professionals that often cannot afford, for instance, the cost of internet fees or software licenses. The AFRICA BUILD project, funded by the European Commission and formed by four European and four African institutions, intends to provide advanced computational tools to African institutions in order to solve current technological limitations. In the context of AFRICA BUILD we have carried out, a series of experiments to test the feasibility of using Cloud Computing technologies in two different locations in Africa: Egypt and Burundi. The project aims to create a virtual platform to provide access to a wide range of biomedical informatics and learning resources to professionals and researchers in Africa.*

## 1. Introduction

Technological differences between many locations in Africa and those existing at many developed countries have generated the so-called "digital divide". While occidental societies seek to integrate and organize the vast amount of information generated nowadays, companies from developing countries need in addition to find the tools and technology that allow them access to resources. Access to computational resources is a challenging problem for developing countries [1]. Without the necessary tools, technology transfer from developed regions to Africa becomes very complicated, given the existing technological infrastructures at many African locations. Although Africa is a continent with a wide spectrum of computational resources and infrastructures, many institutions suffer a lack of resources and a poor Internet connection. This forces to optimize them, such as creating or implementing information systems with low computational load and/or low bandwidth.

In the health domain, this deficiency becomes very visible [2]. Physicians and researchers cannot frequently afford access to health computational or educational resources due to the costs of Internet or software licenses —i.e for commercial computerized medical records, radiology systems, learning resources, and others. This lack of computational resources hampers the daily practice of physicians and health researchers in Africa. In such context, the use of open source resources could alleviate this problem. Thus, various initiatives have proposed the use of open source resources in the healthcare environment in Africa —the potential of using open source in a Hospital in Mali is reported in [3]; in [4], authors describe the use of an open source computerized medical record in Central and South Africa; different policies to promote open source in developing countries are studied in [5].

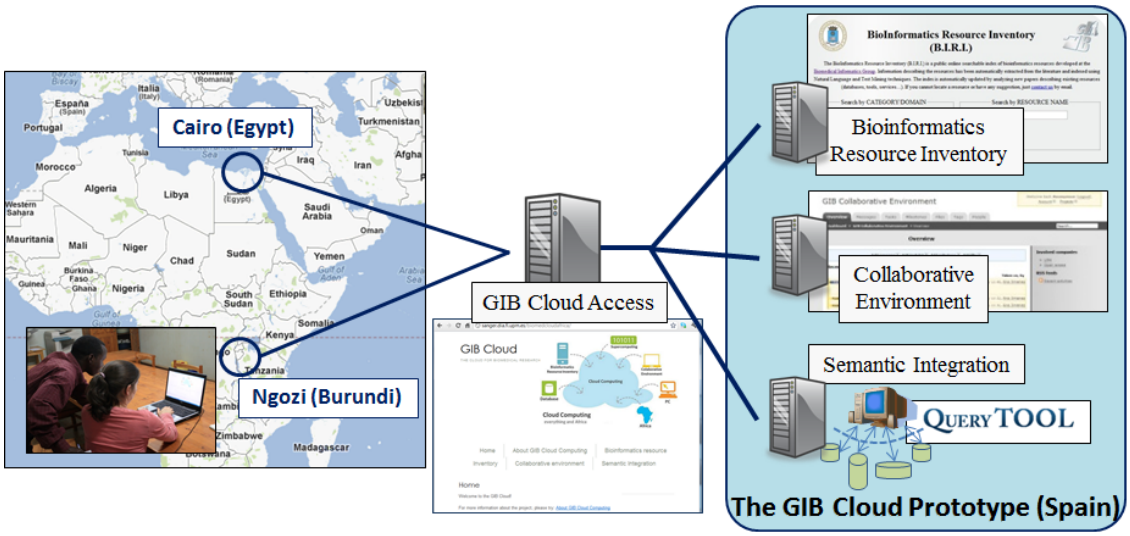


**Figure 1.** Accessing the GIB Cloud prototype from Egypt and Burundi

A large number of NGOs donate hardware to developing countries [6], but frequently such donations include obsolete material or need various components that are not available. To make better use of the resources, grid computing and cloud technology are two technologies which can be used to overcome such situation for some concrete issues [7].

AFRICA BUILD [8], is a European project involving eight institutions from seven countries: Spain, Egypt, Mali, Switzerland, Belgium, Cameroon and Ghana. It aims to improve health education and research in Africa through new technologies. By using cloud services, grid computing and open source software, authorized users from remote locations can access to advanced computing infrastructures that they could not afford otherwise.

## 2. Objectives of the AFRICA BUILD project

The AFRICA BUILD project includes several objectives:

1. Study the state of the art in health research and education in Africa, with special emphasis on the use of Information Technologies. This analysis is intended to lead to a roadmap with actual needs and future actions.
2. Develop a virtual platform where African researchers and physicians could access to several open source computational resources —existing bioinformatics and learning resources adapted to African needs.
3. Create a compendium of courses and learning resources accessible through Internet to improve the quality of African Centers of Excellence.
4. Promote the mobility of African researchers and their participation in international communities.
5. Analyze the impact of AFRICA BUILD approach in HIV/AIDS and reproductive health.
6. Disseminate the results of the project through scientific conferences, journals and media.

The Consortium is currently analyzing the requirement and needs in Africa —through the four African institutions—, considering both information and computational needs. One of the main results of the project is to build a virtual platform that hosts a large number of useful services to the African physicians or researchers.

To test the feasibility of this approach we have carried out two experiments in two completely different African locations: Egypt and Burundi. The Egyptian Ministry of Communications and Technology has high computational resources and a good internet connection, but the Ngozi Hospital in Burundi does not have good facilities and Internet and electricity connection suffers continuous cuts. Such contrast should provide significant clues for AFRICA BUILD.

## 3. The GIB Cloud prototype

A Cloud-based platform (Figure 1) has been created by integrating previously resources developed by the Biomedical Informatics Group (GIB) [9]. We use Cloud technology to facilitate remote access to advanced computing and networking facilities. Thus, we have also eliminated the need to install and

maintain the software in the local machines. Users can access three different systems, based on the Software as a Service (SaaS) approach:

1. The BioInformatics Resource Inventory (BIRI) [10] is a public online searchable index of bioinformatics resources. Through this inventory, users locate and access more than 400 informatics tools.
2. Through the open source tool "ProjectPier" [11], a Web 2.0 collaborative environment was deployed at the GIB. We used this environment for the exchange of documents between members of the GIB. We wanted to use this service to test if it was also useful among physicians and researchers to exchange medical images and documents.
3. The Semantic Mediator [12] was developed by members of the GIB to solve syntactic and semantic heterogeneity between data located in different data sources. With this tool we intended to test the feasibility of a system with many client-server interactions at the two locations of the experiment.

The GIB Cloud prototype was developed using PHP and MySQL. It is a web platform with a web-based user interface that integrates the resources mentioned above, maintaining their interfaces.

The experiment was carried out by experts in computer science and biomedical informatics —from Egypt— and by physicians —from Burundi. The Egyptian infrastructure included a network of advanced PCs with high-speed bandwidth. In Burundi —we taught "in-situ" local users how to carry out the experiments— we used a laptop with a Intel Core Duo processor T2300, 100 GB Hard disk, 1GB DDR2 (RAM) running Windows XP. The hospital's satellite connection was not available at the time of the experiment because of financial constraints (500$/month) and we used a mobile Internet connection with a maximum bandwidth of 306.8 Kb/s through an EDGE connection (40$/month) —connection that was not known at the hospital despite the money they would save using it.

## 4. Results

Results obtained in Cairo (Egypt) and Ngozi (Burundi) using the three selected resources are:

1. BIRI: Egyptian users perform multiple queries and they obtained the results from the tool immediately. Searches launched from the hospital of Ngozi had longer delay than in Egypt due to the quality of the connection —each query took an average of one minute. However, information about different resources was obtained in both locations.
2. Web 2.0 Collaborative Environment: users from Egypt used the environment to upload files, with no problems. Uploading a 1 MB file to the collaborative environment took around 10 seconds, while the same operation in Burundi took around 2-3 minutes.
3. Semantic Mediator: the Egyptian group provided two deanonymized medical databases with data from hepatitis patients. The databases were integrated through the Semantic Mediator and queried through the GIB Cloud prototype. The queries spent an average of 15 seconds. Burundian users accessed the tool and launched several queries against the Egyptian databases and each query took an average of 2-3 minutes.

While in Egypt the three resources were easily accessible through their Internet connection, in Burundi tools like the Semantic Mediator —with a high demand of transfer of information— often could not perform properly.

We found also different interesting needs and opinions from users. In Cairo, the interest in applications like the Bioinformatics Resource Inventory or the Semantic Mediator was greater than in Burundi, given its research-focused environment. In Burundi, local professionals showed more interest in the Collaborative Environment, as it should allow them to communicate with physicians in other parts of the world for assistance and recommendations in their daily work. Physicians at the Ngozi hospital expressed their interest in an e-learning application for physicians and also for hospital patients. They suggested for instance courses for malaria prevention or tools for remote assistance by a specialist in the region. Frequently a patient cannot be assisted by a specialist, since there is only one province-wide.

## 5. Future developments

The AFRICA BUILD Project started on August 1st 2011 and it will last three years. Throughout the course of the project we aim to create a platform based on Web 2.0, Web 3.0 and Cloud Computing to integrate a several bioinformatics and learning resources:

- A "Training and Mobility Brokerage Service" [13], to facilitate researchers' and professors' mobility.
- Open source e-learning tools for distance learning.

- Peer to peer image exchanging tool.
- A software tool for remote collaborative work.
- Supercomputing application to analyze sequences using BLAST.
- Web services for image processing, data management and data mining.

The Consortium is analyzing the computational requirement and needs in Africa to create the virtual platform of the project. This platform ―called the AFRICA BUILD Portal― will support collaborative research and work in the framework of AFRICA BUILD. We will integrate the services by developing a new method of integration of resources, optimizing the performance on the client machine and Internet connection.

## 6. Conclusions

In this paper we have studied the feasibility of the approach that will be used in the AFRICA BUILD Portal, from two different locations in Africa. Results of the experiment suggest that this approach can be helpful to address the lack of computational resources in Africa. In this regard, we have a special emphasis on developing tools that use few computational resources and do not generate so much traffic of information across the network. Although Internet connections are growing in Africa [14], the price of the Internet connection is still expensive [15] and most institutions and professionals have neither the computers nor the necessary Internet connection to carry out their work.

Cloud computing may be a challenging technology for the adaptation of advanced computational resources to developing countries. The AFRICA BUILD Portal will include several cloud services to provide access to a broad range of bioinformatics and learning resources to professionals and researchers in Africa. With the AFRICA BUILD Portal we expect alleviate the deficiency of computational resources in the health domain in Africa.

## 7. Acknowledgements

This work has been partially funded by the European Commission through the AFRICA BUILD Coordination Action under the 7th Framework Programme (Grant Agreement no. 266474). The GIB is also supported by the Institute of Health Carlos III and the Comunidad de Madrid.

## 8. References

[1] Thompson M, Walsham G. ICT Research in Africa: Need for a Strategic Developmental Focus. Information Technology for Development. 2010 Apr;16(2):112-127.

[2] Pakenham-Walsh N, Bukachi F. Information needs of health care workers in developing countries: a literature review with a focus on Africa. Human resources for health. 2009 Apr;7:30+.

[3] Bagayoko CO, Dufour JC, Chaacho S, Bouhaddou O, Fieschi M. Open source challenges for hospital information system (HIS) in developing countries: a pilot project in Mali. BMC Medical Informatics and Decision Making. 2010 Apr;10(1):22+

[4] Mamlin BW, Biondich PG, Wolfe BA, Fraser H, Jazayeri D, Allen C, et al. Cooking up an open source EMR for developing countries: OpenMRS - a recipe for successful collaboration. AMIA Annual Symposium proceedings / AMIA Symposium AMIA Symposium. 2006;p. 529-533

[5] Câmara G, Fonseca F. Information policies and open source software in developing countries. Journal of the American Society for Information Science and Technology. 2007

[6] Computer Aid International. Available at: http://www.computeraid.org/

[7] Greengard S. Cloud computing and developing nations. Communications of the ACM, v.53 n.5. 2010 May.

[8] AFRICA BUILD | Building sustainable capacity for research for health in Africa. Available at: http://www.africabuild.eu

[9] GIB Cloud Prototype. The Cloud Prototype for biomedical researchers. Available at:http://sanger.dia.fi.upm.es/biomedcloudafrica/

[10] de la Calle G, Garcia-Remesal M, Chiesa S, de la Iglesia D, Maojo V. BIRI: a new approach for automatically discovering and indexing available public bioinformatics resources from the literature. BMC Bioinformatics 2009;10: 320.

[11] ProjectPier.org. Easy Online Collaboration. Available at: http://www.projectpier.org/

[12] Perez-Rey D, Maojo V, Garcia-Remesal M, Alonso-Calvo R, Billhardt H, Martin-Sanchez F, et al. ONTOFUSION: Ontology-based integration of genomic and clinical databases. ComputBiol Med 2006;36:712-30.

[13] de la Calle G, Maojo V and Benito M. The INFOBIOMED Network of Excellence: facilitating training and mobility in biomedical informatics in Europe. Stud Health Technol Inform 2006: 124: 893-8.

[14] Les Cottrell R. The Internet, Mobile Computing and Mobile Phones in Developing Countries. In: mScience: Sensing, Computing andDissemination. ICTP–The Abdus Salam International Centre for Theoretical Physics,Enrique Canessa and Marco Zennaro, editors.November 2010.

[15] Hesselmark O. Internet Prices in Africa. A Comparative Study.2003. Stockholm. Available at: http://www.schoolnetafrica.org/fileadmin/resources/Internet_prices_in_Africa.pdf