Journal of Health Informatics in Africa

8th Health Informatics in Africa Conference (HELINA 2013)
Peer-reviewed and selected under the responsibility of the Scientific Programme Committee

Cloud Computing for Health Information in Africa? Comparing the Case of Ghana to Kenya

Olav Poppe [a,*], Bob Jolliffe [a], Denis Leonard Adaletey [a,b], Jørn Braa [a], Ayub Manya[a,c]

[a] University of Oslo, Oslo, Norway
[b] Ghana Health Service, Accra, Ghana
[c] Ministry of Health, Kenya

Background and Purpose: A number of African countries have in recent years deployed online, web-based health information systems (HIS). We look at the opportunities and challenges of this new architecture by comparing recent HIS implementations in Ghana and Kenya.
Methods: This paper is based on several years of involvement by the authors in a large action research project (the Health Information Systems Programme) that focuses on developing and implementing health information systems. The project has a strong focus on active participation of the researchers in the research context, drawing on the Scandinavian tradition of participatory action research. All authors have been directly involved in the HIS implementations in Ghana and/or Kenya discussed in this paper.
Results: We show how the two countries studied in this paper, Ghana and Kenya, have rapidly transitioned from having an offline, decentralised HIS based on standalone software installations, to a new architecture that is online, web-based and centralised.
Conclusions: The cases of Ghana and Kenya demonstrate how a web-based, online architecture for HIS provides a number of advantages over the standalone, offline systems that have been the norm until recently. However, important aspects of such implementations, like developing skills and policies for system administration and ensuring system ownership need emphasis in order to ensure the long-term sustainability of these systems.

Keywords: Health Information Systems, Online Systems, Cloud Computing, Ghana, Kenya, Africa

1 Introduction

Ghana and Kenya are among a number of African countries that have driven an ambitious evolution of health information systems (HIS) from district-based standalone applications to national level web-based architectures. The difficulties of maintaining a decentralised HIS with hundreds of databases installed in district offices have become apparent, and several countries have therefore adopted an online, web-based HIS architecture in the last few years.

Establishing and sustaining an online HIS on a national scale requires a considerable mobilization of productive forces including network connectivity, data centre infrastructure and high-level skills. The resulting concentration of national data and functionality into a single system also raises questions of political significance about the physical location (particularly outside of the country), ownership and control of such infrastructure.

The objective of this paper is to examine the consequences of moving from an offline HIS to one based on an online, web-based architecture. We focus on the implications for end-users and system administrators, for management and hosting of the centralised HIS server, and for integration. What are the advantages and disadvantages of this new paradigm?

*Corresponding author: University of Oslo, Postboks 1080 Blindern, 0316 Oslo, Norway. Email: olav.poppe@me.com Tel: +47-22852408
HELINA 2013 M. Korpela et al. (Eds.)
 DOI: 10.12856/JHIA-2013-v1-i1-45

The empirical setting that we use to place the issues in relief is the implementation of a national health information system by the Ghana Health Service with technical support from the University of Oslo. Each of the authors have been extensively involved at the various stages of the implementation of this system, from its inception and design in 2010 through to the live nationwide rollout in 2012 and subsequent settling into the maintenance and evolution cycle of the production system. We also draw on similar experiences from the implementation of a national HIS in Kenya. We believe that by reviewing and assessing the difficulties we have encountered to get a web-based system functional and active, we can expose crucial factors for the success of similar efforts elsewhere in Africa.

The paper is organized as follows. In the background section, we present a brief historical review of the implementation of health information systems in Africa through the Health Information Systems Programme (HISP) project. In doing so, we highlight particularly the significance of the move from standalone district-based systems to a centralized web-based architecture. We describe the current situation regarding ICT infrastructure in Africa, before presenting relevant literature on outsourcing and cloud computing. The proceeding section outlines our methodology, before we present our main cases of Ghana and Kenya in the results section. In the final section, we discuss our findings.

2 Background

2.1 HISP and Health Information Systems

The Health Information Systems Programme (HISP) is a loose collaborative network of research institutions, government and non-government organizations and individuals. From its origins in post-apartheid South Africa in the late 1990s, HISP has grown to a global network with nodes in Africa, South Asia, Latin America and Europe. The core initiative within HISP is the development of the District Health Information Software (DHIS2). DHIS2 is Free and Open Source Software (FOSS) based on web technologies that support collection, aggregation, analysis and presentation of health information. The development of DHIS2 is coordinated from the University of Oslo, Norway [1].

The goal for HISP is to improve healthcare delivery through better Health Information Systems (HIS). Having reliable and relevant information is important to allow managers in the health sector to make evidence-based decisions. The health sectors in many low and middle income countries have seen developments in the past three decades, especially with the advent of Millennium Development Goals (MDGs), which have increased the need for a strong HIS to support decision-making at different levels [2].

Despite their importance in the management of the health sector, HIS are often dysfunctional. The data being collected is of poor quality, data transmission is often delayed, and more data is collected than is needed for decision-making [2][3]. For health workers, the data collected is often of little relevance and they have little motivation to ensure it is of good quality [4]. Furthermore, use of information in decision-making has not been institutionalized in many countries [5]. Because the national HIS cannot reliably provide them with the necessary information, area-specific health programmes such as Disease Control, Family health, Malaria or HIV/AIDS often set up parallel vertical reporting systems [2]. As these parallel information systems emerge, the national HIS gradually becomes less relevant.

The computer systems that have been built to support HIS in Africa have typically been Microsoft Windows applications that were designed to function autonomously on desktop computers at the various administrative levels of the system. Maintaining integrity and compatibility of the data between the periphery and the centre has proved difficult, for example in Rwanda, Kenya, Liberia, The Gambia and Ghana. Furthermore, lack of availability of the software source code to the various ministries of health meant that as donor support for systems development gradually dried up it was not always possible to modify the software to respond to evolving information needs of the health programs. In each of these countries there was thus a strong motivation to (i) look at FOSS to avoid repeating the problem of dead-end systems and (ii) to embrace the centralizing logic of a national web-based system.

As we describe below, it is only in the last very few years that network connectivity within and between countries has developed sufficiently to support such architecture.

 DOI: 10.12856/JHIA-2013-v1-i1-45

2.2 Improved African ICT infrastructure

The expansion of network infrastructure within many African countries, driven largely by the expansion of coverage by mobile operators, has made national web-based systems increasingly viable (**Fig. 1**). The health management information systems deployed in for example Ghana and Kenya rely on health facility staff and district managers interacting with the system using nothing more than a web browser, with Internet connectivity mostly provided by the mobile networks.

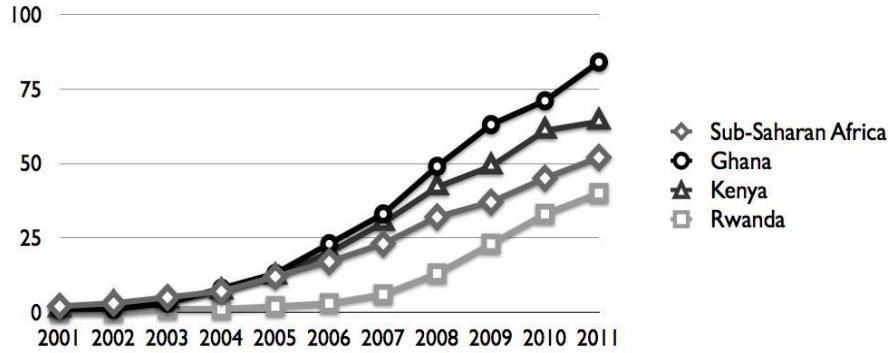

Fig. 1. Mobile subscribers per 100 people [6].

Improved connectivity within and between countries (see **Fig. 2**) makes possible the physical location of servers outside of the Ministries of Health, co-located within private data centres, within purpose-built national data centres, or making use of commercially hosted services offered by global providers. At the same time, this creates challenges with regards to legislation and policy and governance frameworks that are there to guide the procurement, maintenance and use of IT systems. Where such frameworks exist they typically have not foreseen the difficulties and opportunities raised, for example, by the availability of trans-national "cloud" services.

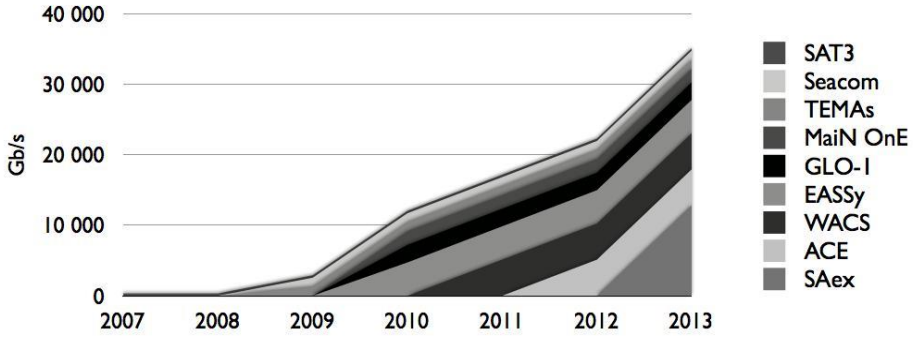

Fig. 2. Total bandwidth of communication cables to the African continent, showing how the African continent is rapidly becoming more connected to the rest of the world [7].

2.3 Outsourcing and Cloud Computing

Enabled by the improved ICT infrastructure discussed above, use of outsourcing and cloud computing is increasingly becoming a viable option in countries such as Ghana and Kenya. Avgerou has commented that whereas outsourcing has been extensively researched in IS (e.g. [8]), the literature is more sparse with respect to developing country clients of outsourcing arrangements [9]. In one such study, Silva describes an outsourcing arrangement where the client is the Guatemalan ministry of health, and he shows how a range of improvisations was made possible by the outsourcing arrangement [10].

 DOI: 10.12856/JHIA-2013-v1-i1-45

Putting a precise definition on “cloud” computing is difficult as might be expected of any new technology trend. Though there are a number of characteristics, which underlie most current uses of the term:

- Almost immediate access to large scale IT resources available over the public internet (usually, but not always, for a fee).
- Low cost of entry
- The possibility of “elastic” scaling of resources to meet demand

These characteristics have led a number of commentators to speculate that the cloud represents a unique opportunity for developing countries to leapfrog from a position characterized as “left behind” in the IT revolution - making available IT services which would not previously have been available [11][12]. Cloud computing can also be understood as just a current manifestation of the old outsourcing phenomenon [13]. And just as evaluation of the shared risks and rewards has been a central concern of the IT outsourcing literature from the outset [14], particularly risks associated with loss of control, these themes also dominate concerns relating to cloud computing [15]-[17].

3 Materials and methods

This paper is based on the continued involvement of the authors over several years in the HISP project in general, and in the implementation of DHIS2 in Ghana and Kenya in particular. From its inception, research within the HISP network has had a strong focus on active participation of the researchers in the research context, drawing on the Scandinavian tradition of participatory action research [18]. Action research is based on the premise that new knowledge can be generated by the researcher actively engaging to improve real-world situations, following a cycle of diagnosing problems, designing and implementing interventions and evaluating the outcome with the aim of developing new knowledge [19].

Building on this participatory action research tradition, the "Networks of Action" concept was developed by Braa et al. to describe the action research process within HISP [20]. The "Networks of Action" approach emphasizes the importance of sharing of knowledge across research sites in order to ensure sustainability of the research projects over time. Through our active involvement in the HIS implementations discussed here, the authors have gathered a large amount of primary data. Through our engagements with actors at various levels of the health system, we have discussed with, interviewed and observed a number of different stakeholders over time. In addition, we have as part of the larger HISP network a number of formal and informal data sources beyond our direct engagements in Ghana and Kenya.

4 Results

4.1 The case of Ghana

Ghana Health Service (GHS) is the implementing agency of the Ministry of Health (MOH) in Ghana, and is responsible for over 4000 health facilities spread across 220 health administrative districts. GHS has a history of computer-based HIS for routine data collection dating back to the early 2000s, when the development of a proprietary Microsoft Access-based HIS software began with financial assistance from the European Union (EU). The system was scaled up nationwide in 2008, but GHS soon faced many of the typical problems of running a proprietary, decentralized HIS system, as discussed in section 2.1 above: funding for further development and maintenance of the software was not available; maintaining and synchronising hundreds of standalone installations across the country proved difficult; and the area-specific programmes became dissatisfied with the situation and set up parallel vertical reporting systems. As a result of these challenges, GHS decided to adopt the open-source and web-based DHIS2 in 2010, which was seen as addressing many of the shortcomings of the previous system while still supporting the same district-centred information flow.

The processes of setting up DHIS2 and building local capacity on the system within GHS began in 2010, and are on-going even after the rollout in April 2012. These efforts were complemented both onsite and offsite by HISP and the University of Oslo. To ensure that the system was incorporated into the

 DOI: 10.12856/JHIA-2013-v1-i1-45

workflow in the districts, five persons from each of the then 170 districts across the country were trained, in addition to users at the regional and national level.

Experience from managing the previous system as a stand-alone system informed the deployment of DHIS2 as an online system. The internet infrastructure, primarily through the mobile networks, was seen as adequate to support a web-based system, and the first experiences from Kenya, where the system was being rolled out online at that time, were encouraging.

During the customization of DHIS2, the system was hosted on a virtual server procured by the HISP group at the University of Oslo. This made it possible to start the customization of the system immediately with technical support from the HISP team abroad. However, GHS wanted its server and data to be physically located in Ghana. They already had a physical server that had been procured for this project and physical location in Ghana was seen as a requirement stemming from public service information system policy. Consequently the server was hosted within a private data centre in Accra, and the system migrated there before the rollout.

Management of HIS with such complexities as DHIS2 poses a number challenges. At the time of national rollout the local team had developed the skills required to do most of the maintenance of the application. However, maintaining the server still required assistance from the HISP team at the University of Oslo. To address this human resource gap, several trainings have been held by the global HISP team for the local server managers. On the technical side, server tools have been developed to facilitate the management of DHIS2 on the server.

4.2 The case of Kenya

The implementation of an online system in Ghana was taking cues from a similar process going on in Kenya at the time Ghana was starting. In October 2010 the Ministry of Heath in Kenya started a project to customise the DHIS2 so that it could replace the Excel based system that they were using, which consisted of monthly transfer of Excel files from districts to the central level using FTP [21]. DHIS2 was implemented on a server rented by an international hosting company, Linode in London.

Testing of the system in late 2010 using modems on the mobile network to access the internet made it clear that an online ‘cloud’ based solution would be possible. The new sea cables had reached Mombasa and fibre cables were being laid out all over the country and the mobile network providers were already providing 3G to many parts of the country. During 2011, after a pilot phase in the Coast province, the system was rolled out to the entire country. This was the first fully online and web-based HIS deployment in Africa, something that was enabling the rapid rollout. While before, the term rollout of systems in Africa meant physically installing the software and ensuring technical support in hundreds of locations, now, in the case of Kenya, it meant training health workers to use the online system. On site technical support also became less critical than before, as any laptop or PC could be used to access the system.

The project in Kenya started by implementing the same reporting forms that were used by the previous system. Similar to the situation in many countries, however, there were many parallel reporting systems run by different health programs. The implementation of DHIS2 on a central server became an enabler for integration, as everybody could access and use the same system. The various health programs saw the benefit of being able to compare and use data across different health services and programs while at the same time reducing the burden of overlapping reporting for health workers.

Politically it was never really accepted to use an international cloud hosting service, as the government policy was to store data in-country. Consequently, the DHIS2 was moved to Safaricom, an in-country mobile network provider and hosting company. Their services are currently not of the same quality, however, as they are not able to provide the same capacity and response time as was available with the international hosting company. The longer term plan is to move to a new server in the MOH.

5 Discussion

The experiences from Ghana and Kenya demonstrate both the opportunities and challenges of a centralised, online deployment. **Table 1** summarizes advantages and disadvantages of an online HIS architecture.

 DOI: 10.12856/JHIA-2013-v1-i1-45

Table 1. Advantages and disadvantages of an online HIS architecture.

Aspect	Advantages	Disadvantages
End-users	• Improved information access, transparency and sharing. • No responsibility for system maintenance. • Continuous system improvements through software updates. • Supports an unlimited number of users at limited additional cost.	• Reduced control of data submission to higher levels. • No direct, low-level access to the data or database. • System can be changed (updated) without warning or training.
System administration	• Only one instance of the system needed to support the whole country. • Getting support from outside is easy, by giving access to the server.	• Requires highly specialised skills that might not be available in the implementing organisation or even in the country. • Can create reliance on outside support for long term maintenance.
Server hosting	• Flexibility in choice of hosting – room for improvisation. • All changes to the server hosting is transparent for end-users.	• Poor hosting environment can bring down the whole system – single point of failure. • Lack of policies and guidelines for secure hosting in many countries.
Integration	• A centralised database makes integration possible. • The potential for integration becomes apparent by showing data duplications.	• Integrating with existing software systems has proved difficult in practice.
System ownership	• Allows system owners to manage risks related to data loss, integrity etc. more verifiably/robustly/scalable than when the systems are dispersed throughout 100's of districts/computers	• Complexities relating to hosting large scale systems have resulted in increased dependency on external agencies such as service providers and development partners for infrastructural and technical support. Dependency = risk. New policy and procurement guidelines required managing new forms of risk.

5.1 End Users

The central concern of the DHIS2 artefact is to empower information users, the health managers in the districts in particular. A centralised web-based system implies some of shift of control from the district users to the national system administrators, for example of when data is revealed to the higher levels, access to the database, or updates to the software platform. However, while losing some control, end-users also enjoy many benefits. The central deployments of DHIS2 in Ghana, Kenya and other countries show that it is possible to satisfy the information requirements of the district health managers without

 DOI: 10.12856/JHIA-2013-v1-i1-45

having the software installed locally in the district offices, so that users no longer need to support and maintain their own system software and hardware.

With an online system, data is transparent and ownership shared among a larger group of users, potentially leading to increased use of information. In Ghana, there can now be 2000 unique users over a 30-day period, while the previous system was only installed on much smaller number of computers (likely in the low hundreds). Furthermore, those responsible for the standalone databases had a strong sense of ownership of the data, and were often reluctant to share it with colleagues. This is no longer a problem in a centralised system.

5.2 System administration

While the issue of how to host the server typically receives much attention among the agencies implementing DHIS2, less attention is given to how to manage the system running on the server. DHIS2 deployments are in most cases running on Linux servers, and DHIS2 requires a stack of software to be installed, configured and maintained. The freedom from having to maintain hundreds of standalone installations comes at the expense of the more complex, but centralized, task of maintaining a server infrastructure. While the requisite skills might be found within the ICT departments of the implementing organizations, they are harder to find in the data use departments that have been pushing the implementations in Ghana and Kenya.

Having a single, central national web-based system makes it easy to take advantage of external technical support and expertise. This possibility has been made use of both in Ghana and Kenya. In a sense, both countries can be seen as, for now, having outsourced the administration of the server to HISP, through the continuous technical assistance that has been provided. Relying on external support for a limited time is not necessarily a problem. However, there is a risk that it creates a longer lasting reliance on outside support and is damaging for the sense of ownership of the system. While the infrastructure for an online system can be changed quite easily, technical assistance can create dependencies that are difficult to remove. It is therefore important that a framework is in place to manage the security and access to the system, so that even while technical assistance is provided from abroad, control remains with the system owners.

5.3 Server hosting

A benefit of the web-based paradigm is that there is flexibility in the potential physical location of the server. Servers can be physically co-located in any data centre that can provide the environmental conditions and connectivity. These include mobile phone operators; internet service providers; and purpose built national data centres. Many of these private data centres are now also now offering virtual server rental, obviating the need for the MOH to invest in server hardware at all. Whereas such virtual infrastructure services are increasingly becoming available in country, economies of scale dictate that they will not be available at the same price as services being offered by large global providers such as Linode or Amazon.

Decisions around the physical location of the service also need not be permanent. We have seen how in both Ghana and Kenya, the service can be migrated from one location and mode of procurement to another without disruption to existing users. Ghana used an international cloud service provider during the customisation phase, before migrating to production server hardware owned by the GHS and hosted in the data centre of a local company. Kenya used an international cloud provider for the first years after the rollout, before recently moving to an in-country cloud provider. The opportunity to outsource the hosting of the HIS to the cloud brings us to Silva's argument that outsourcing has the potential to make room for improvisation [11]. There are a range of factors to consider related to cost, convenience and control that can determine the most appropriate hosting solution.

Our cases also demonstrate the political aspects of the issue of server hosting. In both countries, international hosting would be cheaper and at least as reliable as in-country hosting, yet none of the countries have chosen that option currently. Ghana had as a policy that the system should be hosted in country. Using an international virtual server provider was thus just a temporary measure to quickly get started on the customisation of the system. In Kenya, the plan was initially to host the system in the Ministry of Health, but poor infrastructure made this impossible. An international virtual server provider

 DOI: 10.12856/JHIA-2013-v1-i1-45

was therefore used, and this solution worked well. However, it later became a policy here as well that the data should be hosted in country, and consequently the system was migrated, this time to a national virtual server provider that have struggled with the quality of the service.

In any of the above scenarios, concern for information systems security plays an important part in assessing the suitability of the server hosting. It is our experience that a complex, large-scale system like DHIS2, which is relied upon by many people throughout the country, should be supported by a security management plan, regardless of whether it is hosted internally or externally. The need for clear information security policy, particularly in the context of outsourcing contracts, has been made clear in the literature (e.g. [22]-[24]). The security management plan should be informed by existing public service regulation and legislation and address issues of access control, risk management, service level agreements, non-disclosure agreements, disaster recovery and business continuity.

5.4 Integration

Fragmentation of HIS is a problem often caused by vertical reporting systems set up by area-specific health programmes or divisions within the Ministries. An online HIS architecture has the potential to promote integration and rationalisation of these vertical systems. Conversely, without a centralised and accessible database, integration is very difficult.

In Ghana, integration of the vertical health programme was always seen as critical. Data collection tools from the vertical programmes were included in the system, even though this meant that some of the same data was collected multiple times. Over time the stakeholders' confidence in the system has increased, and the realisation that data from different sources are available for all users has triggered a process of rationalisation of data collection instruments to reduce duplication of data collection.

Interoperating with other software systems has proven more difficult. Integration of data from different systems requires harmonisation of metadata, for example a way of identifying health facilities and data elements across systems. Managing the HIS as a national web based repository of such metadata has opened many interoperability possibilities by raising visibility, though in practice the number of information systems data sources which are actually in active use and are sufficiently stable and institutionalised in Ghana and Kenya has been small compared to the number of failed or incomplete system implementations. Despite these challenges, several medical records systems in Kenya have now been integrated with the HIS, and routinely transmit data that was previously keyed in by hand.

6 Concluding remarks

The cases of Ghana and Kenya demonstrate how a web-based, online architecture for HIS provides a number of advantages and some disadvantages over the standalone, offline systems that have been the norm until recently. We have tried to outline the implications of this new paradigm on several levels: from end-users to administrators, in terms of server hosting, and for HIS integration.

While we would argue that this new architecture brings with it a number of advantages for HIS in Africa, and probably for other categories of information systems, more attention needs to be paid to developing skills and policies for system and server management in the implementing agencies. Addressing these issues is essential in order to ensure the long-term sustainability of the systems.

Acknowledgments

- Anthony Ofosu and the team in Ghana Health Services
- Charles Nzioka and team in the Ministry of Health, Kenya

References

[1] HISP [Internet]. University of Oslo. Cited September 9. 2013. Available from http://www.mn.uio.no/ifi/english/research/networks/hisp/.

[2] Health Metrics Network. Framework and Standards for Country Health Information Systems. Second Edition. Geneva: World Health Organization; 2008.

 DOI: 10.12856/JHIA-2013-v1-i1-45

[3] Lippeveld, Theo, and Rainer Sauerborn. A Framework for Designing Health Information Systems. In: Lippeveld, Theo, Sauerborn, Rainer, and Bodart, Claud, editors. Design and Implementation of Health Information Systems. Geneva: WHO; 2000.
[4] Chatora, R, and P Tumusiime. Health Sector Reform and District Health Systems. Brazaville: WHO; 2004.
[5] Simwanza, Alex, and Church, Mary. Establishment of an Information Culture: Achievements and Challenges in Zambia. RHINO Workshop on Issues and Innovation in Routine Health Information in Developing Countries. 2001: 227–237.
[6] World Databank [Internet]. World Bank. Cited March 4. 2013. Available from http://data.worldbank.org/indicator/IT.CEL.SETS.P2/countries/ZG-GH- KE?display=graph
[7] Fact about Africa [Internet]. AFRINIC. Cited March 4. 2013. Available from http://www.afrinic.net/images/doc/africa_by_numbers2.pdf
[8] Nicholson, B. and Sahay, S. Embedded Knowledge and Offshore Software Development. Information and Organization. 2004;(14):329–365
[9] Avgerou, C. Information systems in developing countries: a critical research review. Journal of Information Technology. 2008;23(3):133-146.
[10] Silva, L. O. Outsourcing as an improvisation: A case study in Latin America. The Information Society. 2002;18(2):129-38.
[11] Marston, S.; Li, Z.; Bandyopadhyay, S.; Zhang, J. and Ghalsasi, A. Cloud computing—The business perspective. Decision Support Systems. 2011;51(1):176--189.
[12] Greengard, S. Cloud computing and developing nations. Communications of the ACM. 2010;53(5):18--20.
[13] Bцhm, M., Leimeister, S., Riedl, C. & Krcmar, H. Cloud Computing – Outsourcing 2.0 or a new Business Model for IT Provisioning? Application management. 2011: 31-56.
[14] Kuk, G. & Davies, T. The Roles of Agency and Artifacts in Assembling Open Data Complementarities. ICIS. 2011.
[15] Chow, R., Golle, P., Jakobsson, M., Shi, E., Staddon, J., Masuoka, R. and Molina, J. Controlling data in the cloud: outsourcing computation without outsourcing control. Proceedings of the 2009 ACM workshop on Cloud computing security. 2009:85--90.
[16] Julisch, K. and Hall, M. Security and control in the cloud. Information Security Journal: A Global Perspective. 2010;19(6): 299—309.
[17] Uusitalo, I., Karppinen, K., Juhola, A. and Savola, R. Trust and Cloud Services - An Interview Study. 2nd IEEE International Conference on Cloud Computing Technology and Science. 2010: 712-720.
[18] Bødker, Sussane, and Yngve Sundblad. Usability and Interaction Design – New Challenges for the Scandinavian Tradition. Behaviour & Information Technology. 2004;27(4):293–300.
[19] Susman, Gerald I, and Evered, Roger. An Assessment of the Scientific Merits of Action Research. Administrative Science Quarterly. 1978;23(4):582–603.
[20] Braa, Jørn, Eric Monteiro, and Sundeep Sahay. Networks of Action: Sustainable Health Information Systems Across Developing Countries. Management Information Systems Quarterly. 2004;28(3):337–362.
[21] Manya, Ayub, Jørn Braa, Lars Helge Øverland, Ola Hodne Titlestad, Jeremiah Mumo, and Charles Nzioka. National Roll Out of District Health Information Software (DHIS 2) in Kenya, 2011 – Central Server and Cloud Based Infrastructure. IST-Africa 2012 Conference Proceedings. 2012.
[22] Lee, M. IT Outsourcing Contracts: Practical Issues for Management, Working Paper #95/05. Information Systems Department, City University of Hong Kong. 1995.
[23] Sherwood, J. Managing Security for Outsourcing Contracts, Computers & Security. 1997;(2): 603–609
[24] Khalfan, Abdulwahed Mo. Information security considerations in IS/IT outsourcing projects: a descriptive case study of two sectors. International Journal of Information Management. 2004;24(1):29-42

 DOI: 10.12856/JHIA-2013-v1-i1-45