Building Sustainable Capacity for Health Research in Africa through Cloud Computing Applications

Ana JIMENEZ-CASTELLANOS[1], Guillermo DE LA CALLE[1], Diana DE LA IGLESIA[1], David PEREZ-REY[1], Rada HUSSEIN[2], Aly KHALIFA[2], Victor MAOJO[1]
[1]*Biomedical Informatics Group, Departamento de Inteligencia Artificial, Facultad de Informatica, Universidad Politecnica de Madrid, Madrid, Spain*
Tel: +34 91 3367467, Fax: + 34 91 3524819,
Email: {ajimenez, gcalle, diglesia, dperez, vmaojo}@infomed.dia.fi.upm.es
[2]*Information Technology Institute, Ministry of Communications and Technology, 6th October City, Egypt*
Tel: +20 2 35355590, Email: {rahussein, alykhalifa}@mcit.gov.eg

Abstract: Access to information and continuous education represent critical factors for physicians and researchers over the world. For African professionals, this situation is even more problematic due to the frequently difficult access to technological infrastructures and basic information. Both education and information technologies (e.g., including hardware, software or networking) are expensive and unaffordable for many African professionals. Thus, the use of e-learning and an open approach to information exchange and software use have been already proposed to improve medical informatics issues in Africa. In this context, the AFRICA BUILD project, supported by the European Commission, aims to develop a virtual platform to provide access to a wide range of biomedical informatics and learning resources to professionals and researchers in Africa. A consortium of four African and four European partners work together in this initiative. In this framework, we have developed a prototype of a cloud-computing infrastructure to demonstrate, as a proof of concept, the feasibility of this approach. We have conducted the experiment in two different locations in Africa: Burundi and Egypt. As shown in this paper, technologies such as cloud computing and the use of open source medical software for a large range of case present significant challenges and opportunities for developing countries, such as many in Africa.

1. Introduction

Lack of access to basic health information hampers the daily practice of physicians and health researchers in Africa [1]. This lack of information could be addressed by providing access to educational resources or other facilities, but often such access is expensive and unreachable for most people, e.g. the cost of the Internet connection to access new technologies or higher education fees. The information that these professionals need is not only associated with courses or didactic contents, but also involves information about resources that can be helpful in their daily work or contacts with other professionals to establish collaborations.

In 1995, Nelson Mandela highlighted the need for access to information in developing countries: "Nevertheless, one gulf will not be easily bridged, that is the division between the information rich and the information poor. Justice and equity demand that we find ways of overcoming it. If more than half the world is denied access to the means of communication, the people of developing countries will not be fully part of the modern world. For in the twenty-first century, the capacity to communicate will almost certainly be a key human right." [2]

Information and Communication Technologies (ICT) have a great potential for improving access to information in Africa, and therefore, healthcare and public health in poor and marginalized populations. However, despite of the great benefits derived from the use of ICT tools, many challenges are still present, such as access to computers, acquiring ICT skills or access to research funding. In recent years, significant improvements have been done in Africa regarding ICT. Growths of Internet and mobiles or donations of hardware equipment from Non-Governmental Organizations (NGOs) provide African professionals with easier access to technology. However, new methods to access information and resources through the network are still needed in developing countries. Open source approaches [3] and cloud computing [4] can decisively contribute to alleviate all these problems.

There are currently many initiatives to use open source software tools in developing economies. For instance, in [5] the authors studied the potential of using open source software packages in the Centre Hospitalier Mere Enfant in Mali. The work reported in [6] addressed policies to promote effectively open source software in developing countries, whereas there are successful examples, as shown in [7], about how to use an open source computerized medical record in Central and South Africa.

Similarly, there are several recent reviews proposing the use of cloud computing technology [8-10]. Cloud computing technology presents advantages over other technologies [11], for instance, access to services at low cost from anywhere in the world only with a Web browser. Using cloud services for accessing information, authorized users from remote locations can have access to advanced computing infrastructures that they could not afford otherwise.

AFRICA BUILD [12] is a European project, supported by the European Commission, which involves eight organizations from Africa and Europe. It aims to improve capacity for health research and education in Africa through Information Technologies by building virtual communities of African researchers.

2. Objectives

The main objective of the AFRICA BUILD project is to promote health care and research in Africa by providing access to a wide variety of bioinformatics and learning resources. In addition, we have proposed six sub-objectives:

1. To analyse the state of the art in health research and education in Africa. A Roadmap for future European actions will be released.
2. To implement an IT-enabled, open and collaborative infrastructure for education, training and knowledge sharing for health researchers in English-, French- and Arabic-speaking African countries, developing virtual communities of practice.
3. To develop and offer a large number of e-learning courses, validated learning resources, methodologies and supporting evidence for improving the education capacities of health-focused centres of excellence in Africa.
4. To facilitate researchers' mobility and participation in local and international meetings.
5. To validate the AFRICA BUILD impact in pilot research and education initiatives related to reproductive health and HIV/AIDS research.

6. To disseminate outcomes in scientific conferences and journals, media and workshops and conferences in Africa.

To achieve these sub-objectives, the Consortium is identifying the current needs and gaps in health research and education in Africa. The analysis of the state of the art in this field is intended to lead to a roadmap with actual needs and future actions.

During the project we will develop a virtual platform (the AFRICA BUILD Portal) based on cloud technology. This Portal will allow communities of researchers in different areas to be created through IT-enabled infrastructure for education, training and research support. This platform will also offer access to a wide variety of courses developed by the Consortium, and will facilitate the mobility of researchers through the Mobility Brokerage Service [13].

Similarly, during the project's lifecycle, two pilots will be launched by creating educational and research programs about HIV/AIDS and reproductive health. With these pilots, the project aims to validate the approach of education and research through information technologies. AFRICA BUILD aims to develop a new approach, based on novel IT and the use of remote resources to enhance research and education, and link these two aspects. We will base these two pilots on previous experiences carried out for years by specialists from AFRICA BUILD Consortium and other organizations. The pilot should also develop a workable model for awarding certificates for the courses dispensed via e-learning, through the formalization of the curriculum, the use of a learning management system and/or a tool for documenting acquired knowledge, and, eventually, the use of local tutors for additional face-to-face courses and exams.

The different e-courses will cover topics specifically needed at various African countries as a whole catalogue is being compiled, besides HIV and reproductive health. While we have been already teaching distance courses with Africa, all the lectures are also offered on a CD-Rom to avoid access problems due to connectivity limitations.

During two pilots, which start in March 2012 lasting approximately two years, extensive use of the AFRICA BUILD Portal will be made. Our group is also carrying out research in integrating public health data from heterogeneous sources. Such experience can be also applied to these two pilots, to show different ways of managing public health data.

One of the main outcomes of the project will be a platform to host cloud-based services to provide information to health professionals. The main objective of this paper is to show the feasibility of the approach of develop and use the AFRICA BUILD Portal for African users. In this paper, we describe an earlier experiment carried out to evaluate the feasibility of our approach. In this experiment we measured some characteristics of accessing three different biomedical informatics services —deployed as cloud services—through the Internet from two completely different locations in Africa: Cairo (Egypt) and Ngozi (Burundi). This experiment will be explained in detail in the next section.

3. The experiment: accessing the cloud from Cairo and Ngozi

Considering the ideas exposed above, we developed a prototype of a cloud platform at the Biomedical Informatics Group (GIB) [14], to test the feasibility of the approach of the AFRICA BUILD Portal. This prototype provides access to three biomedical resources developed by the GIB. As this is a cloud application service (Software as a Service (SaaS)) we eliminate the need to install and run the software on the client computer. In this way users' PCs can be simpler, and not worry about the maintenance and support of the service. Users only need a standard Web browser to access the available services. The cloud prototype (Figure 1) gathers a set of resources that can be accessed from remote locations.

We tested our prototype in two different locations in Africa, involving four end-users: (i) from the Ministry of Communications & Information Technology of Egypt, located in Cairo, and (ii) from the Ngozi Hospital of Burundi. We selected these locations to contrast

the opinions of two completely different environments. They differ in relation to informatics resources, literacy level, budget, or even in their biomedical objectives. For instance, Egyptian users are more focused on biomedical research, but in Burundi users are more interested in primary healthcare. Both scenarios suggest two extremes of a broad range of environments to be found in Africa.

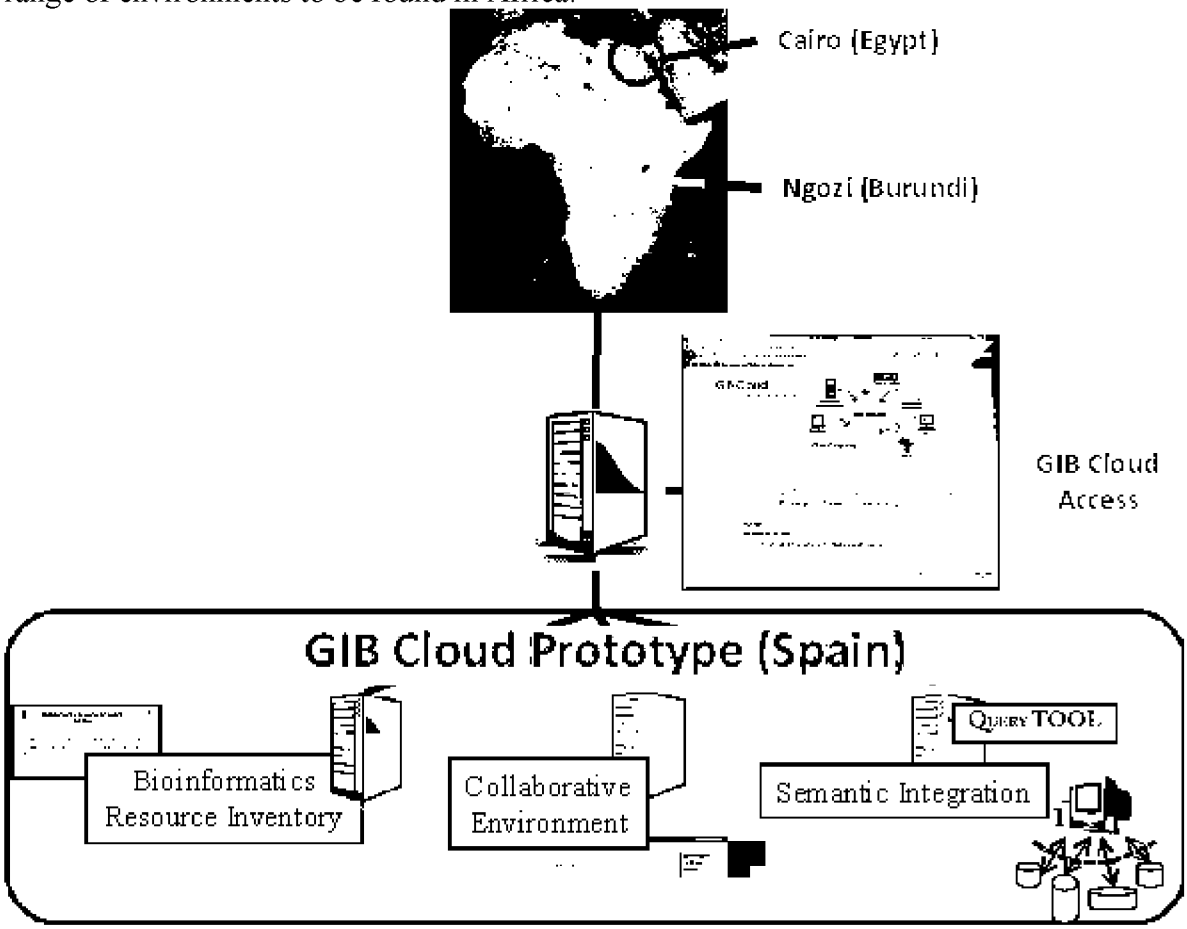

Figure 1 Architecture of the GIB Cloud Prototype accessed from Egypt and Burundi

3.1 Technology Description

The GIB Cloud Prototype has been developed using PHP and MySQL [15]. It integrates three existing resources developed by GIB.

In Egypt the experiment was carried out by experts in computer science and biomedical informatics. Their infrastructure included a network of advanced PCs and a state of the art local communication network with reasonably high-speed bandwidth. On the other hand, in Burundi, we taught "in-situ" local users how to carry out the experiments. For the first 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 (satellite connection costs around 500$/month). Instead of the satellite connection we used a mobile Internet connection with a maximum bandwidth of 306.8 Kb/s through an EDGE connection. The cost of this connection was cheaper (40$/month) than the satellite connection, but real bandwidth was almost the same.

4. Results

Table 1 presents the results of the three experiments carried out from Burundi and Egypt.

Experiment	Results	
	Egypt	**Burundi**
Accessing biomedical Open Source Software The BioInformatics Resource Inventory (BIRI) [16] is a public online searchable index of available bioinformatics resources. It was automatically built by extracting resources from the literature. The resources were indexed using natural language processing and text mining techniques. By using this inventory, users can locate and access over 400 informatics tools.	Multiple searches were performed through the BIRI. They obtained instantly the results from the tool.	Queries launched from the hospital of Ngozi had longer delay than in Egypt, due to the quality of the connection. Information about different resources was obtained and each query took an average of one minute.
Participation in a Web 2.0-based collaborative environment A collaborative environment [17] was deployed at the GIB using the open source tool "ProjectPier"[18]. This service constitutes a virtual space to share experiences and information between different users. We used this environment for the exchange of documents between members of the group and it can be also useful among physicians and researchers to exchange medical images and documents.	Users navigated easily through the system and used the environment to upload files (upload a 1 MB file to the collaborative environment took around 10 seconds).	In Burundi, we uploaded a file of 1MB using the USB mobile connection and the operation took around 2-3 minutes.
Biomedical database integration Researchers often need access to data located in different sources. Although these data are within the same domain, sometimes they present syntactic and semantic heterogeneity. To solve the problem of integrating heterogeneous databases, we have implemented an ontology-based tool [19].	The Egyptian group provided two anonymized medical databases with data of hepatitis patients. The databases were integrated and queried through the prototype. They spent an average of 15 seconds.	Burundian users could not provide databases for the experiment. However, they accessed the tool and launched several queries against the Egyptian databases, taking an average of 2-3 minutes for each query.

Table 1: Experiment results from the evaluation process carried out from Egypt and Burundi

In Egypt the connection was stable and the quality was acceptable during the experiments. In Burundi we suffered frequently cuts in the connection and the speed was quite low. Besides these technical differences, we collected diverse needs and opinions from users. In Cairo, the interest in applications for advanced biomedical services was greater than in Burundi, given its research-focused environment. Nevertheless, 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. Additionally, physicians at the Ngozi hospital (Figure 2) expressed their interest in a future application of learning, not only for physicians but also for hospital patients. They suggested courses for malaria prevention or basic care of babies for young mothers.

Figure 2 – One of the authors presenting the prototype to a local physician (Ngozi)

5. Future Developments

During the past years, the European partners of the AFRICA BUILD project have developed a wide range of advanced health-related information systems. Thus, we have planned to include some of the next biomedical informatics services in the AFRICA BUILD Portal, previously developed by the consortium:

- A vocabulary server, for managing biomedical ontologies and terminologies.
- Text mining tools to extract knowledge from publications.
- Open source e-learning tools for distance learning.
- A software tool for remote collaborative work.
- Peer to peer image exchange tool.
- Web services for image processing, data management and data mining.
- Gene-pdf, a system to convert contents of pdf files containing genetic information.
- A "mobility brokerage service", applied for mobility and training.
- A mapping tool, for semantic integration of terminologies and ontologies.
- An inventory of resources for storing and accessing remote software tools.

The infrastructure currently available in Burundi and Egypt are completely different, showing also some analogy with the variety of African technological environments. To export the use of the resources we will explore the needs of each institution to facilitate their access to resources of the AFRICA BUILD Portal. We will also make use of Web 2.0 and Web 3.0 technologies to create this Portal, to support collaborative research and work in the framework of AFRICA BUILD.

6. Conclusions

In this work we have examined the feasibility of using cloud computing technology in two different locations in Africa within the framework of the AFRICA BUILD project. Results of the experiments suggest that the approach of our project can be helpful to solve, or at least alleviate, some of the troubles detected. During our experiments we have identified two main barriers hampering healthcare education and research in Africa: first, the access to

technology, and second, the access to information. Currently, access to the Internet in Africa is very expensive [20], but connections are growing very fast [21]. It is expected that prices will go down as competition between Internet Service Providers increases. Regarding access to computers, cloud-computing technology allows designing advanced services for average clients. Therefore, technical characteristics of computers do not have to be particularly powerful. Nevertheless some advanced technological training is still necessary to get the most possible benefit from such kind of infrastructures. Regarding the information access, 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. The platform is envisioned as a contact centre for health professionals in Africa. Such a centre will facilitate the establishment of relations and collaborations to promote the South-South Cooperation.

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