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Cloud Computing for Development – Improving the Health Information System in Ghana

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Abstract: The health sector in many developing countries is undergoing restructuring to meet set goals, especially the health related Millennium Development Goals. To be able to monitor the performance of the health sector, an efficient Health Information System (HIS) is essential. This paper describes the process of implementing an online data warehouse based on the open source District Health Information Software 2 (DHIS2) in Ghana, integrating existing vertical reporting systems run by various health programmes. We discuss how an online deployment has solved many of the challenges facing the previous HIS in Ghana, and how it is an example of how cloud computing can be leverage to great effect in developing countries.

Keywords: health information systems, integration, data warehouse, cloud computing, Ghana

1. Introduction

In recent years the demand for health information in developing countries has increased, to enable better supervision of healthcare provision to meet the Millennium Development Goals (MDGs). The Ghana Health Service (GHS) is currently undergoing restructuring to enable it meet its obligations of delivering quality and equitable healthcare to the population. To achieve this objective a viable and efficient Health Information System (HIS) has been identified as key. In this paper we describe how cloud computing has facilitated the implementation of an integrated Health Information System (HIS) in Ghana.

The previous HIS in Ghana suffered from a number of different problems, both operational and in terms of the software being used. In consultation with its partners the GHS therefore decided in late 2010 to adopt and implement on online data warehouse using the District Health Information Software version 2 (DHIS2). DHIS2 is Free and Open Source Software (FOSS) based on web-technologies that supports collection, aggregation, analysis and presentation of health information. The DHIS2 is an initiative of the Health Information Systems Programme (HISP) to support developing countries in their quest to having a decentralized HIS for healthcare delivery, and it has been successfully implemented in a number of countries in Africa, Asia and South America. HISP is a collaborative network of universities, health institutions and individuals, with nodes in Asia, Africa and Europe.

After presenting our methodology, a background on HIS, cloud computing and the previous Ghanaian HIS is given. We then describe the process of implementing DHIS2 in Ghana, focusing on involving stakeholders, customising the software, training of users, and hosting of the DHIS2 server. Finally, we discuss the key lessons learned from this process, focusing on the implications of implementing the system online.

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2. Methodology

The methodology adopted in this project is Participatory Action Research. By definition action research is a qualitative research method where the researcher is actively involved in solving a real-world problem by bringing about change in an organization, while at the same time contributing to development of knowledge and theory. The method produces highly relevant research results, because it is grounded in practical action, aimed at solving an immediate problem situation while carefully informing theory [1][2][3][4].

Action research has been criticised for being impartial, lacking discipline, context-bound in nature and so on. However, these challenges are not unique to action research. We argue that our participation has given us insights it would have been difficult to obtain through a passive role.

The authors are involved in the HISP project, and have been active in the DHIS2 implementation in Ghana. One of the authors is also an employee of the GHS and participated in all aspects of the implementation process. Thus these rich backgrounds provide a platform for the authors to get better insights and knowledge on issues that would not have been possible otherwise. Furthermore, in IS research technology artefacts are perceived as socio-technical and as such our involvement in this project enable us to collaborate with users across all the levels in the GHS. The findings in this paper are from practical analysis of our involvement in meetings, customization of the software to suite the Ghanaian context, capacity building across all levels of the GHS, and monitoring and evaluation of the DHIMS2 in the time after the rollout.

3. Background

3.1 Health Information Systems

Despite the importance of Health Information Systems, they have often been neglected in developing countries. Consequently, HIS often suffer from some typical problems including:

- Collection of irrelevant data
- Poor data quality
- Poor timeliness of reporting
- Parallel and duplicate data collection
- Low information usage and poor feedback [5].

These issues are in many ways interrelated, and a common source of these problems is the donor-driven reporting systems that have taken root in many developing countries. These parallel systems, run by different health programmes such as Malaria, HIV/AIDS or Family Health, typically emerge as a result of pressure from donors that require more data on programme activities than the national reporting systems are capable of providing [6]. Because the health programmes are well funded, they have the resources to set up their own reporting systems, rather than trying to improve the national system. The result is parallel reporting system collecting overlapping data. As data from the national system is used less and less, the motivation to ensure good data quality decreases [7]. This creates a vicious cycle, as poor quality further reduces the use of the data.

Another factor contributing to poor data quality is the fact that much of the data being collected often have little relevance to the staff collecting it. They therefore have little motivation to ensure good quality [8]. Health staff also struggle with overburdening reporting requirements, where data collection often takes several days every month. Again, the duplications in the data being collected caused by parallel systems contribute to this.

Even in those cases where timely quality information is available, it is often not used to support decision-making [9]. There are many reasons for this, but in general, there is a lack

of culture for evidence-based decision-making in many developing countries. Consequently, decision-making is often influenced by political or personal motives rather than hard evidence.

3.2 A Data Warehouse Approach to HIS Integration

In 2008, the Health Metrics Network (HMN) presented a framework for integrating Health Information Systems through a data warehouse approach [6]. The idea behind this framework is to gather all data relevant for decision makers within the health domain in one data warehouse. By making data from different programme areas available in one location, stakeholders do not have to collect overlapping data. Furthermore, a central data repository where all existing data collection tools can be integrated allows the integration process to begin without stakeholders being forced to give up their parallel systems [10].

Braa and Sahay [7] suggest a three-step approach to developing an integrated HIS, built around a central data repository. The first step is to develop political consensus for the integration process, something that is also stressed in the HMN framework. The second step is to develop standards for data and indicators to allow sharing of information. Finally, data should be integrated at the technical level - tightly, by storing all data in one data repository, or loosely, by making data from sub systems available in a common portal. Braa and Sahay [7] further argue that a good data warehouse software can facilitate the integration process, and that the Internet should be leveraged wherever possible.

3.3 Cloud Computing for HIS

While many of the ideas and technologies behind cloud computing go back many years, the term cloud computing itself emerged around 2007. A widely used definition of cloud computing is that of the National Institute of Standards and Technology (NIST):

> *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.*

[11 p. 2].

We argue that cloud computing can be seen from two perspective. One is that of the service users, who get "ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources" – in this case DHIS2. Another perspective is that of the service provider, whether a public company or a self-hosting organization, responsible for making these resources available. How the service provider makes the computing resource available is of little relevance for the *user* as long as it is available.

3.4 HIS in Ghana

While HIS policies in Ghana encourage local use of data in facilities and districts, the information flow has gradually been centralised. Data collected at the periphery passes through the levels to national for collation, compilation and analysis, but little feedback is given back to the periphery. This has contributed to an inefficient, irrelevant and redundant HIS.

The health sector saw major expansions and restructuring in the late 1990s and early 2000s leading to increased amounts of data being collected from service delivery points in the health facilities. As part of the restructuring exercise there was the need to also strengthen the HIS to generate the required information for decision taking in the health sector.

As part of this strengthening, development of a HIS software began with support from the European Union. After a long pilot period, the District Health Information Management System (DHIMS) was implemented nation-wide in 2007, and was in operation through 2011. During this period it did not see any meaningful maintenance and upgrading to meet changing demands of the service and stakeholders. This lack of pace with developments in the sector has forced stakeholders such as the area-specific health programmes (e.g. malaria control or HIV/AIDS) to develop parallel reporting systems to enable them to meet data demands of their sponsors. The situation has resulted in a fragmented HIS, negatively affecting healthcare delivery.

It was against this background that GHS and its partners in 2010 made the decision to upgrade DHIMS to DHIMS2 by adopting DHIS2. DHIS2 was chosen for several reasons. First, the software is free and eliminates the issue of proprietary software and its challenges. Secondly, DHIS2 is designed to support a similar information flow as that in Ghana, with data collection and use at the facility and district levels. Thirdly, DHIS2 supports interoperability with other systems, an important factor to get buy-in from stakeholders. And finally, DHIS2 is ideal for a cloud-based deployment, where all users access one central data warehouse.

4. Deploying DHIS2 in Ghana

This section describes the process of deploying DHIS2 in Ghana, from the initial discussions to bring all stakeholders on board, through the customisation of the software, training of users and hosting of the system.

4.1 Stakeholder Involvement

One of the major factors that led to the DHIMS demise was lack of ownership with respect to the majority of users across all levels of the GHS. A two days stakeholders meeting was therefore held in 2011 where all managers and donors were present. The purpose of the meeting was to build consensus on data standards for input into the new system. Typically the debates that ensued were hard and lengthy especially on the amount of data to be captured by each data set (form). As a compromise the flexible standard approach was adopted [10], that is, all divisions and programmes will have their respective data sets represented in the system as they were, but subject to review when the system is evaluated. Finally there was general consensus that with the DHIMS2 there should be democratization of data throughout the health sector, meaning data should be available at all times for use and data 'silos' should be a thing of the past.

4.2 Customization of the Software

Following the stakeholders meeting a technical team was constituted within GHS made up of staff from Centre for Health Information Management (CHIM) with a mandate of customizing DHIS2 to suit the Ghanaian context. This started in earnest in the first half of 2011, and was done by the staff at CHIM, with support from one of the authors who was then a Master's Student at the University of Oslo.

A general challenge during the customisation phase was poor cooperation and communication between the system implementers and other stakeholders. While all stakeholders were officially committed to the DHIMS2 project, the attitude of several of these was less than enthusiastic. Getting hold of the latest versions of datasets and getting clarifications on issues that came up during the customisation thus became a problem.

In addition to the routine data for which DHIS2 is typically used, GHS required support for anonymous case-based data. This had been supported in DHIMS, and it was therefore

important that DHIMS2 supported it to avoid having to use the two systems in parallel. A case-based module was built in DHIS2, based on a "Tracker" module designed for tracking patients through health programmes. While the basic functionality was in place for the rollout, it had not been optimised for environments with poor network connectivity. This feature was therefore among the major problems from the rollout until a software update was released a few months later.

4.3 Training of End-Users

Several rounds of DHIMS2 trainings where held for end-users at different levels. First, five participants (including hospital staff) from each district participated in trainings in each region. In all, an estimated 850-900 district users were given two and a half days of training, starting in September 2011 and continuing until March 2012. The same week as the system was officially launched in April, an administrators training was held for the appointed district administrators. This was meant as refresher training, with focus on the administrative functions of the system. It was also used as an opportunity to get all districts started on the system from day one. After the rollout, additional trainings were held for district and regional directors and managers, as well as for managers at the national level.

An important additional purpose of the trainings was to get feedback from the end-users on the system. No pilot phase was planned, and the trainings were therefore the only opportunity for a large scale testing. Many issues were identified and resolved this way, leading to important improvements in the system.

4.4 Setting up an Online System

From the beginning, GHS decided that DHIMS2 should be deployed as an online system. This approach was pioneered in Kenya, where DHIS2 was implemented on a central server in 2011 [13]. While DHIS2 is based on web technology, all implementations of the system in Africa before 2011 were based on offline/standalone installations at each location the system was used. In Kenya, the implementation team found that the mobile network coverage was good enough even in rural areas for users to get online using mobile modems. An assessment in Ghana indicated that a similar online approach would be possible.

During the customisation of DHIMS2, the system was hosted on a server rented by the HISP group at the University of Oslo from a private London-based company. This allowed the team of implementers in Ghana to quickly get started on the customisation, and at the same time it meant that getting support from the HISP team abroad was easy.

GHS wanted to move the system to a server within Ghana before it was rolled out. A donor had provided a server to be used, however, the government did not have a location with the required infrastructure to host it. It was therefore decided to locate this server with a private hosting company in Accra.

At the time of rollout, there was no capacity within GHS to configure and maintain the sever, and a member of the HISP network therefore did the initial setup. He has continued to perform the regular maintenance up till this date. GHS wants to develop capacity to take over this role, and has requested training on server maintenance from HISP in early 2013.

An important aspect of hosting is backup and plans for disaster recovery and hardware failure. Off-site backups are currently handled by the HISP group at the University of Oslo, although GHS is in the process of setting up a local solution to this. Plans for disaster recovery and hardware failure situations are not yet ready.

5. Discussion

Customisation of DHIMS2 started in early 2011, and it took only about a year for the system to be rolled out nationally. The use of a central national server, accessible for users over the Internet, has been essential in making this possible. Comparing the current system to the previous, many of the major improvements are direct results of the system being online. Figure 1 illustrates the information flow using DHIMS and DHIMS2. In this section, we discuss the consequences of using an online system, as well as looking at the lessons learned in the key areas of garnering support for integration and capacity building.

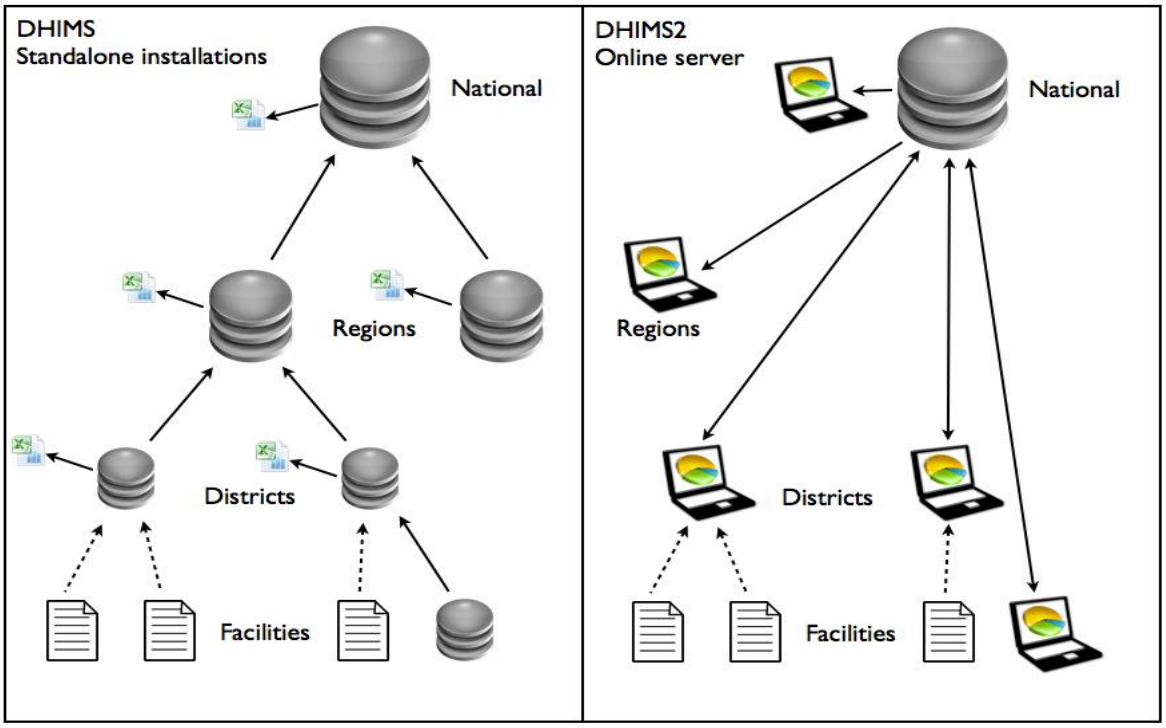

Figure 1. Comparison of data flow under DHIMS and DHIMS2

5.1 Centralisation of Technical Complexity

Using a central server substantially reduces the need to provide technical support to end-users, since any computer with a web browser and Internet access can be used. If a computer fails, another can be used without requiring any installation. With the previous system, software and databases were installed on computers in all regional and district offices, and government hospital, adding up to several hundred installations that needed to be maintained. Computer failure meant that the system needed to be reinstalled, and could lead to data loss unless a proper backup system was in place locally.

One of the most complex technical tasks performed in districts and regions was the merging or compilation of databases. Over time, minor metadata differences developed between the different databases, making the merging process difficult or impossible. With DHIMS2, merging of databases is not longer needed. And because data is no longer transferred via email of physical media, the risk of computers being infected by virus and potentially loosing data is reduced.

While using the system has been simplified in the periphery, a more complex central server must now be maintained. Competency in server maintenance is required to administer the system at the central level, something that has proven to be a challenge. This complexity is increased by the decision of GHS to use a physical server rather than renting

server capacity from a public cloud service provider. For example, GHS needs to develop procedures of what to do in the event of hardware failure, something that is avoided when using a public provider. Complexity has been moved from the end users in the periphery to the server at the central level, which is a typical property of cloud computing [14].

5.2 Improved Flow of Data and Access to Information

A major problem with the previous DHIMS was poor timeliness, resulting from data passing through several levels and databases being merged in districts and regions. This merging process often caused delays: regions would either have to wait for the last district to send their database before they could compile a regional database, or send incomplete data to the national level. Similarly, the national database was not ready until the last region had reported. With DHIMS2, all data goes immediately into one database. This does not guarantee that no data is delayed, but it means that data is available for all users once it has been entered in the system.

DHIMS2 also improves access to information. Previously, each region or district only had one or two users that knew the software and had access to the system. Only Health Information Officers where trained in use of the software, they typically had the database on their computer, and they where often reluctant to share date. Furthermore, DHIMS had limited support for report generation and analysis.

With DHIMS2, this situation has been improved in three important ways. Firstly, any user registered on the system can log in on any computer with internet access and get the information needed. Secondly, more people have been trained to use the system. Thirdly, DHIMS2 has a wide range of easy-to-use reporting tools. Data access is key for a HIS.

5.3 User Participation

An important property of the online system is that any update to the software or in the database made at the central level are immediately available to all users. This was especially important during the implementation phase and the first time after the rollout, when changes to the system were made more or less continuously. DHIMS2 has a built in messaging functionality, which lets end-users send feedback directly to the implementers and system administrators. This feature has been useful in Ghana, both as way for users to get help, but also for reporting errors and suggesting improvements. Braa and Sahay [15] dub this type of collaboration between implementers and end-users "cloud based participatory design", arguing that even though the end users are further removed from the system when it is hosted online (in the cloud), they are at the same time more closely linked to the implementers and software developers.

5.4 Infrastructure Requirements

While online implementation comes with many advantages over standalone installations, there are also challenges. The most obvious is of course that users must have at least some Internet connectivity to be able to use the system. A large proportion of the DHIMS2 users connect to the Internet using mobile Internet modems, as fixed Internet is not widely available, especially in rural areas. A recent assessment concluded that while there are areas in Ghana where users struggle to get connectivity, it has not been a major issue.

An important reason that Internet has not been a major problem is improvements made to DHIS2 during the online implementation in Kenya to make it more resilient to network fluctuations and use with limited bandwidth. For example, it is possible to enter routine data offline, and upload it when a connection is available. The case-based module developed especially for Ghana had not been through the same optimisation as other parts of the

system. While it worked well when Internet was good, it did not work where Internet was slow or unstable. This shows the importance of adopting the software to the context of use.

5.5 The Integration Process

The process to develop a HIS in Ghana over these several years may be seen as a long march towards integration. Braa and Sahay [7] argue that good quality data warehouse software is a critical element for an integration process to succeed. DHIMS is in many ways a good example of what can happen when this advice is not followed. The many flaws in the DHIMS software was an important reason that the initial integration effort failed, and stakeholders reverted to setting up parallel reporting systems. With the adoption DHIS2, which is a FOSS, the GHS now has reliable and resilient software capable of catering for the changing demands of the health domain and will not have to worry about cost in terms of software maintenance and upgrade.

The stakeholders meetings have been instrumental in legitimizing the software. This was evident in vertical programmes allowing their data 'silos' to be integrated and development partners funding the training schedule to roll out the application. Health programmes (notably nutrition and health promotion) took the opportunity to develop reporting forms for inclusion in the new system thus making the DHIMS2 data warehouse more representative of the spectrum of service delivery of the GHS.

At the same time, the customisation phase demonstrated that while all stakeholders were formally on board in the integration process, they were not very committed in practice. The implementation team struggled to get hold of the right datasets to add to the system, and communication with several of the stakeholders was poor. Several health programmes also made it clear early on that while they were part of the new integrated system, they would not immediately stop using their parallel system. In recent months, after the system has been running successfully for some time, several programmes and donors are again showing increased interest in DHIMS2.

5.6 Capacity Building

Other key lessons learnt is the close collaboration with external actors such as HISP, which developed the DHMIS2 application and provided technical assistance during the customization and implementation, without which it would have been difficult to come this far. This collaboration needs to be strengthened and maintained especially in the area of training and capacity building to keep the system operational in terms of future demands in an ever-changing health domain.

For sustainability it is also important to create an active group of super-users with representatives from all partners to work closely with the DHIMS2 administrators at CHIM. This group will present and address all new requirements from the partners or stakeholders to ensure that their interests are articulated. The capacity of the technical team at CHIM needs to be developed, and be strong enough to ensure that the system is properly maintained, data is well managed and new requirements are continuously incorporated in the system. The CHIM team also needs to collaborate closely with the global DHIS2 team and make sure DHIMS2 is continuously updated with new versions and new features.

This collaboration is on-going with recent server training organized by HISP for the core DHIMS2 technical team in Accra in January 2013, and a HISP team visiting two regions to sample views from users to further enhance the system.

6. Conclusions

The DHIMS2 became fully operational from April 2012 and is still being monitored to assess its performance. So far no major problem has been encountered that could impede its functionality as a data warehouse. Thus in a very short period of time, Ghana has gone from having an inefficient and poorly functioning HIS supported by a limited number of stakeholders, to successfully implement an improved system that enjoys wide support. Using a central server available over the Internet – cloud computing - has been central in achieving this. Not only did this solve many of the problems plaguing the previous HIS in Ghana, it also made the rapid deployment and scaling of the system possible.

Another key factor during this implementation has been to learn from previous mistakes. Using FOSS has saved cost, and a software platform capable of withstanding the changing dynamics of the health domain has been chosen. Important stakeholders like TB, HIV/AIDS, Malaria and major donors have come on board. Through theses alliances and support by the HISP team, capacity building in all categories of staff has been possible.

Finally the most significant contributions of DHIMS2 are data transparency and quality of service data as demonstrated in recent 2012 district and regional reviews. Completeness for the majority of the data is high, and DHIMS2 is the source of data used for the performance reviews and in the planning.

Despite these achievements, areas like information use and technical skills in maintaining the system need further strengthening. Building a culture of information use require frequent monitoring and improved feedback to lower levels. To build technical maintenance capacity, continued cooperation between GHS and HISP is essential.

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