Producing the Agora: Appropriation of Health Information Systems in Developing Countries

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Seasons come and seasons go

The vitality of spring

The rustling of autumn

The defiance of heroes

The sacrifice of martyrs

What is done is done

Everything is soon forgotten

But half

Is yet to be told

Hope

-The Elder-

Acknowledgements

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Abstract

With the proliferation of generic software solutions in the healthcare sectors of many developing nations, it is important to understand the processes through which such technologies are appropriated in order that they may meet their system strengthening goals. Generic software is a class of information system that can be used in diverse settings and is developed in such a way that it is customisable to meet local needs. Given that generic software projects in the healthcare sectors of developing nations are largely dependent on the inflow of donor resources, there is a concern that once these dry up the systems will fail. It becomes important to develop theoretical ideas that provide an account of this phenomenon and strategies through which such a problem can be confronted and the technology successfully and sustainably appropriated.

The aim of the study was to develop a relevant and fitting theoretical account on the appropriation of the generic District Health Information Software (DHIS 2) in the context of health ministries in Malawi and Zimbabwe. The theoretical questions that led the inquiry were (i) 'How can we understand and explain the processes implicated in the appropriation of generic open source health information systems in developing nations?' and (ii) 'How can the transformations sought when adopting these technologies be better realised?'. The study adopted a mixed method research approach, largely deriving influences from Grounded Theory methodology and the Case Study method. Data was collected through interviews, observation, emails, official documents and by participating as intermediary or consultant in the change initiatives. While some interviews were recorded, the predominant method of collecting data was the taking of field notes. Data was initially open coded for concepts, but the analysis soon evolved toward iterative engagement with emergent theoretical categories that could fit the phenomenon being studied.

Given the degree of spatial and temporal changes that generic information systems imply, their adoption can be considered as akin to a paradigm shift for ministries of health in developing nations. The global distribution of actors that are essential to appropriating these technologies creates a challenge for the adopting agencies. This is more so in the politicised context of health ministries where there is a need to contend with multiple perspectives and interests. This study develops a theoretical framework that may be useful in shaping the appropriation of generic health information systems in these contexts. The framework is

based on contemporary information systems research which has problematised the spaces which emerge with the adoption of generic software systems. Using these conceptions, we find that the adoption of DHIS 2 signals the emergence of a space similar to an agora. The agora was a central meeting place in ancient Athens and such a conception of information systems has prior to this study been applied to understand the development and use of generic software systems. To complement this perspective, this study borrows conceptions from Henri Lefebvre's theory on the 'production of space' which strengthen the argument for the study of social space and its transformation.

The core contribution of the study is the socio-spatial conceptual framework, termed 'Producing the Agora', which is useful for explaining the process of appropriation of generic health information systems in developing countries. Its application to the study shows how new technologies can serve to reinforce the status quo rather than mediate espoused techno-organisational transformations. It surfaces the dialectical interaction between the domination and appropriation of the agora as a mechanism through which the space attains shape. It demonstrates how Henri Lefebvre's theory on space can reveal the content of the emergent techno-organisational interactions and struggles. It also demonstrates how socio-spatial conceptualisations of technology adoption can enrich the health information systems domain. When sensitised by these ideas, it is envisaged that health ministries will be able to take a more decisive leadership role in order to attain to the goals of adopting these new technologies. The conception particularly revealed how the space of server hosting for the web based application was a central arena where struggles of appropriation ensued, powerful influences dominated and stronger leadership was in want.

1 Introduction

States worldwide, especially in the developing world, have been engaged in processes to develop integrated health information systems in order to improve access to data on healthcare services, which may in turn be used to craft policies and strategies for interventions in the sector. This occurs in the context of complex organisational structures, public and private institutions, numerous technology vendors and a multiplicity of programs which often have their own funding sources (Braa & Sahay, 2012; Pollock & Williams, 2010). Contemporary health information systems development, implementation and use also occurs in a context where global and local networks are enmeshed, to form what has been referred to as the 'glocal' (Robertson, 2012; Swyngedouw, 2004). In particular, the information technologies that often emerge within this glocalised healthcare context are standardised across national and organisational contexts. Such standardised technologies, known as generic software, are typified by the popular Enterprise Resource Planning (ERP) systems which are used in virtually all organisational sectors including healthcare (Pollock & Williams, 2008).

Known generic technologies in the healthcare sector fall into the categories of human resource information systems (HRIS), electronic medical record systems (EMRs), laboratory information management systems (LIMS) and routine health management information systems (RHMIS) among others. There are efforts by many states to develop and implement these classes of information technologies, and for them to be integrated, to enable the storage, use and sharing of accurate up to date healthcare information (Braa & Sahay, 2012). In developing countries, such systems are often developed with the espoused aims of empowering health workers to strengthen the provision of healthcare services and to improve outcomes (Lippeveld, Sauerborn, & Bodart, 2000). Furthermore, the implementation of these technologies falls within the developmental agenda which was until recently promoted through the Millennium Development Goals (MDGs) framework. However, health information systems development is a monumental task, where success occurs far between, comes at an enormous cost and failure is common (Aanestad & Jensen, 2011; Heeks, 2002). A challenge that is found in the domain is the difficulty of developing sustained collaborations across individual, organisational, territorial and regional boundaries in order that the transformatory objectives of the interventions are met and sustained (Braa, Monteiro,

& Sahay, 2004; Ezz & Papazafeiropoulou, 2006; Pollock & Williams, 2008). It is consequently of prime importance to endeavour in substantive theory development within this space in order that the understanding of such technologies can be refined for researchers and practitioners to increase the chances for appropriation (Braa et al., 2004). To appropriate technology is to make it 'one's own' and is concerned with the process through which an artefact is adopted, adapted and integrated into a practice (Arakelyan & Lamas, 2014).

To assimilate the theoretical ideas and formulations to understanding appropriation of generic information systems is not an easy task. Kaniadakis (2009, p. 3) notes that the "*interdisciplinary study of technological and organisational innovation appears fragmented and unable to analytically capture and explore in an integrative way the emergence and the shaping of the global market for techno-organisational change*". In particular, there are intra disciplinary separations into, for instance, practice based studies, Information Technology and Development (ICTD or ICT4D) research, Science and Technology Studies (STS) and Computer Supported Cooperative Work (CSCW) among others, all leaning on different problem contexts and theoretical traditions. However, a realisation for the need of spatially sensitive conceptualisation of contemporary information systems phenomenon is a common and emergent thread (Castells, 2000; Monteiro & Rolland, 2012; Orlikowski, 2010; Pollock, Williams, D'Adderio, & Grimm, 2009). This is driven by the emergence of new modes of IT production where new relationships with spatially dispersed actors and the pervasiveness of the Internet are implicated in local changes (Castells, 2000; Lefebvre, 1991). Furthermore, traditional discipline centred accounts of information systems have either privileged the micro over the macro or the agent over the institution and vice versa thereby neglecting key aspects of the distributed and fragmented social phenomenon (Czarniawska, 2004; Monteiro & Rolland, 2012). Much research has particularly favoured a micro understanding of this phenomenon by focussing on the user level (Carroll, 2004; DeSanctis & Poole, 1994; Stevens, Pipek, & Wulf, 2009). Such accounts tend to propagate the assumption that information technologies are developed in one arena and used in another given their 'black boxing' of the artefact (Jorgensen & Sorensen, 1999; Sanner, Manda, & Nielsen, 2014).

Understanding the creation and evolution of networks of organisations, persons and artefacts in the context of fragmented health systems is a key consideration in any discussion on the appropriation of technology (Braa et al., 2004; Sanner & Sæbø, 2014). This research

develops a spatial theoretical account of this phenomenon, based on data from two empirical cases involving the implementation of the same health information software. The framing of the problem area is informed by literature on information infrastructures (Hanseth & Lyytinen, 2010; Pollock & Williams, 2008; Star, 1999), the global dominance of generic software packages (Pollock & Williams, 2008), and the appropriation of health information systems in developing countries (Braa & Sahay, 2012). The theoretical focus is sensitised by spatial conceptions of generic software (Kaniadakis, 2007; Pollock & Williams, 2008), and the 'social production of social space' perspective (Lefebvre, 1991). In the following sections, the research aims and the questions addressed are presented. Furthermore, an overview of the empirical setting and the contributions of the study are also provided.

1.1 Research Aims and Questions

This study addresses the concern for the development of a spatial theory and concepts that can be used to understand technology appropriation through a grounded study on the implementation of the generic District Health Information Software (DHIS 2). The research sought after the goal of increasing the chances of successful appropriation of DHIS 2 in two developing countries. To achieve these aims, the exploratory questions pursued in this study were:

(i)   How can we understand and explain the processes implicated in the appropriation of generic open source health information systems in developing nations?

(ii)   How can the transformations sought when adopting these technologies be better realised?

1.2 Empirical Setting

This study was undertaken on the cases of health information systems changes in the Southern African nations of Malawi and Zimbabwe. Both these nations were developing their integrated health information systems based on the Internet-based free and open source District Health Information Software (DHIS 2). Due to historical socio-economic imbalances and political problems, health ministries in Malawi and Zimbabwe have become donor dependent. In Malawi, the empirical basis of the study was a pilot project on the development and use of mobile phone based data collection tools to enter information into an online DHIS 2 server. The pilot involved community health workers, and other health information staff

within a district. In Zimbabwe, the research followed the trajectory of a project to introduce and rollout the DHIS 2 technology nationwide, which included a sub-project aimed at developing mobile phone based tools for health workers.

1.3 Research Contributions

1.3.1 Contributions to Theory and Practice

The core contribution in this study is the articulation of a theoretical framework to critically understand the appropriation of generic software in arenas dominated by multiple stakeholder interests driven by donor arrangements. The study utilises the conception by the pre-eminent French philosopher Henri Lefebvre who surfaces a new mode of production of social systems in a globalised world which he terms as the 'production of space' (Lefebvre, 1991). According to this perspective, appropriation is a spatial phenomenon through which sets of relationships of production emerge. This appropriation has a dialectic property whereby it reveals its other side which is domination. The study therefore surfaces the practices of appropriation and domination which unfold in the implementation of generic software. The dialectic between appropriation and domination occurs within an arena which resembles the Athenian Agora, a hitherto central space in ancient Greece where socio-economic and political life unfolded. Kaniadakis (2007) has previously recognised the similarities between the space where global technologies make their way into local techno-organisational change instances and the Athenian Agora. The mode through which manifestations of the DHIS 2 technology emerge in the studied contexts and are shaped is what is termed as 'Producing the Agora'.

It is felt that the perspective on 'Producing the Agora' is an important contribution to Information Systems discourse in a number of ways. Firstly, the application of the theoretical ideas of Lefebvre (1991) is novel in the information systems discourse, with only a handful of studies having attempted to apply his thinking within organisational research. The application, as will be demonstrated, enables researchers to be sensitised on the spatial processes through which information systems are appropriated particularly where there are diverse actors with multiple interests involved. Secondly, it has been said that, just like time, space has hitherto been taken for granted in information systems research and this study offers a socio-spatial theoretical account of information systems change. Third, within the

domain of Health Information Systems (HIS) no known studies have utilised the conception by Kaniadakis (2007) on the evolution of generic software. The Agora concept has been applied to understand ERP systems in the private sector by (Pollock & Williams, 2008), and its application and development in the public health sector has thus far been lacking (Pollock & Williams, 2010). Finally, the perspective of appropriation of technology as a spatial process provides a nuanced understanding of the phenomenon which goes beyond prior conceptualisations in the IS discipline and could also be useful for developing and implementing standards, regulations and policies within health and other government ministries.

1.3.2 Selected papers

Four papers have been included in this thesis, covering different aspects of the phenomenon, yet contributing to the overall theoretical aims of the study. These four are:

(I)   Matavire, R., Chidawanyika, H., Braa, J., Nyika, P., & Katiyo, J. (2013). Shaping the Evolution of the Health Information Infrastructure in Zimbabwe. *Journal of Health Informatics in Africa, 1*(1).

(II)   Matavire, R., & Manda, T. D. (2014). Design Breakdowns As Opportunities For Articulating Mobile Health Information Infrastructures. *The Electronic Journal of Information Systems in Developing Countries, 63*(3), 1-17.

(III)   Matavire, R., Jolliffe, R., & Braa, J. (2015). *Co-optation to Production : Addressing Risk in HIS Implementation and Development.* The 13th International *Conference* on Social Implications of Computers in Developing Countries, Negombo, Sri Lanka.

(IV)   Matavire, R. (2015). *Health Information Systems Development: Producing a New Agora in Zimbabwe.* Paper under review in the 'Information Technologies and International Development' journal

1.4   Outline of thesis

In the next section, a background of the health information systems strengthening domain will be provided. The aim is to provide a rich overview of the problem area. After this, the thesis proceeds by providing an overview of the theoretical ideas that informed the research effort. This will lead into a discussion of the research method adopted to conduct the work, followed by a presentation on the cases. The individual contributions of the papers published to the emergent theoretical framework for understanding the phenomenon under study will be

provided in the findings. Implications of the work and a brief conclusion to the thesis follow thereafter.

2 Health Information Systems in Developing Countries

2.1 The Health Systems Strengthening Agenda

Systems in the healthcare sector are distinguished by a 'public health logic' to have equity in their distribution across the contexts of their implementation, leading to an 'all or nothing' approach to technological adoption (Braa et al., 2004). These factors interact with the global context of development and implementation of these systems, where the 'Alma-Ata Declaration' of 1978 is credited with setting the tone for an agenda to have equal access to primary healthcare worldwide, implicating information technologies therein. In the context of developing countries, much has been said about the millennium development goals (MDGs) which made health information systems a key area of intervention, up till 2015 (Kanjo, 2011). While there has been this global drive towards equitable, accessible, efficient and sustainable healthcare systems offering high quality services, many nations have demonstrated that pre-existing weaknesses such as found in politics, infrastructure and financing are key barriers to reaching these goals (Braa et al., 2004; Taderera, Madhekeni, Zhou, & Chevo, 2012). Furthermore, it is alluded to that with the pre-existing weaknesses in these national health information systems, it follows that challenges in measuring developmental progress arise (Lippeveld et al., 2000).

According to the World Health Organisation, as referenced by Chee, Pielemeier, Lion, and Connor (2012), the building blocks of a health system are healthcare service delivery; human resources; the health information system (HIS); medical products, vaccines, and technologies; health financing; and leadership and governance. The agenda to strengthen health systems aims at "*improving interactions between the building blocks and for sustainable improvements 'across health services and health outcomes'*" (Chee et al., 2012, p. 86). In many countries, projects to strengthen these systems have led to a more complex situation characterised by numerous donor funded healthcare programs and interventions, often with their own vertical systems and operating in silos (Gary, 1996; Lippeveld et al., 2000). Integrated information technologies, buoyed by recent advances in the communication infrastructures of developing nations, have consequently been implicated in the discourse on strengthening these systems (Braa & Sahay, 2012; Sanner, Roland, & Braa, 2012). Mobile providers are playing an increasingly important role by extending the reach of their services thus creating opportunities for wireless technology in rural healthcare facilities (Sanner et al.,

2014; Sanner et al., 2012). The rural facilities are typically isolated, and mobile technologies create an opportunity to overcome the remoteness barrier. There is consequently a need and an opportunity for the healthcare sectors of developing nations to take advantage of recent and ongoing technological developments to strengthen their systems.

2.2 How DHIS 2 'Conquered the World'

When South Africa attained independence from Apartheid in 1994, a Health Information Systems Program (HISP), which was a partnership between a Norwegian PhD student, the University of Western Cape and the University of Cape Town, developed and implemented a district health information software (DHIS) within health facilities in one province. HISP's aim in developing the DHIS software was to alleviate the fragmentation in South Africa's pre-existing health information system which was a legacy of the racial segregation that had been institutionalised by the Apartheid regime (Braa & Sahay, 2012). The new system enabled the routine collection of a set of standardised health indicators from health facilities across poor townships and more affluent areas. The system achieved this while supporting and maintaining the flexibility of individual health units and programs to collect data related to their specific information needs. This increased the appropriation of the system by users since it could be extended to collect additional indicators at the health facility. It utilised a Microsoft Access database containing standardised data collection tools and was developed using a rapid prototyping technique based on what was termed a flexible standards strategy (Braa, Hanseth, Heywood, Mohammed, & Shaw, 2007). Soon, the system was rolled out to the remaining provinces in South Africa, accepted nationally and eventually adopted in other nations in the region and beyond (Braa & Sahay, 2012).

A key aspect of the DHIS was on the focus by HISP to minimise the data collected by health workers to only that which was needed and used at the different levels of the health system – the flexible standards strategy which was based on a limited data set (Braa et al., 2007). Using this software, health workers could collect a small standard set of 'data elements' at the health facility level, aggregate it, export it and send it to the next level in the public health systems' hierarchy. The process would be repeated at each subsequent level, across all facilities, until data was aggregated at the national level. The system also enabled health workers to collect and monitor additional health indicators for their catchment areas through HISP's focus on improving data use at the facility level. This early DHIS system that was

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developed and implemented in South Africa, and adopted in other nations, will be referred to as 'DHIS 1' throughout the thesis, particularly to distinguish it from 'DHIS 2' which is the Internet-based open source data warehouse which was developed later by HISP at the University of Oslo. In this study, both the nations of Zimbabwe and Malawi were engaged in processes of migrating from different versions of 'DHIS 1' to 'DHIS 2' which emerged after 2004.

Over years, the number of nations that have elected to utilise the DHIS 2 technology has risen to more than fifty. Unlike its predecessor, DHIS 2 depends on a centralised server infrastructure and was developed on the BSD open source software license utilising *'bleeding edge'* frameworks of the time (Braa & Sahay, 2012). The open source based generic approach to the development of the software increasingly entailed the need for establishing local and regional networks to bridge the enlarged distances between users across the world and developers mostly based in Oslo, Norway (Braa & Sahay, 2012; Pollock & Williams, 2008). Despite the development of the DHIS 2 technology after 2004, and its piloting in an Indian state in 2006 (Braa & Sahay, 2012), many nations such as Zimbabwe and South Sudan still elected to use DHIS 1 after 2010. This is perhaps explicable due to the greater cost and higher risk associated with being an early adopter of an Internet based technology in developing nations, a challenge which many ministries are unwilling to take on despite potential rewards (Hanseth & Lyytinen, 2010; Shaw, 2012). Furthermore, a gradual development approach from DHIS 1 to DHIS 2 might be perceived as more tenable for many governments.

Other nations who felt they had the network capacity such as India, adopted the DHIS 2 technology early, leading adoptions in Asia, after which Vietnam and Tajikistan followed (Braa & Sahay, 2012). As more nations continued to enrol into the network of developers, implementers and users, the base of expertise on the technology grew in distribution, heterogeneity and specialisation, even as it remained largely dominated by HISP Oslo. However, despite this noted global success, individual technology implementations within countries are still faced with the risk of failure due to a range of technical, social, economic and political concerns emerging amongst stakeholders. A key challenge in implementing the technology has been the short-term nature of funding which is project based and externally sourced (Sanner & Sæbø, 2014). Braa et al. (2004) lament that often times when these

funding windows close, technology implementations fail to persist. They posit that to enable these action-oriented interventions to persist requires that they be looked at not only as individual implementations, but that they be seen as emerging within a network of projects – which should be harnessed to ensure sustainability. However Braa et al. (2004) do not provide adequate tools to conceptualise the spatial and material character of these networks within the donor dominated arena of health systems strengthening. This study aims to take this conception further by noting that for these projects to persist, they should be seen as new modes of production which emerge and are shaped in space through which their sustainability can be understood.

2.3 HIS Strengthening Challenges and Visions

2.3.1 Fragmentation of Health Information Systems

Fragmentation of health information systems is a common concern in many countries which is caused by the implementation of different information technologies, within the context of multiple vertical programs, units and projects which have their own funding arrangements (Braa & Sahay, 2012; Lippeveld et al., 2000; Sahay, Monteiro, & Aanestad, 2009b). As noted, this fragmentation is reproduced in the duplicated efforts of healthcare actors engaged in the development, implementation and use of information technologies. Consequently, health workers at care facilities are over-burdened to collect data using various disease specific registers, and IT systems, often duplicating data across different program specific formats to meet vertical reporting needs (Sahay et al., 2009b). Evidence also suggests that in some cases, paper registers are not appropriated for decision making at the facility level and are only completed for transmission upwards (Braa et al., 2004). This adds to the fragmentation of the health information system which is evidenced by the poor quality of the data from which higher level decision makers are forced to design healthcare interventions (Chaulagai et al., 2005).

2.3.2 Poor Data Quality

Good quality data is important for management and planning in public health systems. The quality of data is indicated on its timeliness, completeness and accuracy (Mphatswe et al., 2012). Good quality data provides an evidence base for decisions that impact on the provision and quality of healthcare services (Mphatswe et al., 2012). For instance, timely and accurate

aggregate figures for malaria cases in a district can lead practitioners to respond quickly to a potential outbreak of the disease through the distribution of resources. Timely transmission of laboratory results to the health facility can also aid a health worker in planning patient treatment. Quality data is demonstrated in its usefulness to decision makers, since use is posited to be positively related to quality (Braa & Sahay, 2012). There are challenges in the quality of data within the healthcare sector, which are compounded by the poor resource context of developing countries which often depend on paper based systems (Braa & Sahay, 2012).

2.3.3 Legacy of paper-based systems

The paper basis of many health systems in many nations makes analysis and use of data cumbersome, particularly where patient name based records are concerned. Paper-based information systems also face other qualitative obstacles such as delays or failures in transmitting data from the health facility to the national level (Sanner et al., 2012). This could be caused by challenges such as lack of fuel to transport paper registers to subsequent levels in the health information system or, in some cases, seasonal phenomenon such as flooding can act to delay data transmission. In other instances, shortages of stationery can mean that health workers are not able to capture health data, leading to poor quality at the national level (Sahay, Sæbø, Mekonnen, & Gizaw, 2010). However, paper-based systems are entrenched in the health systems of many developing nations and changing to software based systems is fraught with risks and uncertainty as it requires a 'paradigm shift' for both health workers and stakeholders (Sahay et al., 2010). There is also a likelihood that such system changes erode stabilised institutions and routines and hence they face resistance from key organisational actors (Arnold, 2003; Sahay et al., 2009b; Witmer, Seifer, Finocchio, Leslie, & O'neil, 1995).

2.3.4 Political Context of HIS

Health information systems strengthening activities are a necessary, challenging and highly politicised affair (Sahay, Monteiro, & Aanestad, 2009a). This is due to the multiplicity and temporality of interests that are found in the health systems strengthening domain (Sahay et al., 2010; Silva & Hirschheim, 2007). Success of technology in this context often relies on the mobilisation of support from key government actors occupying high positions in health ministries (Sahay et al., 2009b). Furthermore, the technologies also depend on ongoing high-level support even after powerful actors inevitably leave their positions, possibly after

government elections, or other institutional and political changes (Matavire et al., 2010; Sahay et al., 2009b; Silva & Hirschheim, 2007). Health information systems strengthening activities, such as the ones reported in this study, can occur under a developmental agenda such as 'power to the users' (Braa et al., 2004; Braa & Sahay, 2012). This can be in contrast to the traditional top down administration and development of health information systems (Sahay et al., 2010). Politics consequently plays a core role in shaping the context of development, implementation and use of health information systems. Building an understanding of how decisions made by actors in political contexts shape user outcomes is an important field of inquiry (Allison & Zelikow, 1999; Gagliardone, 2014). However, there is a paucity of such studies particularly in the context of information technology in developing countries (Gagliardone, 2014). This study endeavours to address deficiencies in accounting for the phenomenon and the next section develops a spatial theoretical framework to explain IT interventions in the context.

3 Theoretical Framework

3.1 Background

This study is about the development, implementation and use of an Internet-based, *generic* health information software. In particular, the research aims at an explanatory theory to understand the appropriation of these systems by analysing the local and global interactions through which they emerge. In this regard, it utilises Kaniadakis (2007) concept of the 'agora of techno-organisational change' which conceptualises a space where technological choices are made and find themselves into local change instances. The study was also sensitised by the theory of 'production of space' by Lefebvre (1991) which provides a broader and deeper theoretical frame for developing and understanding social space. In essence, Lefebvre (1991) notes that there is new mode of production of social systems, which is space, a space which is also the product. The journey that led to such a theoretical formulation began with the realisation that many of the challenges faced in the implementation and use of technologies such as DHIS 2 emanate and are solved at inter-organisational sites which can be quite distant from the users, whom are often restricted to poor communication channels. It became important therefore to conceptualise how such a technology can be appropriated, particularly by the users, under these circumstances.

To understand this phenomenon, Braa et al. (2004) have developed the 'networks of action' approach which encourages implementers to leverage resources across national and organisational boundaries in supporting local information systems development. While acknowledging the need for such network oriented views, it is the processes through which these networks emerge and are appropriated which is the subject of this thesis. In the 'networks of action' approach, Braa et al. (2004) acknowledge that their understanding of networks is '*selective and confined*', leaving therefore an opportunity for elaboration. Traditional units of analysis such as organisations, networks and infrastructures have also proven to be insufficient to conceptualise contemporary information systems phenomenon (Czarniawska, 2004; Jorgensen & Sorensen, 1999; Kaniadakis, 2007). Pollock and Williams (2008) argued for a spatial conceptualisation of generic information systems. However, while pointing to Kaniadakis (2007) Agora of Techno-Organisational Change (ATOC) as a site of contestation and where technological choices are made, they did not adequately address the

appropriation concern (Pollock & Williams, 2008). Through exploring Henri Lefebvre's thinking on social space, a suitable conception to address this shortcoming emerged.

3.2 Biography of Artefacts Framework

To account for the global development and movement of generic software technologies, Pollock and Williams (2008) have posited the Biographies of Artefacts (BoA) framework. The paradox that motivated their work was how software technologies such as the SAP Enterprise Resource Planning (ERP) systems could be used in so many organisational contexts while conventional wisdom seemed to deny such a possibility. Particularly, they were interested in how such technologies were not only implemented at various sites but also how they evolved with their use in these places. Consequently, to understand this phenomenon they traced the emergence of these contemporary artefacts to the older Manufacturing Resource Planning (MRP) systems that predated them. Through this historical biography of the technology they explained the emergence of the global production of ERP systems, including the critical role of social entities that form the global 'network' of industry experts who determine best practice for implementation of such technology as typified, in this case, by Gartner. Consequently, the technology is able to meet requirements generated at numerous sites at any given time and acquires inscriptions of its historical evolution through sites of development and use which together form the 'biography of the artefact' (Pollock & Williams, 2008). This formulation points to a key aspect of contemporary information systems, which is that even globalised software is developed at the places where it is used. This is contrary to assertions, particularly in the ICTD field which posit that technology is developed in the 'North' and used in the 'South'. However, while useful in accounting for the overall evolution of an artefact over the long term, it was not clear how the biographies framework could be sufficiently applied to understanding instances where generic technology is implemented over a shorter duration in multiple sites.

Still, Pollock and Williams (2008) do point to an arena where negotiations between the global production and the local implementation and use of a technology occurs, that is Kaniadakis (2007) Agora of Techno-Organisational Change (ATOC). The 'Agora of Techno-Organisational Change' (ATOC) refers "*to a marketplace for technological artefacts and expertise, but it is also a political arena where actors negotiate and pursue their interests and exercise power and control over the choices regarding innovation*" (Kaniadakis, 2008). This

concept points to an arena which has both global and local aspects, also referred to as glocal (Robertson, 2012), as the site where generic technologies are produced for implementation and use within particular 'techno-organisational change instances'. However, while wielding analytic qualities which account for key aspects of generic systems phenomenon, the concept does not provide specific tools to understand the process of appropriation. Lefebvre's (1991) theory on social space which he terms 'the production of space' perspective helps to complement Kaniadakis (2007) notion of agora. Lefebvre (1991) argued that social relationships of production have a spatial existence which is also their product and without which they remain abstract. Lefebvre's (1991) perspective is a formal theory on social space which was adopted in this study to understand the strategies through which technology is appropriated in the Agora, or even how the Agora as a space is itself appropriated.

3.3 Appropriation of Information Systems

The term appropriation has a Latin root and it comes from the word '*appropriare*' which means "*to make one's own*". This should be considered as distinct from the concept of 'property' and should rather be thought of as the artful integration of an 'object' within its context of use. Consequently within the information systems discipline the concept is related to ideas of user adaptation of artefacts to fit context, sometimes in ways unforeseen by the designers (Draxler & Stevens, 2011). Appropriation is also closely related to the concept of 'affordances' whereby technology is neither judged according to the specific features within it nor the organisational objects for which it is adopted but rather on how it is perceived to permit or constrain certain activities in practice (Majchrzak & Markus, 2012; Markus & Silver, 2008). However, there is a distinction between the terms. Whereas appropriation refers to the act of adopting a technology to specific uses in practice, affordances are the potentials for which a technology might be put to use which might or not be desirable. And given that the meaning of appropriation is "*to make one's own*", it should be considered as a process.

Indeed an appropriated technology provides, or potentially provides, certain affordances to its users. However, it is important to note that these concepts emerge out of an attempt to escape technological determinism on one hand and institutionalism on the other. These ideas have consequently found fruitful expression through Structuration theory which emphasises the role of human agency in producing and reproducing social structures (Giddens, 1986). In

elucidating the applicability of Structuration theory to information systems, Giddens and Pierson (1998) as referenced by Jones and Karsten (2008, p. 131) state that *technology does nothing, except as implicated in the actions of human beings*". This is given that researchers in information systems have sought to espouse formulations of Giddens (1986) theory that are relevant to the discipline. Among these are DeSanctis and Poole (1994) who have proposed Adaptive Structuration Theory (AST) and Orlikowski (2008) who develops a technology-in-practice lens. A consequence of such perspectives is that there are differing views as to whether the appropriation of technology by users is desirable. On one hand, the appropriation of a technology can lead users to enact its unintended affordances while on the other this also demonstrates their freedom in its use (Baillette & Kimble, 2008). This challenge is also evident in the conceptions of appropriation within Marxist thought where it is related to the idea of alienation, that is as man appropriates advanced industrial technologies, they are alienated from nature (Baillette & Kimble, 2008). For Lefebvre (1991) the concept of appropriation can therefore not be meaningfully defined and separated from domination. There is therefore an intense dynamic of power and its symbolisms within appropriation. As Lefebvre (1991) contends, the question becomes appropriation of what, by whom and for whom?

In information systems research the concept of appropriation is largely used to describe how users or user groups make a technology their own. This unfortunately, as can be seen in the work of Markus and Silver (2008) and also DeSanctis and Poole (1994), creates the impression of users isolated with a technological artefact within their hands which through their agency they continually interpret to suit their local settings. However, it is true that Markus and Silver (2008, p. 627) allow room for further work by asserting that "*the continual emergence of new technologies inevitably requires ongoing conceptual development*". This study has particularly been interested in the generic DHIS 2 software and argues for additional conceptualisation. In particular, information systems studies have increasingly been interested in the interrelationships between technology designers and users as intrinsic to understanding generic software phenomenon (Pollock & Williams, 2008). This is due to the varied sets of intermediaries through whom generic IT artefacts are interpreted in local contexts by users and also understood by their developers. In these contexts, appropriation is shaped in arenas that are distant from the users. The concept of space is therefore emergent

when attempting to conceptualise the appropriation of generic software systems (Lefebvre, 1991; Pollock & Williams, 2008).

3.4   Emergence of Spatial Concepts in Information Systems

The spaces, and times, in which constellations of actors occupy, and act on the implementation, development and use of generic technology in diverse settings have been increasingly problematised in information systems research (Clausen & Koch, 1999; Monteiro & Rolland, 2012; Pollock & Williams, 2008; Sahay, Sæbø, & Braa, 2013). Czarniawska (2004) proposes to think of the "*actual interactions taking place within time and space*" as an 'action net', which analytically shows that the relationships amongst actors are themselves products of an organising process. Jorgensen and Sorensen (1999) have also looked at 'development arenas' as spaces of interaction where technological artefacts are developed. They conceptualise the development arena as a cognitive space in which diverse processes that shape a particular technological innovation, or product, can be considered together (Jorgensen & Sorensen, 1999; Pollock & Williams, 2008). What is similar between development arenas and action nets is that both seek to conceptualise a local technological phenomenon based on activities occurring in disparate spatial contexts (Pollock & Williams, 2008). In these cases, the technological innovation process is distributed and diffused. This can be more broadly seen as a shift in attention by researchers to the globalised nature of modern life and work, and the need to account for such phenomenon in information systems. What is challenging about their perspectives however is that they arguably still take time and space for granted and fail to define clearly what they mean by those terms.

Building on this emergent field, recent research suggests that an improved conception of space is still lacking and is important to build an understanding of how generic software comes to be adapted to meet the needs of numerous users in diverse settings (Kaniadakis, 2012; Pollock & Williams, 2008). As highlighted earlier, the spaces of development, implementation and use of IT where globalised interactions are shaped into, and consequently shape local interventions have been conceptualised as the "Agora of techno-organisational change" (ATOC) (Kaniadakis, 2012; Pollock & Williams, 2008). An immediate benefit obtained in this conception is the ability to consider development, implementation and use of generic technology within a single frame. This enables researchers to overcome a

predominant assumption in ICTD discourse which sees technology as created in the 'developed world' and used in the 'developing world'.

3.5 The Agora metaphor

3.5.1 The Athenian Agora

It is important to note that the Agora of technology development is founded in metaphor of the ancient 'Athenian Agora' and is meant to trigger certain conceptions of space. Consequently, there should be no conflation of the 'Athenian Agora', and this study's 'Agora' which refers to the 'Agora of techno-organisational change' as presented by Kaniadakis (2007). Agoras are traditionally open spaces, or market places, where people interact and which constitute the centre of their community life as shown in Figure 1, below (Kaniadakis, 2008; Thompson & Wycherley, 1972). They are constituted of structures that are produced and reproduced in practice by diverse actors (Giddens, 1986; Lefebvre, 1991). The ancient agora was the focus of life in Athens which, over time, was constituted of public buildings, walks, assembly areas, law courts, cemeteries, shrines and altars (Thompson & Wycherley, 1972). The understanding of modern agoras as markets or shopping areas is different from the classic view of the ancient Agora (Kaniadakis, 2008). Growth of the ancient Agora started with simple structures, was "*spasmodic*" and not subject to any architectural master plans by single actors but rather represented a medium and product of changes in urban life (Thompson & Wycherley, 1972).

Figure 1: Impression of the Athenian Agora attributed to architect Joseph Bühlmann (1881)

3.5.2 The Agora of Techno-Organisational Change

The agora of techno-organisational change is a 'multidisciplinary space' in which the designers, implementers, and users of an organisational technology potentially interact to conceptualise, design and intervene in information systems change initiatives (Kaniadakis, 2007; Pollock & Williams, 2008). According to Kaniadakis (2008, p. 4) , it refers to

"a marketplace for technological artefacts and expertise, but it is also a political arena where actors negotiate and pursue their interests and exercise power and control over the choices regarding innovation. It is a place where vendors, suppliers, consultants, user organisations, the state, technological promises, visions, and rhetorics on a global scale, find their way into local, particular situations".

It is "*an alternative concept seeking to integrate multiple levels of analysis in exploring and understanding innovation as it takes place in the space between local [techno-organisational] change instances and the global knowledge economy*" (Kaniadakis, 2007, p. 75). The agora does not have any clear boundaries, yet it is prudent to develop bounded perspectives of it in order to understand and to intervene within it (Pollock & Williams, 2008).

The agora is characterised by "*asymmetries and entrenched conflicts as well as alignments of interests*" (Pollock & Williams, 2008, p. 99). It is an ensemble of spaces demarcated by both physical and abstract boundaries and constituted by a myriad of organisations representing international, regional, local, private and public interests (Pollock & Williams, 2008). Collaboration is a key aspect of the Agora, where organisations with competing interests are forced to work together in order that they may build expectations about a technology, while simultaneously competing to establish themselves within their niche spaces (Pollock & Williams, 2008). This interplay between competition and cooperation (co-opetition) has also been demonstrated in other distributed spaces of innovation such as the action net (Czarniawska, 2004). The Agora is also a site where actors accumulate power through their ability to mobilise resources to pursue projects which address techno-organisational challenges (Pollock & Williams, 2008). Through such activities, actors seek to secure their own role by becoming control points in the evolution of a particular information infrastructure. Being a multi-disciplinary space, various orientations to a technological offering exist in the Agora. This diversity of orientations is the basis of negotiations as a

mode through which alignments, and *sub rosa* activities, are pursued by actors to meet their commitments (Grisot, Thorseng, & Hanseth, 2013; Pollock & Williams, 2008). Furthermore, given that technological offerings have embedded in themselves certain visions of 'best practice', intermediaries play a crucial role in moving across different places in the Agora and sharing, and being custodians, of community perspectives in relation to particular IT offerings (Pollock & Williams, 2008). They carry with them what can be thought of as the 'spirit' of a technology (DeSanctis & Poole, 1994). Intermediaries thereby play a crucial role in the configuration of these complex spaces of production in diverse settings.

3.5.3 Managing the Agora

The 'agora' metaphor has aided in framing the emergence of heterogeneous sets of people and objects that occurs when generic or contemporary information systems are adopted in organisations, marked by the increased participation of global actors. Such a metaphorisation has a strong history in organisational studies and provides the opportunity of linking theory to practice by offering an alternative understanding of techno-organisational change (Byrne, Jolliffe, & Mabaso, 2006). For instance, Kaniadakis (2009) has highlighted how choices made by actors contribute to shaping the Agora. Furthermore, Castells (2000) notes the essential role of the state as a decisive factor in shaping the relationships between technology and society. Consequently, by utilising this metaphor it is possible to conceptualise intervention in the Agora to improve the outcomes of techno-organisational change (Kaniadakis, 2009). That the Agora can be structured toward the attainment of techno-organisational goals is an important consideration for its relevance in this research. This is particularly sought after given the context of developing countries that are studied here which are engaged in interventions to improve the quality of life of their citizens through technological innovation (Avgerou, 2010; Braa et al., 2007).

A number of metaphors have been utilised in the health information systems discipline to account for the processes through which innovations are appropriated and shaped in local contexts such as 'grafting' (Sanner et al., 2014), 'bootstrapping' (Hanseth & Aanestad, 2003), and 'cultivating' (Braa et al., 2004). What is immediately peculiar about such views is how they see technology as something that is introduced from outside hence failing to diminish suspicions of their persistence of a top-down, north-south or 'developed nation-developing nation' view of development and implementation. Such perspectives have been critiqued for

blurring the distinction between the technical and the social, privileging the perspective of the researcher, and failing to systematically account for the antecedents of techno-organisational change (Kaniadakis, 2007; Timmermans & Berg, 1997). Furthermore, the failure of prior conceptions to explain the relationship between IT, its cognitive aspects, and the political contexts in which it is adopted in developing countries presents a theoretical gap in literature (Avgerou, 2010). Consequently, there is room for a vocabulary of 'space' since, like time, it is taken for granted and ideas such as 'structuring space' do no answer the question as to what this 'space' is, that is whether it is geometric, cognitive, absolute, objective, subjective etc (Kaniadakis, 2009; Orlikowski & Yates, 2002; Sahay, 1997). Of the literature that has attempted to answer these questions, Henri Lefebvre's view is pre-eminent, and he boldly states that 'social space is a social product', therefore it is 'produced' (Lefebvre, 1991). The fit, meaning and implications of his work to this study and the resulting theory on the 'Producing the Agora' is elaborated on below.

3.6 Lefebvre on the Production of Space

The concept of production of space presents an interesting way to think about the emergence of sets of networks in HIS intervention. It helps to see success of techno-organisational change as a process of production, not of a technical artefact, but of sets of relationships of production which unless they are manifest in space, could be considered as failures. Furthermore, it helps to understand how 'new' relationships can form and in what mode they exist, and are applicable in the implementation and development of generic software. It therefore presents a platform for the critique and development of strategies aimed at sustainable health information systems centred on a perspective of collective management of space. As noted earlier, space and time are often considered in an objective and primordial manner making the "production of space" seem illusory and paradoxical. However, seemingly paradoxical ideas are not out of place in information systems research as exemplified by such terms as 'guided emergence' (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011), 'flexible standards' (Braa et al., 2007) and the 'development arena' (Jorgensen & Sorensen, 1999).

For Lefebvre (1991), claims by states that followed a capitalist, communist, socialist or other ideal should have been evident in the space of their cities. Lefebvre (1991) saw a close relationship between the plan of a city, urban life, and the capitalist mode of production.

Accordingly, Lefebvre (1991, p. 59) posits that "*new social relationships call for new space, and vice versa*". Lefebvre (1991) was critical of predominant perspectives which focussed on the products which emerged in social space, such as commodities, without considering the space in which they emerge as itself a product. The development of this perspective of production of space was motivated and necessitated by the emergence of new globalised modes of production which did not fit the traditional models for explaining socioeconomic phenomenon (Lefebvre, 1991). Castells (2000) has called this a new form of capitalism which is 'informational'. Lefebvre (1991), notes that in the new mode of production, social space "*serves as a tool of thought and of action; that in addition to being a means of production it is also a means of control, and hence of domination, of power; yet that, as such, it escapes in part from those who would make use of it*" (Lefebvre, 1991, p. 26). This is concordant on the views of Kaniadakis (2009, p. 4) on the Agora as providing "*a new meaning to the notion of strategic management of technological change*". In the context of the study, the implementation of DHIS 2 represents a particularly new mode of production, particularly occurring in what has been called the "*informational age*" (Castells, 2000; Matavire, 2010).

According to Lefebvre (1991), software like DHIS 2 can be considered as a kind of fetishised commodity which conceals elements of how it is produced when it is packaged. However, it cannot escape the emergence of sets of relationships between objects and people just prior to its use. The process of emergence and shaping of relationships that occurs when generic software is adopted is what is termed 'Producing the Agora'. The challenge is therefore the shaping of this Agora such that the objectives of implementing health technologies in developing countries are met, particularly the realisation of the ideal of freedom underlying open source software. This implies the collective management of the Agora, which is a key element since it has been noted that cooperation is essential in understanding contemporary modes of production (Braa et al., 2004; Lefebvre, 1991; Pollock & Williams, 2008). To elucidate appropriation of the DHIS 2 software, the possibility for collective management within the Agora and the role that technology plays in transforming practice we need to understand the moments (elements) of this produced space as enunciated in Lefebvre's (1991) spatial triad.

3.6.1 The Spatial Triad

New technology, means new relationships between people, organisations and products, a phenomenon which is more acute in the current global paradigm where local changes imply the management of resources that are widely distributed (Robertson, 2012). The new relationships only have a real existence to the extent that they have a spatial existence (Lefebvre, 1991). As noted, Kaniadakis (2007) posits that a new space emerges with the development, implementation and use of generic software technology, and this space is considered as an agora. This agora is constituted of sets of relationships that emerge at the sites where a technological offering is adopted. A fitting metaphor, borrowed from Lefebvre (1991), that is used to account for the process of emergence and shaping of the Agora is 'production'. In explicating how such a space is produced, or the moments of its production, Lefebvre (1991) posits an interconnected triad. The triad is composed of (i) spatial practice (perceived space), (ii) representations of space (conceived space), and (iii) representational spaces (lived space) (Lefebvre, 1991; Zhang, 2006). Lefebvre (1991, p. 46) critically notes that "*it is reasonable to assume that spatial practice, representations of space and representational spaces contribute in different ways to the production of space according to their qualities and attributes, according to the society or mode of production in question, and according to the historical period. Relations between the three moments of the perceived, the conceived and the lived are never either simple or stable*". This shows that each space has its unique attributes which when analysed through a production of space perspective will surface different relationships between its three moments which also change according to the historical period. In essence, an identifiable social space can be deciphered through Lefebvre's spatial triad.

The 'spatial practice' maps a particular space to its social uses. The ' *spatial practice of a society secretes that society's space ... it produces it slowly and surely as it masters and appropriates it*' (Lefebvre, 1991, p. 38). The Agora, studied here, is the central space which ought to be secreted when generic software technology finds its way into local contexts of use (Kaniadakis, 2012). It is through the interactions of diverse sets of people representing developers, implementers and users of a generic technology that this space 'slowly' emerges and is appropriated. Representations of space are the conceptions of space as given by "*planners, urbanists, technocratic subdividers ... social engineers [and] artists ... all of whom identify what is lived and what is perceived with what is conceived*" (Lefebvre, 1991,

p. 38). Representations of space "*have a practical impact ... intervene in and modify spatial textures which are informed by effective knowledge and ideology*" (Lefebvre, 1991, p. 42). In the Agora, these could be constituted of visions, plans, standards, architectures and the affordances that shape use of the generic technology artefact itself (Kaniadakis, 2007).

Representational spaces are considered to be elusive in the triad of production of space (Carp, 2008; Zhang, 2006). They are lived spaces "*embodying complex symbolisms, sometimes coded, sometimes not*" (Lefebvre, 1991, p. 33). This space is "*directly lived through its associated images and symbols, and hence [is] the space of 'inhabitants' and 'users'*" (Lefebvre, 1991, p. 39). Representational space is "*alive: it speaks. It has an affective kernel or centre: Ego, bed, bedroom, dwelling, house; or:square, church, graveyard*" (Lefebvre, 1991, p. 42). Representational spaces are historical, and contain images and symbols which are appropriated by users and inhabitants over time (Lefebvre, 1991). Representational spaces partially escape coding through representations of space which rely on systems of texts which they exceed, but rather are more amenable to the coding through works of art or other writings which do not seek to change them (Lefebvre, 1991). The 'users' and 'inhabitants' occupying representational spaces such as health workers often accept new representations injected into their spaces passively, but can also resist, disappropriate or reappropriate them (Wasserman & Frenkel, 2011).

3.6.2 The Appropriation of Space: Making it one's own

The concept of appropriating space denotes struggle and process, sometimes slow, sometimes spontaneous and revolutionary. Lefebvre (1991) contends that by developing an understanding on the appropriation of space we surface the strategies through which it is produced. It is important to think holistically about the spatial triad as explained in the section above to illuminate this process. In particular, the symbolic elements that intercede in the production of space should not be neglected. According to Lefebvre (1991, p. 165), "*it may be said that of a natural space modified in order to serve the needs and possibilities of a group that is has been appropriated by that group*". In contemporary times, the pure space of nature is hard to come by and has been superimposed through historical changes in modes of production through capitalism and beyond (Castells, 2000; Lefebvre, 1991). New space is consequently developed on the bedrock of these pre-existing practices which can not dissapear completely and evidently continue to struggle for their restitution in contemporary

society. Some ancient cultures, such as in Africa can be thought to have appropriated the space of nature, building temporary shelters and adopting nomadic lifestyles based on seasonal patterns. While there is a tendency to romanticise the past, it can be considered that such type of appropriation occurred without domination which "*has grown pari passu with the part played by armies, war, the state and political power*" (Lefebvre, 1991, p. 166).

Appropriation is concerned with the use of a space to achieve the goals of a group. Domination is the emptying out of a space of its particular features and replacing them with technologies and their practices (Lefebvre, 1991). In the modern world, there is no shortage of dominated spaces. In the context of information technology, there are enormous, sometimes underground, data centres connected by grids of electricity, undersea internet cables supported by corresponding practices slicing through space. Large cities are also connected by elaborate motorways, rail systems and monumental bridges built and maintained by heavy industrial equipment all signalling the domination of space. While dominated and appropriated space can be, and ought to be combined, Lefebvre (1991) admits that it is domination that has been the winner, particularly where antagonisms persist. Within the Agora, hegemonic influences are abound, particularly in developing nations where external and neo-colonial influences have dictated the terms of 'development' aid (Escobar, 2011). In this context, the external space of the community can be considered dominated while the internal space of the state is appropriated. Consequently, the Agora can be considered as the site where the struggles of domination and appropriation unfold, where the global becomes local and the local becomes global and new practices emerge. It is within this framework that this study sought to understand the appropriation of generic technology, particularly by considering it as the appropriation of space. Once again it is important to remember that it is social space, consisting the triad of the perceived, conceived and the lived that is spoken about here – not space as emptiness.

3.7   Summary of Conceptual Framework

The preceeding sections develops theoretical ideas that can be useful for conducting a spatial analysis of a techno-organisational change initiative. At the core of the framework is the 'production of space' perspective of Henri Lefebvre which highlights that changes in the modes of production are real if only they become concrete in space. At the core of Lefebvre's (1991) conception is the realisation that social space is itself a mode of production and its

product. A change in technology gives way to the emergence of a new mode that can be analysed spatially (Smith, 2008). To conduct such spatial analysis Lefebvre (1991) proposes a spatial triad which links the mental space where conceptions emerge, the social space where they are perceived and the day to day life of the users where they are injected. Lefebvre (1991) surfaces a dialectic which operates to shape these aspects as new modes of production emerge, with particular emphasis paid to that of domination and appropriation. These ideas of Lefebvre (1991) have been supplemented with concepts from the information systems discipline where Pollock and Williams (2008) have demonstrated how a space which has been likened to the ancient Athenian Agora emerges when generic technology is adopted. The agora is a space which is continuously structured through the activities of the different actors as they bring technological promises into local contexts. While Kaniadakis (2009) has discussed the structuring of the agora, a clear framework to expound on this process has not been developed. This study has therefore utilised the conception of Henri Lefebvre on the *production* of this space. Production is concerned with the activity through which the agora emerges with generic software and how is developed in order that it may address the different needs of the diverse actors. Producing the agora is a process through which the different aspects of the triad of Lefebvre (1991), that is lived, conceived and perceived space, are shaped. The dynamic between appropriation and domination is understood in this study as the struggle between the diverse actors to appropriate the space to suit the multiplicity of agendas and resources at the disposal of different actors. Consequently the theory is a sensitising device to understand the imbalances that can be propagated with new technology and the possibility for collective appropriation of the agora, which would mean sustainable adoption of generic technology by users in developing countries.

The following section will present the research method after which the case studies are presented. Then, I will discuss the findings in relation to the theoretical ideas presented here. Finally, the implications of the work will be elaborated on, leading into the conclusion.

4 Methods

This study is a grounded case study on the development, implementation and use of generic open source health information software in developing countries. The grounded case study approach, whose tenets were adopted for the work, is a mixed method which aims at developing theory through case studies (Eisenhardt, 1989; Matavire & Brown, 2013). The use of mixed methods is considered essential in the study of large-scale generic software systems such as enterprise solutions which evolve at numerous localities and levels (Pollock & Williams, 2008). Alone, the case study method is an approach that is used to research complex situations where the boundaries between the phenomenon being studied and the context are not easily delineable (Flyvbjerg, 2006; Stake, 2005; Yin, 2013). It is possible to make theoretical or analytical generalisations from case studies (Stake, 2005). On the other hand, the grounded theory methodology is a research approach that provides analytical techniques for developing theory from empirical cases (Glaser & Strauss, 1967; Matavire & Brown, 2013; Strauss & Corbin, 1990). A number of studies within the information systems discipline have made use of a grounded case study approach (Matavire & Brown, 2013).

This research was concerned with theory development from cases in which two nations adopted the DHIS 2 software in the context of constrained and fragmented resources. It was action-oriented given the researcher's involvement in the planning and implementation stages of the interventions. Due to practical considerations that permeate public health sector interventions within developing countries, it was not possible to fully apply the principles of an action research methodology (Davison, Martinsons, & Kock, 2004). According to Maslow's 'law of the instrument', "*it is tempting, if the only tool you have is a hammer, to treat everything as if it were a nail*". For this work, it was essential that the design incorporated the reflexivity discussed by Alvesson and Sköldberg (2009) so that a faithful account of the unfolding phenomenon could be constructed. Given the aim of developing explanatory theory, the principles of the grounded theory methodology were applied in attempting to make plausible and relevant conceptual inferences (Glaser & Strauss, 1967; Matavire & Brown, 2013; Strauss & Corbin, 1990). The main principles from grounded theory adopted in this study are open coding, memoing and the constant comparative technique (Matavire & Brown, 2013). Open coding was done on empirical material obtained in the cases such as from interviews and other relevant documents, including project reports,

while seeking a suitable theoretical framework through a constant comparative method. Constant comparison involved the systematic review of literature guided by empirical observations.

4.1 Access to cases

A colleague in the PhD program invited me to participate in the pilot of a mobile health information system in Malawi. The Health Information Systems Programme (HISP) at the University of Oslo had been involved in the implementation of DHIS 2 in the country, a project which was beset by numerous challenges such as limited financing. The mobile pilot project was therefore conceptualised to attempt to bridge some of these concerns and improve the quality of data in DHIS 2 for which a window of financing was found. Access to the site of the pilot was requested from the Ministry of Health (MoH) through the PhD colleague and granted. It was possible to interact with actors at multiple levels of the pilot and observe other health information systems projects in the arena, such as an electronic medical record system being implemented in many of the facilities visited.

In the context of Zimbabwe, initial access was granted when a DHIS 2 based system was being implemented for a program in the Ministry of Health and Child Care (MoHCC). At this point, there had been no decision by the MoHCC to migrate to DHIS 2 across all programs. However, my presence in the situation and the subsequent interactions with ZimHISP, a project run by an international agency supporting HIS in Zimbabwe, provided a means to access stakeholders from the MoHCC. Discussions about my being a Zimbabwean based at the University of Oslo with the HISP project led to easier sharing of the challenges with a possible move to DHIS 2 for the country being discussed. Research permission was granted to a limited extent with interactions restricted to a few people in the national office of the MoHCC. With the serendipitous emergence of more funding from an international donor a few months later, a larger project was jointly developed which had a role for the University of Oslo. It is through this project that it became possible to involve more actors from the university, negotiate for more access and obtain clearance to interact with more people, particularly the users of the system. I consequently participated in training workshops, stakeholder meetings, email discussions and other forms of interaction with sufficient access to the multiple levels of the MoHCC's health information system.

4.2 Data Collection

4.2.1 The case of the Malawi mobile tools pilot

Having been invited to Malawi to participate in a pilot study on mobile health tools, I planned with my colleagues to spend 6 weeks (April to May 2012) in the field. I followed up on a project in which mobile phones had been given to health workers months prior, and training had been provided on how they could use the devices to enter data into the DHIS 2 database. I was only partly involved in the earlier mission when the training was done, and had been in Malawi for only a brief period then in December 2011. However, the follow up visit was much more structured and involved participating in the day to day activities to keep the intervention afloat. This involved planning and organising meetings with key stakeholders, and researchers, in order to understand their key concerns. It also involved negotiating with stakeholders and actors such as the mobile provider and donor agencies on how the project could be sustained. This was a team effort, where we discussed on a daily basis what was to be done, who we could talk to, when, and how to ensure that the project moved from piloting to a full scale rollout. In this period, activities were mainly centred on 5 healthcare facilities, that is Ukwe, Kabudula, Nsaru, Chankungu and 'Area 25', all located in a single district, Lilongwe. Furthermore, we spoke to officers at the Ministry of Health (MoH) headquarters and followed data-flow in the information system.

At the health facilities visited, four focus group interviews were held with health workers, that is Health Surveillance Assistants (HSAs), data clerks and nurses in charge. HSAs are health workers responsible for monitoring health at the village level and also collecting data and reporting it to the facilities of their respective catchment areas. They also engage in other outreach activities such as immunisation, and can also complement staff at health facilities, for instance when no data clerks are available. Over 15 health workers participated in the interviews which lasted over half a day at times. We also helped the data clerks with challenges that they encountered on their mobile devices, such as replacing SIM cards which had been damaged and configuring phones which were 'misbehaving'. Consequently, some facilities were visited repeatedly if issues had not been sufficiently resolved, or involved other actors such as the Blantyre based server administrators, Oslo based developers or the Vietnam based mobile development team. The field work involved interactions with a range of actors both locally, and globally through which the empirical material emerged. A number

of documents on the status of the health system were also shared with us in order to understand the condition of the HIS in the MoH.

Meetings were organised with the mobile provider in order to facilitate the resolution of challenges such as designing the appropriate payment mechanisms, airtime top up routines and refreshing data bundles on a regular basis. Meetings were also organised with actors from programs which were implementing other healthcare software solutions. The aim was to leverage the existing space to support the mobile pilot. We also interviewed members from the Ministry of Health (MoH) headquarters who were responsible for health information in Malawi, and followed up on the issues that they raised as pertaining to the DHIS 2 solution. While we were not able to resolve all the issues arising due to limited resources, we managed to keep the pilot afloat through our engagements and the project continued to grow. The primary method of data collection throughout these activities was the taking of field notes which enabled the simultaneous collection and analysis of data (Eisenhardt, 1989).

4.2.2 The case of the Zimbabwe DHIS 2 Project

The first visit to the Ministry of Health and Child Care (MoHCC), which was called the Ministry of Health and Child Welfare (MoHCW) then, was in February to April 2012, just before the 6 week field visit to Malawi. At this time, the MoHCC had not yet decided to implement DHIS 2. However, one of the partner programs to the health ministry had decided to engage developers of DHIS 2 based in Tanzania to customise an instance of the system. I was invited to train information officers and to help set up the system for the organisation. We decided with the partner program, called ZimRBF, to take the opportunity to engage with the MoHCC on their possible transition to DHIS 2. Consequently, I was invited to make a presentation on the mobile tools in DHIS 2 within the ministry headquarters, a topic I was familiar with given my ongoing engagement with the Malawi mobile project. Other presentations on the overall system were given by the Tanzania based consultant. It was during these presentations that I became familiar with the key people and organisations whom were interested in implementing DHIS 2.

Having introduced myself to the MoHCC and its health information systems partner (ZimHISP), I was asked to support the planned migration to DHIS 2 in "*any way possible*" given the constraints they faced. I expressed my interest to conduct action research in the implementation of DHIS 2, and volunteered to do what I could on a 'local' and 'global' level

to support the planned activities. Even as I stayed in Zimbabwe for 6 weeks, it was difficult to get opportunities for research as some key personnel were sceptical about the system. Given a small opportunity for funding, the University of Oslo supported two developers from organisations partnering the MoHCC to be trained on DHIS 2 in India in May 2012. Furthermore, we invited the MoHCC and ZimHISP to participate in a DHIS 2 training academy in Mombasa, Kenya, in June 2012 for which they sourced funding and attended. It was at this meeting that some discussions were held with HISP Oslo on how the MoHCC could be supported if it decided to rollout the system. What was important to note at this time was that they had minimal capacity and funding which made it impossible to buy even a laptop for their national health information officers. They had also been using DHIS 1.4 since 2010.

Towards the end of 2012, the MoHCC planned a pilot of DHIS 2 in one province. Eager to get access, which was not forthcoming, a visit to follow up for 4 weeks from January to March 2013 was planned. I presented my letter from the University of Oslo seeking permission to conduct research. I waited some weeks before getting verbal communication that it had been given the green light and could start interviews with health information officers and other managers. I managed to interview 1 developer, 1 director, and 3 health information officers. I also had a number of opportunities for meetings with 2 directors from partner programs. I also used the observation technique since it was evident there was limited access. I documented the challenges that had been discovered in the pilot and tried to resolve them, or engaged developers in Oslo for support. Overall, after this pilot, the MoHCC made a decision that it had been a success and the system could be rolled out nationally. I continued to take field notes of all the encounters I had with the MoHCC and its partner organisations.

Globally, discussions had been started between an international sponsor, the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund), and HISP Oslo to support the rollout of DHIS 2 in a number of countries, including Zimbabwe. In Zimbabwe, the United Nations Development Program (UNDP) and the MoHCC were also engaged in discussions with Global Fund to finance the implementations. A convergence of these discussions led to the disbursement of over 2.7 million US dollars to support the initiative, and other related health information systems projects, between July and December 2013. Participating as an intermediary, already engaged with the MoHCC and the University of Oslo, my role was to

support an effective collaboration. I assented given the tremendous opportunity to conduct more field work, and to finally obtain access to the health facility level which had been challenging. I was consequently involved in the construction of plans, writing of reports and drawing out budgets for the project. As part of this initiative, we planned 3 field visits between July and December 2013, of which only 2 materialised in July and in December.

Two senior DHIS 2 consultants from the University of Oslo joined the project. During the first visit in July, which was termed an exploratory trip, I went to Zimbabwe with one of the DHIS 2 consultants. We attended high level meetings with a range of stakeholders including heads in the MoHCC and diplomatic personnel from US agencies. We were also given access to the pilot province. We visited Manicaland provincial health office, Chimanimani district office and two rural hospitals, that are Chimanimani and Biriiri, which were already utilising the DHIS 2 system. The two hospitals visited had been provided with laptops for data entry. The district offices had also been provided with laptops. We interviewed officers at all the stations that we visited and took additional documentary evidence such as photographs. Over the two visits, we also observed the practices of the health workers, who were very cooperative and supported the rollout of the new system. Given that we travelled with the national health information officer, we were also involved in resolving and documenting user problems. I continued to take field notes to reflect on the visits and to develop emerging theoretical ideas.

During the second visit in December, I went to Zimbabwe with two DHIS 2 consultants. Given the background of the first visit, we aimed towards building the server infrastructure which had been allocated only a few thousand dollars of the millions. We organised a server and security training for IT experts from a number of organisations, including the IT unit of the MOHCC. We experienced some resistance as we had not been given access to the server room, or provided access privileges into the DHIS 2 system. These were firmly in the hands of ZimHISP, particularly a developer within the organisation. Requesting access, we were finally given permission to see the physical server room which was in a shambolic state and was used to dump technological waste, see Figure 2 below. Even though 4 new servers with significantly higher specifications had been acquired through the Global Fund budget, the space was inadequate for their set-up.

Figure 2 Room shared with servers in a partition to the right

 In addition to conducting training, we also managed to visit more districts in the pilot province of Manicaland. Once again we first visited the provincial office, as we had been kindly received by the officer on the previous visit. After this, and over a period of two days, we had meetings with information officers from the districts of Makoni, Mutasa, and Nyanga. In the mountainous and scenic Nyanga district we visited a total of 5 health facilities inclusive of a district hospital, two mission hospitals and two rural health centres. The health facilities visited are Mount Melleray Mission Hospital, Nyautare Rural Health Centre, Gotekote Rural Health Centre, Elim Mission Hospital, and Nyanga district hospital. At each facility visited, interviews were conducted with health information staff and nurses in charge in order to understand their usage and challenges with the DHIS 2 system. After the first round of funding by Global Fund, the project continued with the disbursement of more funds in 2015.

In February 2015, we planned a trip to Matabeleland South province which required the development of an integrated system for the eradication of malaria. We visited and spoke to health information officers at Matabeleland South provincial offices, Maphisa District hospital, Homestead Rural Health centre, Gwanda district offices, Beitbridge district offices, Chikwalakwala rural health centre, Chitulipasi rural health centre and Chasvingo rural health centre to understand the pre-existing elimination system and demonstrate a new Android based mobile prototype that had been developed by a Masters student. In all these encounters

I continued to take field notes and photographs while doing data analysis. Data collected in Zimbabwe during the study is summarised in Table 1, below. A total of 34 interviews were conducted, with participation in at least 12 meetings and 3 training workshops. More data was collected in formal and informal encounters surrounding the projects. The interviews were either semi-structured or open since I was dealing with an unfolding phenomenon where opportunities for data gathering had to be reflexively taken.

	Summary of data collected in relation to research in Zimbabwe	
34 Interviews	Health Program Directors	7
	Programmers	3
	Provincial Epidemiology Managers	3
	Health Information Officers	9
	Health Facility Workers	12
Other	Meetings I participated in	12
	Training sessions attended/facilitated	3

Table 1 Data Collection in Zimbabwe

4.3 Data Analysis

Data analysis revolved around five interrelated aspects involving different levels of abstraction, (i) the writing up of field notes (ii) the generation of conceptual codes through open coding (iii) the development of reports on interventions to share and obtain feedback from stakeholders and the development of theoretical memos (iv) continuous application of the constant comparative technique from grounded theory and (v) a continuous in depth literature review (Eisenhardt, 1989; Matavire & Brown, 2013). Earlier empirical material from both cases was entered into the NVivo software package for analysis. The technique applied on the material was open coding, which involves the line by line analysis of text to generate conceptual codes, sometimes *in vivo* (see Figure 3 below). 'In vivo' codes are those which are taken directly from the text to represent a conceptual category. Open coding in NVivo was largely restricted to the early and intermediate stages of the research. Much of the theoretical coding that occurred later in the study was through a literature review in pursuit of ideas that had traction with the empirical material and conceptual codes. Open coding generated numerous themes of enquiry but did not reveal the relationships among them.

Reports provided a frame of thinking towards a few core issues, and also provided an opportunity for discussions with stakeholders.
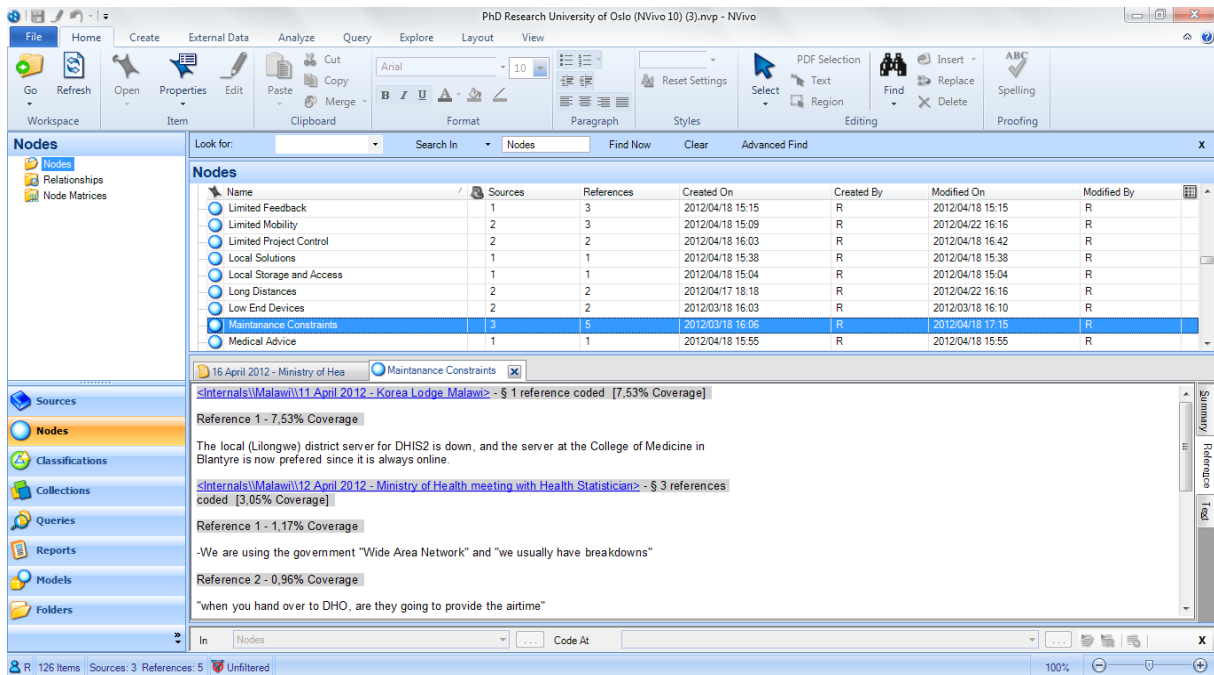
Figure 3 Screenshot of Open Coding in NVivo

There are three means through which conceptual codes can be generated from data (Glaser & Strauss, 1967). The first is a case whereby a researcher is guided by a specific research question, when he will seek concepts in the data guided by that question, that is to prove or disprove a proposition that has likely been obtained from literature. In this case all data is coded first, and then another stage where it is analysed follows. The second is when an analyst of data goes through the material looking for new categories and their properties based on pre-held notions and an evolving theoretical conceptualisation which is simultaneously integrated. The third, which Glaser and Strauss (1967) prefer for the generation of theory is 'constant comparison', which is a technique that involves both approaches highlighted above. It is also a technique that allows for the collection of data based on emergent hypothesis, and is open to the generation of 'new' theoretical conceptualisations. It systematises the second approach through its reliance on 'explicit coding and analytic procedures' (Glaser & Strauss, 1967). The researcher is not asked, as some have assumed to erase any prior conceptualisations from his mind, but rather that these should not be permitted to constrain the possibility for the emergence of alternative conceptualisations. The constant comparative method is "*designed to aid the analyst, who*

possesses these abilities, in generating a theory that is integrated, consistent, plausible, [and] close to the data" (Glaser & Strauss, 1967, p. 103). The limit imposed on the use of this technique was primarily that the study did not utilise the full 'classic' grounded theory methodology as espoused by Glaser and Strauss (1967).

4.3.1 Emergence of key concepts

The first stage of the constant comparative method involved coding each incident of case data into categories (Glaser & Strauss, 1967; Matavire & Brown, 2013). Many codes where generated through open coding which, as has been highlighted was done in NVivo. A particular incident which struck the researcher was when in a rural clinic in Malawi, a barcode reader that was being used to scan patient codes into an electronic medical system broke down. To alleviate this concern, a PhD researcher on the project got a new scanner and we had to hire a car in order that we could assist in resolving this concern. The mobile intervention that we were engaged in was meant to reduce such challenges since the idea was that these technologies should be easier to maintain in the local context of users given the proliferation of mobile phones. However, it emerged that there were numerous breakdowns, not only in the hardware, but the software and other organisational issues which required assistance from people who were not only distributed locally, but also globally. It is in this context that the concepts of 'breakdowns' and 'articulation work' emerged as central and informed 'Paper II' that is included in this thesis. As can be noted, 'articulation work' is a concept that is found in literature within the IS field, therefore a sensitivity to this literature was essential. Such theoretical sensitivity is essential in studies utilising grounded theory techniques.

When the study context shifted to Zimbabwe it was important not to take the concept and follow it up in the new context but to allow for emergence of new ideas, except if the data demonstrated otherwise. While there were divergent views on this amongst the researchers with whom the work was shared with, the decision was made to allow for further emergence. To improve theoretical sensitivity, there was a continued review of literature, particularly in the information infrastructures discourse. Within this literature there was exposure to concepts from complexity science, particularly on the 'installed base' as the foundation on which these technologies are used. A comparative technique was central as the researcher continually compared this literature with what was being observed. Ideas of an evolving

socio-technical base, which was being shaped, and needed to be shaped by the multiple stakeholders in order that the technology could be successfully implemented were explored. The metaphor of 'evolution' of this base was explored. Other ideas on 'attractors' and 'flexible standards' were also explored and led to publication of 'Paper I' in the appendix. However, the concept of 'network' started to emerge more strongly in the work. Ideas on inter-organisational networks were becoming particularly strong in the analysis. Literature on networks was extensively surveyed in order to develop these ideas. It soon emerged that this literature was very sparse and not well considered in information systems research but appeared in literature from other domains. The challenge was there was no central thread to this literature which was also largely quantitative given the large scale networks appearing in the social networking world. Ideas on shaping these networks were explored and a defining challenge led to the consideration of time and space.

A key challenge that was observed in the health information systems strengthening phenomenon was that it was difficult to claim that a network existed, except spasmodically. Each time that we engaged with the health systems players to conceptualise an intervention, small or large, it felt as though we had to start over from scratch. Literature seemed to point towards an exploration of the temporal aspects of networks and the work of Orlikowski and Yates (2002) and Sahay (1997) suggested that there was indeed a scarcity and need for such studies in the information systems discipline. Furthermore, Pollock and Williams (2008) suggested that the temporal dimension of generic information systems phenomenon was important in order to foster an understanding of these technologies. Ribes and Finholt (2009) also suggested that it was important to balance short term aspects of such projects with the long term dimension. Concepts to explore the spasmodic appearance of networks were explored such as kairos, which is a concept which highlights the significance of opportunity in the evolution of technology systems. In the same vein, issues on 'space' were also raised as key concerns relating to the evolution of generic software systems by Pollock and Williams (2008). As compared to networks, the idea of space was thought equipped to grasp the phenomenon as it did not take the pre-existence of networks for granted.

The central analytic technique of constant comparison was useful, as through all these developments it was important to ensure a balance between theoretical concepts and the empirical material. It was important to specify, despite the application of grounded theory

technique, which gap in literature was being addressed by this study. It emerged that in many information systems studies space and time were generally taken for granted (Pollock & Williams, 2008). Furthermore, in the area of generic software systems, these dimensions were emerging as needing development in order to account for the contemporary contexts in which these systems were developed and used (Monteiro & Rolland, 2012; Pollock et al., 2009). The metaphor of Agora by Kaniadakis (2007) reflected the state of the art in understanding these technologies through a spatial perspective as characterised by Pollock and Williams (2008). Further exploration of this concept, particularly its usage by Pollock and Williams (2008) surfaced influences from the social shaping of technology perspective (Williams & Edge, 1996). Development of the ideas within this tradition was difficult since they wielded largely descriptive qualities. The aim was explanatory theory development, and other perspectives were explored to capture the 'evolutionary' aspect of the agora. Colleagues in the research group were exploring ideas from Henri Lefebvre, whose work shaped much of the theoretical development that followed. In particular Lefebvre's ideas on the 'social production of social space' and 'appropriation' captured much of the empirical material and emergent theoretical constructs. The real challenge was in grasping them given the sparsity of literature in information systems on these concepts. Feedback from colleagues and experienced researchers was useful at every stage in refining the theoretical concepts. Consequently theoretical development is really an ongoing activity, and the concept of 'space' is open to further elucidation in information systems.

4.4 Reflections on method

The grounded case study approach enunciated here demonstrates an instance in which research methods are mixed in the pursuit of concepts. Using the techniques of grounded theory and case study within a single information systems research project is not novel to this study. What could have been novel was the level of reflexivity that characterised the usage of the techniques in this research due to its action orientation. Reflexive methodologies are relevant to the qualitative study of complex phenomenon such as health information systems (Alvesson & Sköldberg, 2009). While these technologies engender 'new' challenges for the field, they also present opportunities for 'new' ways of doing science (Nowotny, Scott, & Gibbons, 2001). Consequently, reflexive methods need to be encouraged in the study of complex information systems and I feel that in time as more studies emerge, they can be

further codified. This will lead to the emergence of new tools to study complex information systems phenomenon in addition to the 'biographies of artefacts' framework posited by Pollock and Williams (2008).

My role in both projects was supportive, and involved understanding the challenges experienced in the context and resolving them. In cases where I could not assist with my background, I would convey the challenges to those who had the capacity. This role was amplified in the Zimbabwe case given the closer engagement and my being considered as an external consultant. My engagement in this case included supporting customisation, bug fixing and reporting, coordinating software development, developing reports for sponsors and stakeholders, developing rollout plans and seeking funding. This work was well received by the senior management in the MoHCC as important for the successes recorded in the implementations. Health workers were eager to get the system running given the challenges that it resolved for them in their work, particularly the information officers. On the other hand there was mistrust among different stakeholders that felt threatened by the engagement of the University of Oslo. Furthermore, not all the planned activities were successful given the multiple responsibilities and commitments of the stakeholders involved. The action component of the study was useful to reassure the MoHCC that the research would make a concrete contribution to their work. The MoHCC expressed that they had in the past been involved in research studies which had not improved the circumstances of their work and I had to assure them that this study was action oriented so the practical output was an improved information system.

4.5 Ethical Considerations

Data obtained in this study was not shared with third parties, and was kept, with some reservations on a cloud which could be accessed only by the author. Other data remained in the note books of the author. All files were duplicated onto the local drive, and a backup was also kept throughout the study to protect against the event of accidental loss. Research participants were notified of the aims of this study, with much of the work conducted under the supervision of ministry officials who demonstrated a keen understanding of boundaries, perhaps given their sensitisation by the government since they are in charge of securing national information. A challenge occurred when the initial small research project in Zimbabwe, started attracting the interest of other global stakeholders who wanted to support

the initiatives in the country. When this occurred, efforts were made not to disturb the trust given by implementers of the system in Zimbabwe by not disclosing any information which was shared by participants; in particular none of the documents, interviews were shared. However, the growth of the project forced me to change my role to one where I was recognised as a consultant by stakeholders. This while typical of many contemporary research studies, can be consequential to the 'theory' (Nowotny et al., 2001). One advantage is that this allowed me to get further access to the research site. Care was taken to remain faithful to the original goals of the research despite the changes. I also attended a compulsory course on ethics in research to improve my sensitivity to possible issues of conflict. The domain of health information systems strengthening has many potential pitfalls as far as ethics is concerned, particularly given that the participants can speak out against a research activity (Nowotny et al., 2001). This was alleviated through collective development and sharing of reports on findings with stakeholders.

The issue of entering and exiting the field is particularly important in research. During a PhD study, this issue is moderated through the finite length of the research process. In this study, complete disengagement with the implementation and development of the DHIS 2 system is difficult since the research is conducted within a specialist discipline which is highly interconnected on a global scale. Furthermore, the engagement with donors in this study meant that I had some resources to implement projects within the context. I ensured that these resources were utilised for the tasks assigned with the reports generated for such projects maintained and shared with stakeholders. While it is important not to cause problems for informants in their work, some proposals which we presented to stakeholders implied the need for institutional rearrangements. It is fair to say that through this process I have witnessed significant progress in the health information system from early engagement up to finalisation of research. In that sense, I am also glad that I managed to make a meaningful contribution to these large infrastructural projects. However, from the critical perspective, the intervention into systems can be a cause of disillusionment. For instance, given the mere stature of the stakeholders involved, and their immense power, financially and politically, I have often had to battle finding some sort of meaning in continuing engagement with the work. In one sense, I had to guard against being used by people who might not have been bound by similar ethical concerns, which of course includes peers. In another sense, I had to accept that I could make some contribution which could positively impact the lives of the

participants therefore renunciation of the study did not become an option. The work that is presented in this thesis is wholly conducted by my hands as has been articulated in the methods, with collaborations on papers on which I have been main author. In the following section I provide a description of the cases and the context in which the work ensued.

5 Research Cases

In this section I will give an overview of the contexts in which the DHIS 2 technology was studied, that is in Malawi and Zimbabwe. The background of these nations and a brief history of the evolution of their national health management information systems is provided. The particular implementations of the DHIS 2 technology as experienced and followed is also provided.

5.1 Malawi's Context

5.1.1 Country Background

Malawi is a landlocked country in South Eastern Africa with a fast growing population which, was 8 million in 1987, rose to 14.4 million in 2011, and was projected to reach 16.3 million in 2016 (Kanjo, 2012; MOH, 2011). Occupying an area of 118,484 square kilometres (km²), of which 94,276 km² is land and the rest is mostly covered by lakes, the nation borders the three African states of Tanzania, Mozambique and Zambia (MOH, 2011). The nation has a population density exceeding 150 people per square kilometre, with some areas such as the Southern regions exceeding 180 people per square kilometre (MOH, 2011). However it is important to note that some official figures are contested due to a range of factors such as missing data on rural communities (Kanjo, 2012). The nation is divided into three administrative areas, that is northern, central and southern regions, and it contains a total of 28 districts, which are themselves further divided into Traditional Authorities (TAs) presided over by Chiefs (MOH, 2011). The nation had a literacy rate of 62%, and has up to 39% of its population living under the 'poverty line' (MOH, 2011). Malawi is currently considered as one of the poorest nations in the world, and was classified as a 'least developed country' by the United Nations (UN, 2011). The nation fares poorly, but is improving, on socioeconomic and health indicators such as the infant mortality rate, where 66 deaths occurred in a year per 1000 live births between 2005 and 2010, as compared to 81 from 2000 to 2005 (NSO, 2010). The nation does not have adequate systems to capture vital statistics such as registration of births and deaths (Kanjo, 2012; MOH, 2013). Citizens of Malawi did not have a nationwide identity system during the course of this study.

5.1.2 Malawi's Health System

Healthcare services in Malawi are provided at primary, secondary and tertiary level facilities by the government (60%), Christian Health Association of Malawi (CHAM) (30%), private institutions (3%) and alternatively through other care givers such as Traditional Birth Attendants (TBAs) (7%) (Kanjo, 2012). The health sector is administered by the Ministry of Health (MoH) through a hierarchical structure containing the national, district, facility and community levels (Chaulagai et al., 2005; Kanjo, 2012). It is at these levels that data is collected, analysed and disseminated to stakeholders. Two broad distinctions are also relevant in the Malawi health system, that is the modern and traditional healthcare system (Kanjo, 2012). The severe shortage of 'modern' health facilities and human resources in the sector, particularly in rural areas where more than 80% of the population resides, leads to a dependence on the traditional healthcare system which is constituted of traditional birth attendants and healers. Poor policies, such as the ban on TBAs from assisting child deliveries, have led to negative results such as a diminished trustworthiness of vital statistics (Kanjo, 2012). To meet the nation's healthcare service objectives, the MoH is dependent, to a high degree, on donor funding and technical assistance.

5.1.3 Malawi's Health Information System

The basic elements of a health information system in Malawi can be seen emerging in the colonial period where the British government in 1912 tasked village heads with the duty to collect vital statistics on behalf of the district officer (Kanjo, 2012). This colonial legacy can be observed in the continuing dependence of the country's HIS on a legal framework established in the African nations' 1948 Public Health Act, before it attained independence (MOH, 2013). To address these deficiencies, and the challenges of a growing population, new public health challenges and a legacy healthcare system, the Ministry of Health in Malawi initiated a reform project to develop a comprehensive health management information system starting with an assessment of the pre-existing system in 1999 (Chaulagai et al., 2005; MOH, 2003). The exercise led to the development of some interventions aimed at establishing a 'culture of evidence based decision making' (MOH, 2003). This culminated in the establishment of a nationwide integrated health management information system based on a minimum set of health indicators and utilising the DHIS 1 technology in the year 2002 (Chaulagai et al., 2005). Chaulagai et al. (2005, p. 378) noted that for "*the first time the*

country [had] continuous monthly data on all agreed indicators for each facility, district and the nation. It [was] also the first time that each public health facility and district health office [knew] the catchment area and population to be served".

With the DHIS 1 system, health surveillance assistants (HSAs) were responsible for collecting data at the community level on a weekly and monthly basis and reporting it to the health facilities. Each HSA would have a catchment area of responsibility which was assigned based on geography, population and training. For illustration, one HSA in a relatively accessible terrain could have a target population of 1600, while another in rocky and mountainous terrain could be responsible for a population of 700 people. Some of the catchment areas could be as far as 15 kilometres away from health facilities. HSAs utilised paper based registers to collect data such as on new births and immunisation. Shortages of registers were common, unless donors were targeting the area with their interventions. While each village was meant to have its own register, HSAs combined them due to shortages. On the job training was common, as a health worker noted "*we go to the assigned catchment area with the register and start registration while that HSA is around, and then next time they go alone*". However, sometimes after training some HSAs would still not have access to registers. It was the task of the senior HSA to receive reports and tally data from the HSAs in the catchment areas for forward transmission to the health facility, which also had to aggregate and submit data to the district through the health area. On this, a health worker noted "*in compiling we do not have any challenges, in submitting we suffer from transport difficulties*". Another retorted, "*transport is a main problem. We run out of material like stationary. We can stay three months no stationary*".

When data was aggregated at facility level it would be sent to the health area facility. For instance, "Area 25" health facility had 8 facilities for which it was responsible. They also obtained reports from some private facilities within the health area. Analysis of data also occurs at the health area facility, for instance when measles is detected they follow up until it is eradicated in the area. Similar to the lower levels, on the job training is conducted for the health information staff. Furthermore, due to transport and stationary shortages there were delays and inconsistencies in collating and transmitting health information to the district level. However, the health area officers were responsible for compiling data from the health facilities, including the health area hospital and transmitting it further up to the district. A

health information officer at this level noted, "*we only know that we are sending data to the District Health Office (DHO), not to DHIS, and we know it is going to headquarters*". At this level the information officer also highlighted the difficulty of collating data from different units within the hospital due to differences in coding schemes.

At the district level, the district health office receives registers from the health areas. These are in paper format and need to be entered into the DHIS 1 desktop system. After this, the data is sent to the national level in the standardised format. In Lilongwe district there was a challenge with internet connectivity and the information officer had to copy the data onto a memory stick and move to another office in order to email the files to the health statistics office at the national level. At the national level, internet connectivity was a huge problem as well with intermittent connections and long periods of unavailability. For instance, at one point internet connectivity to the government offices was down for 5 months. Furthermore, there was limited technical assistance internally in the headquarters of the health ministry due to limited skill levels of IT officer and the organisational structure where the officer was not the health statistics office. Numerous donors were involved in trying to resolve this challenge, particularly by seconding staff from their organisations since creating an IT position in the government unit can take years. These challenges in the MoH, particularly in rural areas, coupled with the emergence of a stronger mobile telephone infrastructure in remote communities led to the development and pilot of DHIS 2. This study focusses on a sub project to implement 'DHIS 2 Mobile' health tools to strengthening the HIS.

5.1.4 The 'DHIS 2 Mobile' Pilot

An additional health information systems assessment was conducted by the Ministry of Health and the Health Metrics Network (HMN) utilising a universally agreed framework in 2009 (MOH-HMN, 2009). HMN, which is now defunct, was a global network launched by the World Health Organisation which was aimed at strengthening national HIS. The assessment found a challenging health information context, which was characterised by an inadequate policy environment, limited infrastructure particularly in rural areas, poor coverage and use of vital statistics, inadequate institutions and a weak ICT infrastructure among other concerns (MOH-HMN, 2009; MOH, 2013). A key recommendation in this exercise was for the MoH to support the development of a national data warehouse – which led to initiatives to implement DHIS 2 technology to replace DHIS 1.

The MoH also collaborated with the University of Oslo to develop and implement mobile phone based data collection tools in 2011, and conducted the pilot later in the year. The mobile tools were consequently seen as a means to overcome the material barriers between the urban, rural, central, and peripheral arenas in the MoH where the DHIS 2 technology was to be utilised for data collection. The pilot was also organised with the goal to test and compare the suitability of a Java based J2ME data collection client and a browser based solution, also customised for mobile devices. The pilot planning and implementation was largely conducted by a HISP Oslo team of PhD students. Limited and erratic funding for these projects was at the time coming from the HISP Oslo budget. I participated in this study by supporting users of the technology through following up on problems that emerged in its implementation and attempting to theorise the results of the pilot.

A total of 17 health facilities from 2 health areas within Lilongwe district were engaged in the pilot. Of the 17 facilities, 9 from Kabudula health area were piloting a browser based 'DHIS 2 Mobile' solution. In the other health area, known as 'Area 25', a J2ME application was installed on the mobile phones of participants from the remaining 8 facilities. Nokia feature phones, model C1-01, were provided to 25 health information workers, with participants from 'Area 25' getting two phones per facility aimed at different datasets and users. Overall, 2 workers were trained on the devices in each health facility, particularly those dealing with routine health management information data and those dealing with notifiable disease data. Consequently, attitudes towards the sharing of, the usually personalised, mobile devices within the health facilities could be explored. A post-paid internet package for the devices was negotiated with one of the larger mobile networks in Malawi, a recurring cost which was borne through funding secured for the project through the University of Oslo. Usage of the devices within the contexts of the health facilities was observed in the pilots.

With the mobile devices, health workers could enter data into an online DHIS 2 server from the rural facilities. Internet connectivity was a key challenge in these settings as it was intermittent and dependent on the availability of electricity which was not reliable. Health workers also experienced other challenges, such as dependency on the limited data and airtime which was loaded onto the devices. In addition, given the coordination of the project by the Oslo team, if users faced challenges such as broken down SIM cards they had to depend us to resolve them. When health workers noticed the reduced transportation

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challenges with the new system, they stopped submitting data through the paper system. At the health area level for instance, data was no longer passing through in paper format for verification as it went straight to the server. At the district level, the officer who was receiving data in DHIS 2 from pilot sites and on paper from the rest of the facilities had to compile data into DHIS 1 from both systems. Other facilities had problems when personnel who were trained on the mobile system either left or were not performing data collection tasks, meaning the devices would be unused thereby impacting on data quality. In some health facilities that had electricity and computers, health workers preferred to connect dongles to the machines and access the web-based version of the system. At one facility, there were challenges of topping up data on the dongles. They noted that they still kept hard copies at the health facilities but did not need to travel long distances to submit the data. However it emerged that the workers needed more training and support on the system as they could not understand why it was not storing 'zero' data for instance. The DHIS 2 system could be configured to not store 'nil' values since this would unnecessarily increase the size of the database.

Numerous organisational challenges were also experienced in the pilot, starting from the conception of the pilot itself. For instance, the importation of mobile phones surfaced a conflict with the list of devices supported by the mobile provider, essentially making it impossible to configure the 'foreign' devices for Internet access on the local network. Consequently, new phones that worked on the mobile network had to be acquired in a local context. Challenges in the hosting arrangement around the DHIS 2 server also made it difficult to integrate the mobile pilot into the larger project. In addition, the MoH had limited support in integrating the DHIS 1 data into the new DHIS 2 system. With the existing DHIS 2 server hosted outside of the MoH, in a city 300 kilometres from the headquarters and within an organisation that had limited technical resources to support the ministry in its implementation, the mobile tools were difficult to implement. This meant that decisions had to be made on a suitable and sustainable server environment. At the point, an official from the MoH concurred that "*we have a central server which is supposed to be in this office. [The] department of HIV has a big server. It can be used by us as well as by HIV/AIDS. Actually AgencyX want to engage somebody to start maintaining that server. We want to meet next week to start discussing on this*". The ministry was highly constrained for technical competencies and financial resources, and dependent on fragmented donor support that was

uneven. For instance, up to 10 districts had no donor pledged assistance while 18 others had multiple commitments from aid agencies. Furthermore, the mobile provider struggled in providing flexibility in their products, failing to cater for the requirements of the pilot. Broader socio-economic conditions, such as nationwide fuel shortages at the time, not only affected the movement of data but also the production of the 'new' mobile technology supported information infrastructure.

When users faced challenges with functionality in the mobile tools, there was often a need to involve programmers located either in Vietnam or Norway. This was difficult as they had their own priorities. Locally, specific programs in the health ministry such as the HIV and AIDS unit had significant computing infrastructure which included large servers, IT administrators and were expecting a new fibre optic cable while the information unit was awaiting support from donors and other agencies for basic connectivity. Some agencies had difficult terms such as highlighted by a health information manager who noted that aid agencies "*put all sorts of conditions, like DonorY, they give you money, then you are supposed to liquidate and report. If they find that one department has not submitted reports, they stop funding for the whole ministry*". As highlighted earlier, for basic IT support, the information unit placed their hope on a donor organisation which was offering to second an IT expert to the ministry. This was necessitated by the sheer difficulty of creating a position in the ministry, also by the low remuneration in the public sector that was not attractive to experienced professionals. Furthermore, the socioeconomic conditions in the sector made it difficult to prioritise health information requirements in the national budget.

5.2 Zimbabwe Context

Zimbabwe is a landlocked Southern African nation, not far from Malawi, bordered by Mozambique (East), South Africa (South), Botswana (West) and Zambia (North). The country covers an area of 390,757 square kilometres (km²) and is divided into 8 administrative provinces, and two cities with provincial status, altogether containing 62 districts. A nationwide census in 2012 revealed that the nation had a population of over thirteen million (13,061,239), a population density of 33 people per square kilometre, an infant mortality rate of 64 deaths per 1000 live births and a life expectancy at birth of 38 years (ZimStat, 2012). Zimbabwe has also been prone to a number of droughts and, like most nations, has experienced shifting socioeconomic fortunes which were exacerbated through structural

adjustment programmes in the nineties (Gary, 1996). Many socioeconomic gains made in the nation after independence from Britain in 1980 were eroded during a period of unprecedented economic decline triggered by numerous factors after 1997. This period was followed by the rapid redistribution of land from white farmers to black families. The consequences of this were dire, with many international agencies rolling back their support for the government even in key areas such as healthcare, and Britain rallying the world to take punitive measures. As a global and local political battle raged, a humanitarian situation emerged from this. This was characterised by mass outmigration of an educated and experienced Zimbabwe workforce and the collapse of state institutions which was marked by record breaking inflation rates by 2008. To alleviate these troubles, the nation abandoned its local currency, adopted the US dollar and South African rand among other currencies as official tender. They also formed a government of national unity for 5 years from 2008 to 2013.

5.2.1 Zimbabwe's Health System

In Zimbabwe, healthcare services are provided at primary, secondary, tertiary and quaternary level health facilities. Primary facilities consist of rural health centres and small clinics in urban areas, with the secondary level consisting of larger facilities such as district and mission hospitals, the tertiary level being provincial and general hospitals and the quaternary level having the central and specialist hospitals. Ideally, patients are meant to be referred from the primary level, up to the next, depending on the acuteness of the condition, but often the higher level facilities are preferred for better services and shorter distances (MOHCW, 2010). There are over 1500 public health facilities in Zimbabwe. Healthcare delivery in the country is decentralised, with services provided in an integrated way at the relevant healthcare service levels. The public health system in Zimbabwe is organised into facility, district, provincial and national levels. There is also a community health level reporting to health facilities where we can find village health workers.

5.2.2 National Health Information and Surveillance System

The health information system in Zimbabwe has a legacy spanning pre-colonial times, even as it had been originally developed on a premise of a racially segregated healthcare sector (Sanders, 1990). The colonial system had no uniformity in data capturing and dealt with data mostly from major health facilities. According to Sanders (1990), the colonial *system had all the features typical of an inappropriate, inequitably distributed developing country service,*

compounded by inequalities based on racial discrimination". While racial segregation is largely a thing of the past, much inequality has persisted in the healthcare system with most affording Zimbabweans shunning the public health sector for 'better' private and international care (MOHCW, 2010; Sanders, 1990). The pre-existing information system was reviewed in 1984 leading to a pilot of a new paper based National Health Information and Surveillance system in two districts in 1985. The pilot led to the production of new data entry formats and the training of health information staff between 1986 and 1987, soon after which the system was rolled out nationally in 1988.

As the strategic importance of health information became recognised in the MoHCC, a celebrated certificate program was initiated in partnership with a local polytechnic college to train health information staff in the nineties. However, during the period of economic decline, from 1997 onwards, the health information system suffered due to extraordinary rates of outmigration of the trained information officers whom were in demand regionally and internationally. Despite the encroaching collapse of the system, the Zimbabwean HIS was still recognised as the best in the region and was given an award in 2004 (MOHCW, 2010). However, continued drastic decline characterised by fuel shortages, donor withdrawal, severe power outages, outmigration, hyperinflation and an increasing disease burden – epitomised by a cholera outbreak in 2008 which led to the death of more than 4000 people – marked the collapse of the health system. The celebrated certificate program for health information officers lacking funding was also suspended in this time period. With the advent of the government of national unity, a 100-day action plan to 'get *the healthcare system functioning again'* was initiated in March 2009 (MOHCW, 2010). The importance of the health information system was recognised, leading to the emergence of the Zimbabwe health information systems strategy, alongside the national health strategy (MOHCW, 2009a, 2009b). A health information systems implementation plan was also produced to guide the interventions.

The outcome was that the state chose to implement the DHIS 1 software, with a pilot in March 2010 and nationwide rollout starting in August 2010. Data collection formats were also revised. At the facility level, the health worker (who is usually a nurse), maintains a set of paper registers making up the health information system. These include tally sheets, notifiable disease forms, monthly return forms among other registers. In some health

facilities, shortages of specific registers leads health workers to improvise and create similar registers on plain paper. Once filled, standardised aggregate reports are sent to the district level utilising whatever means available such as ambulances or visiting agencies. The district information officer (DHIO) captured the data from health facilities in their catchment area into the DHIS 1 software. The data file would be exported and sent to the province, where after further review and consolidation, the information would be emailed to the head office. The process, from the incidence of a condition to receiving the data at the national level, could sometimes take between one and two months. However, at the facility level it was clear that the practice of data collection and analysis has been institutionalised since prior to DHIS 1 as can be seen in Figure 4 below.

Figure 4 Catchment area charts in rural health facility left and registers on the right

While the DHIS 1 system performed well regarding accuracy of data, it fared poorly on timeliness of reporting to the national level (MOHCW, 2010). A key factor that made it difficult to report data from the facilities to the district was limited transportation, more acute in rural areas. To circumvent the challenge, particularly in regards to time sensitive data for notifiable diseases, a weekly disease surveillance system based on the open source FrontlineSMS software was implemented on mobile devices. The system was successfully rolled out across all health facilities, where they entered selected data weekly through feature phones into a remote repository. However, even this system suffered due to lack of airtime on the devices, system bugs, limited electricity for charging the phones, poor mobile network connectivity and broken down phones. To circumvent such challenges, the district officers could sometimes call the facilities to get the data, even as they used their own financial resources. Other innovative health workers could send the data to the district via SMS. Two

examples of the messages sent to district officers on suspected and tested cases of disease for rural health facilities are:

i) *"Sus Mal 3 13 tested 3 13 pos 0 3 diarrhoea 2 8"*

ii) *"Rdns for .. clinic. Susp mal 25&59.tested 25&59.pos 15&48.diarr 2&3.influe 17&11"*

These messages were sent to district officers using simple SMS technology, when the FrontlineSMS system had 'broken down', due to phone loss or application malfunction such as failure to receive data submission notifications. In 2012, DHIS 2 was piloted and eventually rolled out to aid in resolving some of these challenges. This study discusses this rollout and theoretically elaborates on some of the key findings during implementation and development of a generic software on top of this pre-existing system.

5.2.3 The Nationwide DHIS 2 Implementation

The MoHCC began a pilot of the DHIS 2 software in one of its 10 provinces, Manicaland, found in the eastern region that borders Mozambique, in November 2012. At that point, the pilot was conducted through a MoHCC partner organisation, ZimHISP, and was quickly declared a success by March 2013. ZimHISP through funding from US agencies had also been engaged with the prior implementation of DHIS 1 in 2010. This had been done with some support from the South African Health Information Systems Programme (HISP SA). ZimHISP was operating from the MoHCC headquarters, highlighting a close relationship between it and the ministry. It consequently played a significant role in the ministry's decision to migrate to DHIS 2 through its offer of technical support. By the time the MoHCC had conducted the pilot, discussions with HISP Oslo to support the initiative had been started, at a time when there were minimal financial resources. During this early migration period, even the senior national health information officers did not have laptops consequently needing to carry the national server with data when they travelled through the country for training or other data oriented activities.

After the declared success of the pilot, and the decision by the MoHCC to migrate its HIS to DHIS 2, the project started to generate a lot of discussion at the University of Oslo, with potential international funding partners such as Global Fund emerging thereby raising the level of political engagement and scope of the project. A donation of 2.7 million United

States dollars was consequently secured for the project through efforts by the MoHCC, UNDP, Global Fund, ZimHISP, HISP Oslo and ministry health programs. The funds were also meant to support the development of an electronic medical record system. For the DHIS 2 implementation, HISP Oslo offered technical assistance and quality assurance, with ZimHISP being the local implementation partner. Local technical development support was expected from UZDev and other vertical disease specific programs. Over the roll out period, other nodes of the global DHIS 2 community such as Tanzania were involved. It was important to include disease programs since according to the strategy their data flows were to be integrated with DHIS 2. Furthermore, some of these disease specific programs had significant technical capacity such as system administrators, programmers and implementers whom could theoretically be leveraged for a successful DHIS 2 project.

Over 1300 laptops were acquired for information officers and managers at the national, provincial and district levels, and also those at large facilities such as rural health centres. A training of trainers workshop was organised by the partners, and marked the initiation of the nationwide rollout of the system. Contracts were offered to 2 competing bids to lay a fibre optic cable network to all the district health offices in the country. Where accessibility was a problem, satellite technology and other mobile options were also pursued. A training schedule was also designed and rolled out across all provinces in the country in the duration of the project, that is from June 2013 to December 2013. One caveat was that the donor funds had to be utilised before the December deadline. The University of Oslo organised a team of three, of which I was included, to conduct consultancy visits in that timeframe, of which only two materialised. The major tasks for the university consisted of supporting the configuration of the system, assuring the quality of the plans and also the development of a secure server environment, while simultaneously helping to resolve bugs and support training initiatives. The tasks also included the development of local capacity to ensure that future resolution of challenges occurred mostly in a local context. Furthermore, if a team of experts was developed, they could also participate in global development initiatives in the DHIS 2 community.

In reality, the collaboration was difficult, beset with many challenges and inevitably failed to reach its core objectives for the time period. At the centre of the project, ZimHISP being housed in the MoHCC contributed to delays in providing system access to key consultants

from HISP Oslo. A programmer at ZimHISP had full control of the DHIS 2 system and had an arm's length relationship with a HISP Oslo consultant who could have participated in DHIS 2 customisation and server configuration. The argument was that if access was given to the Oslo consultant it could raise resistance on the overall project in some quarters. This was despite the fact that the MoHCC had already given the go ahead to provide this essential access. On the other hand, the MoHCC had limited control given that they depended on ZimHISP for different aspects of the system as they did not have any technical expertise within their organisation. Given the limited skills of ZimHISP, benefit could have been obtained by engaging the UZDev project at the University of Zimbabwe which had a number of programmers. However, pre-existing challenges in collaboration between the two agencies made this difficult. UZDev also had its own interests as it was seeking funding from some US agencies for its projects.

The IT Unit in the MoHCC was basically isolated from the project and had little say in the implementation process, except that they managed the poor server environment in the building. Much of the IT work regarding the maintenance of the system was outsourced to ZimHISP which had limited capacity. This included keeping backups, managing the servers and customising the system. The newest databases where in the hands of the ZimHISP programmer. The information unit in the MoHCC was facing numerous challenges with the technology, in which case support was limited. They had no other route to express the challenges they faced except through ZimHISP, which was also constrained. Inevitably they failed to utilise some of the functionality in the DHIS 2 system which could have aided in their work. In the meantime, the server suffered from erratic downtime an issue which impacted health information workers. While the internet had been improved at the district level health facilities, it had remained inadequately addressed at the national level. A project to improve internet connectivity to the MoHCC proved a difficult task. The core issue was that internet connectivity was provided by a government agency which had limited capacity. To get better connectivity, the server was moved from building to building, changing IP addresses. Users of the system were also suffering during these shifts as it was not communicated to them. The option of utilising a cloud solution proved a sensitive issue to which few assented.

At the facility level, challenges remained with access into the DHIS 2 system. For instance, some of the health workers who had been trained on the system had very limited IT skills. Consequently, they would simply stow away the laptops which they also could not use due to erratic electricity and internet connectivity. Furthermore, when they experienced challenges in utilising the system, they received limited support from the district, provincial and national levels. For instance, a health worker entered wrong data on malaria cases and when this was seen at the provincial level in the DHIS 2 system, the relevant officer thought that there was a disease outbreak in the region. It was only after following up that they realised that it was mistake in data entry. On trying to correct this error, they realised that they did not have the right privileges. The process to resolve this challenge through ZimHISP took over a period of six months. On the other hand, another health facility was faced with a challenge of entering data into the DHIS 2 system since the trained worker had left the centre. Access to the laptop was managed through an Internet based software and they also could not create a new user on the laptop. To get support from the national level or ZimHISP was neither easy nor straight forward for these users. As one manager noted "*I think as we speak we have lots of technology around and we have pushed a lot of computers and other gadgets down there. But we have a small, I wouldn't say a small challenge, but a big challenge with one, IT skills themselves among the health workers involved in data collection and transmission*". The MoHCC with donor funding later contracted a number of IT personnel, one per province, in order to decentralise the resolution of these and other challenges.

Given the aim to integrate vertical silo systems in the MOHCC through the implementation of DHIS 2, it was a challenge to get personnel from the programs to participate. It was noted by participants that some projects had significant donor resources and would continue to develop their own systems. The malaria program, which had a weak information system and limited resources demonstrated the keenest interest to work towards DHIS 2 integration with the Oslo team. Consequently, a project to develop an Android operating system based mobile malaria pre-elimination system for Zimbabwe was started by HISP Oslo in early 2014. It was only after significant momentum in the project that the capacity to integrate different systems through DHIS 2 was recognised by other programs which had more resources. Earlier on, other stakeholders had noted that they were focussed on "*implementation and not development*", a challenging position given the open source nature of the DHIS 2 technology and the broader developmental agenda in Zimbabwe. Getting the actors involved in a

collective process towards an integrated HIS was a difficult and politicised task given the divergent interests and different funding sources of the programs. For instance, it was difficult to obtain documents on an electronic health record project which was ongoing and related to the DHIS 2 intervention.

Overall, after the period of national rollout of DHIS 2 to every district elapsed, the MoHCC was still sitting on a weak national server infrastructure, a weak IT unit, politicised and restricted system access where only a developer from ZimHISP was allowed full privileges and control to the physical and virtual spaces of the system. This emerged as a salient risk to the implementation's ability to reach its objectives for all actors involved. Users were suffering due to lack of timely support when they experienced bugs, or misunderstood the operation of the system – compounded by a lack of IT skills. Local implementers of the technology had limited understanding of the paradigm shift that the new technology implied, choosing to instead keep an arms-length relationship with other stakeholders such as HISP Oslo. The ministry also had limited physical ownership of the system. Consequently, considering the generous investment into the MoHCCs HIS by donors, other countries such as Malawi had achieved significant results in some aspects, notwithstanding their longer and still unfolding history with the DHIS 2 system.

6 Findings

To summarise the findings, I will make a presentation of the four papers that were developed for the thesis. Further to this, I will also synthesize the findings from the papers at the end of this chapter. The selected papers are:

(I)   Matavire, R., Chidawanyika, H., Braa, J., Nyika, P., & Katiyo, J. (2013). Shaping the Evolution of the Health Information Infrastructure in Zimbabwe. *Journal of Health Informatics in Africa, 1*(1).

(II)   Matavire, R., & Manda, T. D. (2014). Design Breakdowns As Opportunities For Articulating Mobile Health Information Infrastructures. *The Electronic Journal of Information Systems in Developing Countries, 63*(3), 1-17.

(III)   Matavire, R., Jolliffe, R., & Braa, J. (2015). *Co-optation to Production : Addressing Risk in HIS Implementation and Development.* The 13th International *Conference* on Social Implications of Computers in Developing Countries, Negombo, Sri Lanka.

(IV)   Matavire, R. (2015). *Health Information Systems Development: Producing a New Agora in Zimbabwe.* Working paper under review in the 'Information Technologies and International Development' journal

I was the primary and corresponding author in all the papers presented above. This means that for all papers I was involved in data collection, data analysis, conceptualisation, theoretical elaboration and writing. I coordinated the process in all multi-author papers, and shared with the others to get feedback on the emerging ideas and also for them to contribute their ideas to the manuscripts. Paper III was collectively developed by the authors, from data collection through analysis and writing. The last paper was single authored. Summaries of the papers and the contributions they make to the emergent conceptual framework and to practice are provided in the sections below.

6.1 Paper I: Shaping the Evolution of Health Information Infrastructures

Purpose - The paper represents an early effort to develop a holistic theoretical explanatory account on the development, implementation and use of the DHIS 2 technology within the context of Zimbabwe. To confront this issue, the paper leans on literature within the information infrastructures discipline and makes use of the 'shaping' and 'evolution' metaphors to account for the techno-organisational change effort and the means through

which it can be controlled in order that objectives of the interventions are met. Even at the early stage of the research project we see this paper trying to develop theoretical concepts for relationships between the inter-organisational network level of implementation, the global development of the generic technology, and the localised strategies of users in its appropriation.

Research Approach - A mixed research method leaning on the networks of action approach and a grounded theory inspired analytical process was utilised in the study. This was also due to the participation of different authors coming from different backgrounds. Data was generated first through participation in the health information systems strengthening initiative initially as an action researcher, then as a consultant tasked with quality assurance on the project. Interviews were done with implementers across organisational boundaries and through the multiple levels of the national health information system in Zimbabwe. The interviews were either semi-structured or open and could also be performed in panels. Official documents, emails and other literature was reviewed to obtain a good understanding of the system. The observation technique was also utilised in order to understand the work practices. Theoretical inferences were also developed through conducting a review of literature within the information infrastructures domain.

Findings - The paper demonstrates that shaping interactions at the inter-organisational level through choices of technology, standards and the development of policy is critical for health ministries to meet their HIS strengthening objectives. The study also demonstrates that it is however insufficient to concentrate solely at this politicised level of analysis, as understanding the relationships between this inter-organisational arena and the user context can provide a relevant frame for explaining the evolution of the DHIS 2 based information system. The study does not go as far a developing an overarching theoretical framework, yet it surfaces the elements of such a theory through demonstrating the alignments and conflicts between developers, implementers and users of the generic technology.

Theoretical Implications - The study represents an effort to synthesise micro conceptions of information infrastructures with their meso and macro aspects. It therefore demonstrates a clear theoretical gap in extant literatures' theorisation of generic health information systems development, particularly in developing countries. Such literature has hitherto largely focussed on either the institutional level or the level of practice in accounting for

contemporary techno-organisational phenomenon. Therefore, this work began to seek an understanding and theoretical framing of the relationships that exist between the inter-organisational level, the user level and decision making processes among stakeholders.

Practical Implications - The theoretical ideas discussed in the paper were grounded in the context of implementation of the DHIS 2 technology. The work demonstrates the practical challenges of intervening with information technologies at a single level and encourages a broader understanding of the dynamics of techno-organisational change if the systems are to be appropriated locally. It deals explicitly with the challenge of collaboration across organisational and institutional boundaries in the development, implementation and use of information systems. It points to the weaknesses in the health information system such as poor collaborative practices which need to be addressed if the DHIS 2 system is to be successfully appropriated.

Contribution to theoretical framework - The study surfaces aspects of the techno-organisational change phenomenon, which is the system supplier level, decision making inter-organisational level and the level of users. It points to, without full elaboration, a theoretical need to understand the interrelationships between them. Such a conception is necessitated in the domain of health information systems strengthening given the persistent fragmentation of the space and the many dispersed actors with multiple interests who collectively shape local interventions. The paper presents, descriptively, an early theorisation of the generic health information systems phenomenon in the local context.

6.2 Paper II: Articulating Mobile Health Information Infrastructures

Purpose - Mobile technologies are perceived to present new opportunities for the development of sustainable health information infrastructures in developing countries and this study describes a project that sought to integrate such technology into the national health information systems within a limited resource context. The challenges are discussed from the level of practice, where numerous actors participated in attempting to institutionalise the technology. To demonstrate the challenges experienced by users and the processes that they undertake in order to avert them the concept of 'articulation work' was used, and extended to account for the more distributed manner in which threats of break downs in the innovation are addressed.

Research approach - The study leans on the action research paradigm and utilises the principles of grounded theory in developing a conceptual account of the phenomenon. The pilot was designed based on a conception from information infrastructures where users and stakeholders are continuously enrolled into an emerging information system. Empirical material was collected through participating in the pilot project, panel interviews, official documents, individual interviews and observation. Field notes were taken and analysed in the NVivo software for conceptual categories. Literature was used to develop the emerging theoretical conceptualisation of the phenomenon.

Findings - The finding is that what might seem like a localised problem when mobile interventions fail, can be in fact require an institutional, inter-organisational or global solution. It also demonstrates that while mobile technologies have indeed attained widespread usage in developing countries, the use and sustainability of mobile applications in the healthcare sector still requires wide-ranging techno-organisational collaboration sometimes with private entities. In the case of Malawi and within the limited duration of the study, limited funding for the project constrained the development of the necessary networks to support the innovation locally.

Theoretical implications - The study shows that practice oriented conceptions of contemporary techno-organisational change can and ought to be extended to account for the global contexts in which technologies emerge and are shaped. It shows the local difficulties that are presented by the distributed forms of technological innovation which should be addressed if such interventions are to persist. The study particularly points towards the necessity of developing theoretical conceptions that shed light on how to leverage distributed organisational contexts for successful appropriation of technology in developing countries.

Practical Implications - The study shows that mobile technology interventions in the healthcare sector that depend on a client-server architecture still require significant investment into physical infrastructure and consequently cannot avoid political considerations in this arena. Despite the widespread proliferation of mobile phones, a lot of the applications that appear on the client side depend on significant infrastructural investments down the stream. This demonstrates the opportunity that exists overall for the development of more mobile centred technologies within limited resource settings and the need for political

strategies to concurrently aim at strengthening the organisational IT structures on which they depend.

Contribution to theoretical framework - The study is an attempt to develop a practice oriented conceptualisation for explaining a distributed techno-organisational change phenomenon. It is therefore an interpretive analysis of how users of generic mobile technology appropriate it to their local contexts. It demonstrates the entanglement of the global in the local and the need for underlying modes across these arenas to be understood and developed if generic technology is to be successfully appropriated. The study deals with the specific issue of breakdowns as a means to understand the production of a system. However the concept of breakdowns is not adequate to give an account of how less catastrophic and softer aspects such as decisions to adopt and choices of technology also shape appropriation processes. A broader theoretical framing was therefore needed to more faithfully capture the phenomenon.

6.3 Paper III: From Co-optation to Production

Purpose - The paper develops a theoretical conceptualisation of the challenges experienced in producing a central server infrastructure for a web based health information system in Zimbabwe. It utilises the spatial conceptualisations of Lefebvre (1991) to demonstrate the politics of appropriation of the server space, and the domination of more politically aligned actors in what needs to be a collective developmental process, and the path dependencies that are observed as the phenomenon unfolds. The challenges of collaborating that emerge from the pre-existing configuration of actors are highlighted, along with the strategies that can be adopted so that the technology is appropriated.

Research approach - The study followed an action oriented grounded research approach where data was collected through interviews, a training workshop on implementation risks and participation in the resolution of challenges. This occurred in the context of a DHIS 2 project involving the large scale rollout of internet infrastructure and computer hardware in Zimbabwe. The theoretical ideas that shaped the paper emerged through discussions among the authors and a review of literature that could be useful to interpret the phenomenon. The paper is also developed from reports that were written by the authors and shared with the stakeholders in Zimbabwe.

Findings - Political challenges in the appropriation of the new server infrastructure led stakeholders and users to make do with an untenable hosting solution run by the MoHCC and ZimHISP which had bad internet connectivity among other issues. Furthermore, absence of clear access protocols restricted positive contributions from other stakeholders. The study shows that some sacrifices need to be made at the decision making level in order that technological changes at user level can be possible. Pre-existing relationships between actors, uneven relationships and conflicting interests can become a barrier to reaching HIS strengthening objectives.

Theoretical implications - The spatial conceptions of Lefebvre (1991) are appropriate tools to understand and intervene in generic software implementations in developing countries. These concepts are useful in understanding how different actors in a fragmented space can be organised and come to shape the appropriation of an information system. Arguably, theoretical ideas that have emerged in the study of such systems have not paid adequate attention to the material, and spatial aspects of technological appropriation. The conceptions of Lefebvre (1991) are therefore useful in addressing those weaknesses and should be encouraged in the discipline.

Practical implications - The ideas of Lefebvre (1991) have the implication that technologies meant for developing countries should increasingly be oriented towards developing collective frameworks for server hosting given the persistent difficulty of building large data centres for keeping data by individual actors. We find donor agencies in many developing countries having greater capacity to run server infrastructures with national data compared to government agencies. Governments are left with the choice to have poor connectivity or to host have their systems controlled by these agencies. Risk assessment exercises as performed in the study are valuable tools for bringing up and discussing the concerns around server infrastructure with concerned stakeholders.

Contribution to theoretical framework – The paper was an attempt to understand an unfolding sociotechnical phenomenon through the ideas of Henri Lefebvre on the production of social space. In this paper the ideas on the appropriation of technology within a spatial context are developed. The idea of co-optation enables the research to problematise some relationships between health ministries and donor agencies. It also enables the possibility for a reflection of the meaning of such relationships for the appropriation of technology.

Borrowing Lefebvre's (1991) ideas on 'production of space' is seen as a fruitful direction for IS research, yet the concepts presented in this paper were not fully elaborated and needed further development.

6.4 Paper IV: Producing a New Agora

Purpose - The paper aims to develop a broader conceptualisation that can be useful in understanding the context of a generic health information systems' adoption and use. In particular, it draws upon the agora metaphor to form a bounded perspective of the distributed and fragmented space in which the technology is developed implemented and used. It frames the dynamics that occur in the arena as processes and struggles around the appropriation of the technology. The struggles of appropriation are consequently the struggles of power and control that unfold within a space dominated by non-government and government agents. Ultimately, the framework provides a means of conceptualising and intervening in the agora to achieve desirable outcomes.

Research approach - The study followed a grounded case study approach in order to investigate the phenomenon. Data was collected over a period of 3 years by following the development, implementation and use of the DHIS 2 based health information infrastructure in Zimbabwe. Interviews, observations, official records and other secondary data sources were pursued. A predominant method of record keeping and analysis was the use of field notes. Reports were also produced on behalf of the varied stakeholders in the arena. Data analysis revolved around the constant comparative technique which involved a continuous review of literature in order to develop a richer conceptualisation of the empirical material. Other analytical techniques were also utilised such as memoing and discussion.

Findings - Among the numerous findings are (i) mobile technology has the potential to advance the broader goals of health information systems strengthening by presenting the possibility of a decentralised infrastructure yet there are risks that the benefits of such technology can accrue to players more strategically positioned in the agora, (ii) consequently, it is important to be organised locally in order to balance global domination or counter it by generating local value from innovation. (iii) The centralised client-server infrastructures in developing countries are problematic given the poor resource settings where server hosting capacity is highly constrained and (iv) the spatial basis on which such Internet-based systems

emerge is taken for granted in such projects. There is a need to collectively develop the agora so that the different aspects above can be addressed through a holistic framework.

Theoretical implications – The paper conceptualises appropriation of generic technology as a spatial phenomenon, particularly the development, implementation and use of technology in local contexts as the production of space. It consequently make two clear contributions to theory in information systems, (i) that appropriation of technology can be seen as the appropriation of space where generic software is concerned and (ii) pre-existing spatial conceptions in the discipline can be extended through the work of Henri Lefebvre. This broadens the understanding of what appropriation of technology means, particularly in the domain of information technology in developing countries (ICT4D or ICTD).

Practical implications – There is a risk that without a paradigm shift in the conceptualisation of generic technology, much of the touted benefits will not be realised. In this case there is the risk that the differing interests among stakeholders can get in the way of developing an infrastructure that is appropriated by the users. Despite the significant investment into the development of the health information system, many basic aspects such as focussing on the user level and the development of a server infrastructure were largely ignored. There is need therefore to support the development of the users, particularly as their IT skills are constrained.

Contribution to theoretical framework - This paper develops and applies a spatial theoretical framework of the development, implementation and use of integrated health information systems in developing countries. Utilising this framework it is possible to uncover the social, physical and conceptual relationships and dynamics that are implicated in the realisation of technology change initiatives within these nations. Having thus uncovered them, it is therefore possible to observe and develop strategies for the appropriation of the technology. Furthermore, the framework provides a basis for understanding the continuity of techno-organisational change with new technologies emerging to address contradictions raised by previous ones.

6.5 Synthesis of Findings – 'Producing the Agora'

This thesis has been concerned with the successful appropriation of health information systems technologies in developing countries. In particular, given the changes in the modes

of production of these systems from 'localised' processes to spatially distributed arrangements enmeshed with the global development and use of generic artefacts, it is important to develop suitable theoretical frameworks to account for this phenomenon. It is important as well for the health ministries involved to develop substantive accounts which are relevant to the particular contexts in order that interventions can be sustained in these complex arenas. Such frameworks can aid in improving the design of interventions and, more significantly, the choices of technological artefacts made by health ministries and other stakeholders in a global knowledge economy permeated by diverse and confusing solutions. The four articles presented in this chapter demonstrate some key aspects of, and are indeed steps made towards, an emergent theoretical framework.

The articles on shaping information infrastructures in Zimbabwe and articulation of mobile health information infrastructures in Malawi contribute by describing the multiple levels, across organisational and national boundaries, and the processes that are implicated in a techno-organisational change initiatives involving generic software. Also the character of the fragmentation across these layers, the domination by global aid agencies and the limited participation of private players in the public health sector are demonstrated to be problematic for information infrastructure development in developing countries. It is clear from these studies that a relevant and fitting theoretical framework should be able to account for these multifaceted aspects, including the global distribution of key stakeholders, and should not be restricted to single levels of inquiry. When contrasted, these papers show the different contexts and strategies adopted in the cases of Malawi and Zimbabwe. In the case of Malawi there is extensive fragmentation and lower level engagement which fails to address the political aspects of techno-organisational change. In Zimbabwe, the political aspects dominate thereby impacting the possibility of change at the lower levels where the technology is used.

The third paper on 'co-optation' to 'production' demonstrates clearly the taken for granted aspects of adopting these internet-based technologies in developing countries, particularly around the server infrastructure in Zimbabwe where political contests unfold to shape appropriation. It deals with the multiplicity of actors and their diverse interests, including their political positioning, as key elements shaping and even threatening the information system. The study develops a socio-spatial lens to frame and unravel the phenomenon. This

article offers a firm grounding for the argument to develop decentralised technology solutions in the healthcare sectors of such nations. Where this is done, the role of ministries is not to develop and manage risky large scale server infrastructures but to continually search for and choose technology solutions that increase control at the nodes where the technology is used, particularly within their organisations. However, transformations at the decision making level are inevitable if techno-organisational changes at the low level are to be realised.

The forth paper on a 'new agora' in Zimbabwe is concerned with how technologies that are chosen in the healthcare sectors of developing nations surface and indeed partly shape sets of relationships amongst diverse stakeholders within a social space. Consequently, it is the processes of choosing technology and shaping this space for sustainable appropriation of software artefacts that is problematised. In this arena, the study demonstrates how Lefebvre's (1991) concept of production of space is very fruitful in understanding the underlying processes through which such arrangements emerge, and strategies that can be adopted to direct them. Appropriating technology and meeting developmental objectives in consequently considered as 'producing the Agora'. The Agora is traditionally an arena where the life of citizens in a city converge in order to participate in socio-economic and political activities. In the domain of information systems, it is considered as the space between a global knowledge economy and local arenas where generic systems such as DHIS 2 find their way into particular situations (Kaniadakis, 2007). 'Producing the Agora' is therefore a theoretical concept that reveals the processes and strategies through which the space where technology is appropriated is structured. It particularly the study problematises the modes of production through which these systems emerge in developing countries. The role of the state in shaping this space is demonstrated to be particularly tense in developing countries where funding emanates from external donors.

6.6 Paper contributions to the research questions

The section seeks to elaborate on how the research questions are addressed in the papers presented. As earlier expressed, the research questions addressed are:

(i)   How can we understand and explain the processes implicated in the appropriation of generic open source health information systems in developing nations?

(ii) How can the transformations sought when adopting these technologies be better realised?

The contributions made by the papers to addressing the research question are displayed in Table 2, below.

Paper I: Matavire, R., Chidawanyika, H., Braa, J., Nyika, P., & Katiyo, J. (2013). Shaping the Evolution of the Health Information Infrastructure in Zimbabwe. *Journal of Health Informatics in Africa, 1*(1).	
Contribution to research question (i)	The paper seeks to develop an information infrastructure perspective based on the evolution metaphor in order to understand the processes through which technology is appropriated. The paper demonstrates a gap in conceptualisation of such phenomenon when relating micro processes of users to inter-organisational processes of development and implementation.
Contribution to research question (ii)	It is important to engage in negotiations with powerful actors across organisational contexts, in addition to supporting users in order that health information infrastructures are successfully appropriated in local settings. There is need to pay attention to the multiple interests across these settings in order that they may not constrain the emerging systems at user sites.
Paper II: Matavire, R., & Manda, T. D. (2014). Design Breakdowns As Opportunities For Articulating Mobile Health Information Infrastructures. *The Electronic Journal of Information Systems in Developing Countries, 63*(3), 1-17.	
Contribution to research question (i)	The paper develops a practice oriented perspective to understanding the appropriation of a health information infrastructures. The concept of articulation work is utilised to understand the tasks necessary to sustain an information system in the face of breakdowns. This concept is extended to account for the type of articulation work that is distributed and fragmented across time and space and the challenges of harnessing it to support appropriation.

Contribution to research question (ii)	In this paper we find that health information systems interventions that focus on building user bases of mobile technology applications should also focus on engaging political actors who can enact organisational rearrangements to support the innovations. Even where mobile usage might be high such as in many African countries, rearrangements across institutional boundaries are necessary if the technology is to be successfully appropriated. It is also important not to neglect the material basis of health sector information systems interventions, even where mobile technology is concerned.
Paper III: Matavire, R., Jolliffe, R., & Braa, J. (2015). *Co-optation to Production : Addressing Risk in HIS Implementation and Development*. The 13th International *Conference* on Social Implications of Computers in Developing Countries, Negombo, Sri Lanka.	
Contribution to research question (i)	This paper develops a spatial conceptualisation of the processes through which server infrastructure is appropriated in a health information systems project. In doing so, it manages to demonstrate the difficult spatial changes necessary for the successful appropriation of a generic open source software technology.
Contribution to research question (ii)	The hosting arrangements for internet based applications in the public healthcare sectors of developing countries present a salient risk in the appropriation of these systems. The study shows how in aiming for low hanging fruit, key politicised aspects of health information systems interventions such as found around servers are neglected leading to potential failure. With the developed social-spatial framework, suitable intervention strategies sensitive to the political aspects of the phenomenon can be developed and implemented. In this study, the strategy was to conduct a risk assessment workshop, which can be used in other contexts.

Paper IV: Matavire, R. (2015). *Health Information Systems Development: Producing a New Agora in Zimbabwe.* Paper under review in the 'Information Technologies and International Development' journal	
Contribution to research question (i)	The paper develops a social-spatial framework to understand processes of appropriation of generic software in the healthcare sectors of the studied developing nations. The framework utilises the ideas of Kaniadakis (2007) on spaces which emerge with generic software adoptions in conjunction with concepts from Lefebvre (1991) on an epistemology of space.
Contribution to research question (ii)	For health information systems to be better appropriated, space needs to be taken into consideration particularly when generic technologies are involved. In the context of the studied developing countries, this space cannot be taken for granted and rather understanding the processes through which it emerges and is shaped is important for the successful appropriation of generic technology. The study shows that it is important to take into account the struggles and influences of the different stakeholders across organisational boundaries and to intervene to shape these interactions in order that they may not constrain the emerging information system.

Table 2 Contribution of papers to research questions

7   Discussion and Implications

In this section, I shall discuss 'Producing the Agora' as a theoretical contribution made to the information systems discipline and demonstrate its implications to the design, implementation and use of information infrastructures. Producing the Agora refers to the processes through which a space emerges in which generic technological innovations find their way into local settings and attempts are made for their appropriation. It is argued here that the theoretical formulation made in this study enables a holistic understanding of information infrastructures through expounding on their often neglected and taken for granted spatial aspects. The study goes beyond dichotomous distinctions made between subject and object, global and local, and developed and developing country in understanding generic software development, implementation and use. Instead it unravels the space that emerges when new technologies are implemented in the domain of health information systems strengthening, and consequently the struggles that emerge around the appropriation of the artefacts. In doing so the study enables the possibility for a comparative analysis of the different strategies adopted in disparate regions where particular technological offerings are chosen and also for the development of suitable strategies to meet espoused visions in local settings.

7.1   *Theoretical Contributions*

7.1.1   Appropriation of Information Systems

Generic software solutions signify a contemporary mode of producing technology, particularly where open source software is concerned (Pollock & Williams, 2008; Sahay et al., 2013). There is an appreciation that space should be explicitly considered in understanding these endeavours, given that interrelationships between local and global settings that are found when such systems emerge (Castells, 2000; Jorgensen & Sorensen, 1999; Monteiro & Rolland, 2012). In particular, the agora as a space that emerges when such technologies are adopted constitutes a mode of production which diverse actors seek to appropriate. The 'network' metaphor that has hitherto been widespread in information systems research to analyse such phenomenon is limited, since it is often poorly defined and loaded with assumptions about space and time (Braa et al., 2007; Braa et al., 2004; Pollock & Williams, 2008). Within these networks, space and time are often considered as either

subjective or objective phenomenon, and in many cases even primordial therefore escaping analysis (Orlikowski & Yates, 2002; Sahay, 1997). Furthermore, the focus on specific levels at which information systems phenomenon unfolds such as the micro, meso and macro levels provides an insufficient picture of organisational appropriation of generic technology (Kaniadakis, 2007). Consequently, the development of spatial conceptions to further the understanding of the appropriation of information systems is necessary to alleviate these challenges.

Through its elaboration on the nature of space in social practice, this study makes three unique contributions. These are the adoption of the agora metaphor as espoused by Kaniadakis (2007) in the domain of generic health information systems and secondly, the extension of this conception through the ideas of Lefebvre (1991) in order to unravel the processes through which such a space emerges and is structured. Finally, it enables a reconceptualisation of the appropriation of technology as a spatial process, or in particular as the appropriation of the agora of techno-organisational change by users and other actors. Borrowing from Lefebvre (1991), three interrelated aspects of the agora are presented, that is the emergence of dominated spaces occupied by knowledgeable actors such as managers, system architects and designers; the perceived space in which the health information systems practice unfolds including the relationships between diverse actors, the pervasiveness of internet infrastructure connecting actors, and the large distances between participants; and finally the space where symbolisms, old technologies, and history imbue the agora with meaning. As can be seen, these three aspects should be considered together and not as distinct elements if the process through which the Agora emerges and is appropriated is to be understood.

In the context of the mobile project in Malawi, we see a spatial practice emerging with the purchase of mobile devices and the training of health workers on its use. Articulation work, which can be thought of as appropriation work, ensues and through this activity the space of the mobile health technology emerges and struggles to appropriate it emerge. The challenges that emerge to constrain the innovation were largely those related to extending the spatial practice across organisational boundaries and also to support the multiple levels of the health information system. These were primarily due to divergent interests among stakeholders and the limited resources in the project. In the context of Zimbabwe, a spatial practice emerges

with the rollout of training, internet infrastructure and computer hardware to the districts and some rural health facilities. Unlike the intervention in Malawi, in Zimbabwe the users of the technology were largely information officers up to the district level. While these are a specific group of users of the information system, the larger base of health workers who actually collect the data in the field was largely neglected in the development of the spatial practice. The workers in the facilities in Zimbabwe had historically appropriated their space in terms of data collection and analysis on paper registers, and also on a weekly mobile disease surveillance system. However, the new 'technological space' had not been appropriated and it can be considered that the agora in this case was rather dominated by the interests of the multiplicity of stakeholders, both internal and external to the MoHCC, with limited participation by the health worker. The difference between the contexts demonstrates the differences in spatial representations in the paper-based, PC-based and mobile-based systems and the implications they have for the appropriation of space for the users.

7.1.2 Information Infrastructures

Arguably, information infrastructure theory as particularly espoused by Hanseth and Lyytinen (2010) takes space for granted. For instance, they consider a key challenge of implementing technologies, or designing information infrastructures, to be the challenge of bootstrapping. This challenge is primarily concerned with the identification of early users of a technology so that it may be accepted and then be diffused. They utilise the conceptions from complex adaptive systems (Holland, 1992) in order to explain how these initial users grow and evolve. While the adoption of a socio-technical view to understand information systems enables a view beyond the technological artefact, there is little consideration of the space which encompasses the interrelationships between powerful actors, political decision making processes, users and the physical aspects of these infrastructures and how these shape successful appropriation processes. The understanding of how knowledge and technologies are appropriated by political actors and how success and failure is often defined through a political lens by state actors is essential to the development of strategies for strengthening health information systems given the unique set of risks that emerge, particularly in developing nations.

In taking space for granted, the dichotomous views of top-down and bottom-up approaches are propagated which fails to adequately account for the economic and political forces which

shape technological appropriation (Pollock & Williams, 2008). While the perspective on 'Producing the Agora' does not discount the possibility of structures emerging through social activity at the level of users of a technology, it does not assume that this is the primary mode through which these institutions emerge. In fact, taking from Lefebvre (1991), it is the constant interplay between top-down and bottom-up strategies which is at stake. Observation demonstrates that top-down domination often triumphs, which is a problem if it dis-empowers the users and thus the need for better strategies (Lefebvre, 1991; Sahay et al., 2010). The challenge is therefore to ensure that domination and appropriation can be balanced of which Lefebvre (1991, p. 166) contends that these spaces "*may in principle be combined and ideally … they ought to be combined*". These issues are more acute in developing countries with a history of colonisation and neo-colonisation where external actors seek to appropriate local institutions. A spatial extension of Information Infrastructures thinking is therefore necessary to overcome the challenges highlighted, and others.

In the context of Malawi, it is likely that the intervention could be insufficiently considered as a bottom up 'ethnography-oriented' intervention given the focus at the 'user' level. Information infrastructural conceptions of 'cultivation' and 'ecology' have therefore been used to account for such a scenario and arguably shaped the intervention in the first place (Sanner et al., 2014). However, the project was conceived at higher levels in the MoH and many of the challenges that emanated in the project had to do with the representations that emerged from the organisational, and inter-organisational space perhaps given the dominant role of the Oslo team. For instance, the conception by the team of post-paid mobile package made it impossible for users to buy their own data bundles in order to submit data. The purchase of phones in India, which failed to work on the local network is another case in point. Conceptions from information infrastructure inadequately capture these multiple levels and decision making processes which shape the innovation. Earlier attempts to utilise the information infrastructure perspective in the Zimbabwe case also proved inadequate to account for the links between the inter-organisational level from which representations emerge and the user space where struggles of appropriating the technology unfold.

7.1.3 Information Systems and Development

In many studies claiming to address the development agenda of information systems in developing countries the concept of 'development' is not adequately addressed. This leads to

a failure to sustain innovation which on the façade look to be succeeding while some systemic issues have not addressed which inevitably lead to failure (Silva & Hirschheim, 2007). Some studies have however looked at this issue particularly in the area of global sourcing of technologies where they address the socio-economic imbalances that characterise the adoption of these systems (Heeks, 2013). There is also a recognition that the dichotomy of use versus design of systems, where users are in developing countries and designers in developed nations, fails to address the concerns of development (Madon & Sharanappa, 2013). Additionally, there is a discourse which has emerged in this domain which highlights the essential nature of politics in technology appropriation within developing countries (Gagliardone, 2014). However, little effort has been made to holistically elaborate on and to understand these spatial concerns. The conception on 'Producing the Agora', while specifically dealing with issues of generic software phenomenon in these arenas addresses the challenges as it integrates the numerous perspectives within a single theoretical framing. It also lays bare the potential domination that arises with technology adoption and thus sensitising researchers and practitioners to the accrual of value in the arenas where representations emerge as compared to the representational space of users in developing countries.

The emphasis on 'production' helps to focus the issue of appropriating technology to the related concept of *value*. Borrowing from Lefebvre (1991), there is use value and exchange value, where in the case of generic technologies – exchange value is often held by the suppliers of the technology. However, in the Agora, a space, which is neither global nor local, the right strategies should enable the collective development of exchange and use value. In the case of Malawi, when challenges arose in server hosting and the provision of day to day support which would aid in its appropriation, attention shifted to players in the broader DHIS 2 community as it was difficult to interest some local players in the project. Consequently, even if new features of the technology are developed based on the Malawi case, the nation retains use value and the exchange value returns to the North. In the case of Zimbabwe, in the Android project for Malaria pre-elimination, we find the difficulty of engaging local agencies to participate in the development of the application. Consequently, even as the requirements and the proof of concept originated in Zimbabwe, the exchange value returned to the North as more nations took an interest in the technology. The exchange-use value difference is also mirrored in discussions of domination and appropriation of space which enables researchers

to re-engage with the 'development' agenda of information systems in developing countries. In particular, the issues of development that arise with open source technology can be fruitfully analysed with the perspective developed in this thesis.

7.1.4 Social Production of Social Space

It has been lamented in the information systems discipline that despite the limited development of theory, there is also a limited reflexivity in the adoption of theory from reference disciplines whereby researchers do not contribute back to the sources of the theories that they borrow (Gregor, 2006; Truex, Holmström, & Keil, 2006). While Lefebvre's (1991) aim was a science on social space, much of the discussion that permeates his work hints at a possibility of applying the ideas within the field of 'information science' or at least in technology dominated arenas. This study has therefore provided an example of a social space within the field of IT which the ideas of Lefebvre (1991) can be extended to consider. Much of the discussion on the production of space deals with the broader social spaces such as entire states and regions, and the application to particular state institutions in the technological arena is novel and thus demonstrates the extensibility of his ideas.

In the study of organisation, only a few articles have utilised Lefebvre's ideas on the 'production of space' to understand organisational behaviour. Wasserman and Frenkel (2011) for instance have utilised the 'production of space' perspective to develop a theoretical framework to understand how space and aesthetics play a role in shaping identity, and how also space becomes a site of struggle between diverse actors. Additionally, De Vaujany and Vaast (2013) have studied how organisational space and legitimacy are mutually co-constructed. Outside of these studies, there is little evidence to suggest the appropriation of Lefebvre's (1991) ideas in either organisational or technology fields. This study therefore makes a contribution to this stream of literature by demonstrating how the 'production of space' perspective can be used to decipher information systems phenomenon. There is consequently enormous room for the application of Lefebvre's ideas on space in the information systems discipline which is starting to scratch the surface of social-spatial phenomenon in this age of uncertainty and risk. This study has therefore made a modest contribution in this regard, thereby reflexively feeding back to the development and application of the perspective.

7.2 Practical Contributions

A key understanding emerging from this study concerns the manner in which technology and knowledge can be appropriated by diverse groups, including the state. Technology, or generic software in this case, loses its espoused neutrality when it interacts with the context of its adoption and use. Being explicit about this, and developing relevant strategies around such technology is therefore a critical cornerstone in order to moderate these effects and shape outcomes. Strategies for HIS integration should therefore reflect not only on utopian goals but on the concrete reality of a fragmented health information systems development space and its sustainable transformation. Without this, the fragmented space will only give rise to another fragmented space, even with new technology. Such strategies should then not focus only on specific standards, architectures or technology solutions but also on the manner in which these artefacts are appropriated by the state and other actors given the political and economic forces at play. They should also consider how technological artefacts in the health information systems domain can potentially mask hegemonic influences. In doing so, the adopted strategies would re-centre the issue of development which, it can be argued, is largely neglected in HIS strengthening endeavours where implementation seems to be prioritised over tackling the root causes of 'underdevelopment'. Such consideration could alleviate the challenge of health technologies not getting appropriated due to their failure in engaging with the 'deep-structures' of state institutions (Silva & Hirschheim, 2007).

In the context of health information systems in developing countries, there is a predominance of aid agencies that fund most of the HIS strengthening activities. A collective framework is needed to leverage changes in technology, such as the move to DHIS 2 on one hand and the emergence of new technologies such as the mobile internet and social networking tools amongst users on the other. There is a need for the consideration of how the pre-existing relationships between donors, the state, users and technology suppliers can be structured to meet the challenge of a changing representational space and arrive at the vision of an integrated or unified HIS. This should occur without increasing domination of the users of the technology by the technological structure comprised of aid agencies and other interested actors. As noted by Lefebvre (1991), when the forces of production change as occurs when new technology is adopted, the relationships of production resist transformation. As highlighted in this thesis, the agora is a space in which such a transformation can be pursued, and its restructuring which has been termed 'Producing the Agora' should be a collective goal

of multiple stakeholders. Producing the Agora goes beyond relationships established only with the short term goal of implementation, but is concerned with longer term developmental visions. Consequently, it should be seen as encompassing the physical, social and lived aspects of the spaces where the phenomenon unfolds lest it remain a mere abstraction. In practice, it is clear that the multiple interests of the diverse stakeholders, including the fragmented funding from international donors, challenge user appropriation of the agora as these agencies are focussed on appropriating it to their benefit. In short, stakeholders are beneficiaries to the status quo and inevitably resist changes which could ensure the benefits of new technologies are sustainably appropriated. This is seen in Zimbabwe where the bulk of the investment into the HIS did not transform the user space, even as it was only over a limited duration.

A key arena of contestation in the agora is the server space, including the practices around system access and maintenance. In both cases studied, the DHIS 2 server infrastructure was managed by external actors, particularly due to lack of staff, funding, know-how and resources in the ministries. The question of where to host servers for the system is necessarily political and involves high level decision makers, external agencies like donors and IT suppliers, government IT agents, and users. This requires health ministries to develop and implement policy broadly and collectively with stakeholders within this space. Once the policy is developed, it is important to organise actors with the relevant knowledge to achieve the objectives, necessarily with the relevant authority and leadership emanating from the state. This should include the identification of physical spaces which can be appropriated/reappropriated by the actors to set up the infrastructure. The users of the space, that is health information personnel and health workers are key participants in the development of a practice around this space and the designers should endeavour to meet their requirements. A production of space perspective enables the understanding of the interrelationships between these different aspects of the server infrastructure, the necessity of spatial rearrangements and the strategies through which a suitable spatial practice can be realised.

A specific strategy that has been highlighted for 'Producing the Agora' in this study is that of reappropriation of space. For instance, in the health ministries studied in this research, it was evident that the IT units were largely incapacitated, and without adequate authority, to deal

with the emerging technologies. These units have largely been occupied with the traditional tasks of computer and network maintenance having very little to do with health information systems administration. Furthermore, in both cases, IT staff were even in a parallel organisational hierarchy to the HIS unit. A strategic perspective on Producing the Agora should realise the necessity of a space where issues such as system access and maintenance policies are crafted and implemented, combining both the IT and HIS functions. Such a space should be developed collectively with other actors in the agora, including private and individual actors, consequently implying the necessity for high level decision makers to be involved since there are policy issues to contend with. The production of this space also means the emergence of a practice, where for instance different vertical fragmented systems now alter their processes as regards HIS functions.

An additional challenge experienced in the cases studied has been the concern about programming capacity and its development. A spatial view has enabled us to see the widespread proliferation of computing devices and other Internet technologies to the hands of health workers. Social networking mobile applications in particular have become widespread in developing countries. In the fragmented agora, different health programs pursue their IT solutions within this space. It is possible for the state, its programs and partners to intervene and choose standards and technologies in seeking to integrate these systems. With integrated generic software such as DHIS 2, there are programming interfaces which can communicate with other systems. Furthermore, the system requires the development of local customisation capacity in order to meet changing requirements. To administer and develop tools for the system requires some programming capacity. As yet, much of the programming capacity comes from external organisations funded by donor agencies and exists in silos for limited periods. In producing this space in the agora and perhaps through a strategy of reappropriation of space there is a need to enrol local programmers.

8 Concluding Remarks

The study has contributed a theoretical framework to understand and intervene in developing sustainable health information infrastructures in developing nations. The persistent challenge in these contexts is that health information systems fail to sustain once donor engagement ends. Consequently, the study sought to improve the understanding on appropriation of these technologies in these contexts. This was done by participating in health information systems interventions in Malawi and Zimbabwe. A social-spatial theoretical account was developed to explain the phenomenon and as a means to shape processes of successful appropriation. The processes of appropriation were conceived to occur in an agora, of which the moments of its production, that is the spatial practice, representational space, and space of representations, were illuminated.

The aim of the study was to participate in the processes of appropriation of generic technology in order to develop a theoretical explanatory account of the phenomenon. The theoretical framework developed would have to be relevant to the actors, and be able to fit to the empirical material. The broad questions pursued are: How can we understand and explain the processes implicated in the appropriation of generic open source health information systems in developing nations? Also, how can the transformations sought when adopting these technologies be better realised? In addressing these questions, the study found that spatial perspectives can contribute to a better understanding of processes of health information systems adoption. In particular, spatial conceptions can aid in the development of suitable strategies for the appropriation of information systems that go beyond the contradictions between utopian ideals and lived reality. The research contributes by developing a spatial substantive theory which is relevant and applicable to the cases studied which it calls 'Producing the Agora'. This perspective brings to the fore some of the struggles that occur and shape the appropriation of generic software which should be considered in such interventions and have been neglected in other theoretical accounts. The study also provides a more critical view to help question what appropriation should mean in these contexts dominated by fragmentation and multiple and sometimes divergent interests. Consequently it defines appropriation not only in terms of the technological artefact, but rather as the appropriation of the space by diverse actors where the technology emerges to shape practice.

This thesis introduces the spatial conceptions of Henri Lefebvre to understanding generic software appropriation. Lefebvre's (1991) views on space can assist in discussing the developmental aspect of health systems in developing countries. In particular we are able to see the different aspects of a technology's appropriation, including the lived, social and physical space in which it emerges. It was also possible to conceptualise the state's roles in the production of the information technology. Unlike views on information infrastructures which have taken a largely evolutionary perspective to the development of integrated systems, the theoretical view presented here does not take the space in which this phenomenon unfolds for granted. Furthermore there is an increased sensitivity to issues of domination which are foundational within the context of information and communication technology for development (Escobar, 2011). It is believed that the spatial theory presented on the appropriation of generic health information system in developing nations will help practitioners and researchers to design interventions that engage with underlying structures for more sustainable outcomes.

While the availability of donor funds often shapes the direction of intervention, within the disparate silos, this study suggests that such activities can further alienate the state in its ability to manage the divergent flows of information. Technologies such as DHIS 2 emerge as a possible means through which these pathways can be integrated, however with a weakened state and vertical systems accustomed to their silos, new technology will not address the underlying concerns of a fragmented information infrastructure. The challenge of fragmentation, through the perspective on 'Producing the Agora', is recast as the challenge of changing the relationships of production from those focussed on particular artefacts to those on the collective management of the space in which those artefacts emerge. It is consequently a revolutionary conception of what is actually needed for health ministries and other stakeholders to get the most out of the diverse technology and artefacts that they are appropriating. Consequently, there are diverse approaches through which these changes can be sought, some slower than others, but ultimately there is a realisation that the new modes of production that are introduced through new technology, should be inscribed in space if they are meant to generate value and be more than just theoretical.

More research needs to be done in order to understand how the ideas on the production of space can continue to improve and complement the understanding of information systems.

Additionally, the spatial ideas presented here could be further developed by engaging more widely with literature on the sociology of space. Using such an approach, it will be possible to further operationalise the ideas to be more useful to practitioners and researchers engaged in the field. However, it is important to remain sensitive to Lefebvre's (1991) view on a concrete, rather than a conceptual space, which is very important in the material world of technology. Still, the scope of the volume of Henri Lefebvre is enormous, and this study has only begun to scratch the surface of this important work. This is a large opportunity for the application of the theory information systems research. This study has also looked primarily at generic software, but the theoretical ideas can potentially be extended to account for other technologies, and technological artefacts, in different contexts. Furthermore, continuing to study the specific cases of Malawi and Zimbabwe can improve the understanding of the processes and trajectories traced in the intervention, thereby refining the spatial concepts. Therefore, studies of longer duration can aid in further development of the framework, meaning the temporal dimension should be explored further. The aim of the study has not been to develop formal theoretical ideas that are generally applicable, but rather on an explanatory substantive theory that is sufficient to account for the observed phenomenon. Such a theory should be extensible to other situations, but is meant to contribute to strategic thinking in the health information systems for development field.

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Shaping the Evolution of the Health Information Infrastructure in Zimbabwe

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Background and Purpose: This paper describes the implementation process of an integrated health information system within the context of a developing nation. The Ministry of Health and Child Welfare (MOHCW) in Zimbabwe was engaged in migrating legacy paper and desktop based information systems to the District Health Information Software (DHIS2), a web enabled and open source technology. The aim of this paper is to contribute to the development of theory that can be adopted to improve outcomes in such endeavours.

Methods: The study is conducted using the Action Research (AR) approach whereby the authors were actively involved in shaping the implementation of the information system. It occurs within the broader context of the Health Information Systems Programme (HISP), where an AR approach, the Networks of Action, has been developed for sustainable interventions in developing nations. The work is also informed by the grounded theory methodology, whereby empirical data was the basis for making a theoretical contribution.

Results: An interorganisational network consisting of actors interacting at the administrative level of the public health system plays a central role in determining the trajectory of the health information infrastructure. Collaborative challenges at this level are demonstrated to lead to further fragmentation of the health system thereby increasing the inertia of the installed base. At the user level, numerous strategies to cope with the challenge of supporting the health information system are described. The development of capabilities at this level is shown to be key in increasing the adaptability of the installed base.

Keywords: Health Information Systems, Information Networks, Action Research, Developing Nations, Grounded Theory, Integrated Delivery Systems

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1   Introduction

The health systems in Zimbabwe are constrained due to a shrunken infrastructure and increased information needs. The nation experienced major socio-economic and political vicissitudes in the period spanning 1998 to 2008. This eroded the significant gains that had been made in health information infrastructure strengthening which can be traced back to independence in 1980, with transformatory activities being recorded from as early as 1982 and computerisation in 1985 [1-3] (as referenced in [4]). However, the nation witnessed resurgence from 2009 to 2013, during a period when a unity government was in place. In this time frame, the Ministry of Health and Child Welfare (MOHCW), in partnership with stakeholders, started to migrate its information from decentralised, paper, and standalone software systems to an integrated, centralised, and web based system utilising the District Health Information Software (DHIS2).

A rallying point for stakeholders within the discourse on HIS strengthening was, and continues to be, the prevalence of fragmented systems and the need for standardisation [5]. In order to direct scarce resources to critical and high impact areas, program specific systems flourished in many developing nations [5]. These were isolated from the broader health systems leading to their characterisation as vertical, siloed and fragmented [6]. Programs, such as those focusing on AIDS and TB, had their own information systems and funding arrangements, which contrasted with the poor condition of the surrounding infrastructure. The flow of information across the vertical organisational boundaries was therefore problematic. As information needs continued to increase, and resources decrease, many nations have chosen to develop 'shared' information infrastructures, thereby the call to integration of disparate systems [5, 7].

Advances recorded in the internet infrastructure within many developing countries are lauded as an opportunity to achieve health system integration [8]. Projects aimed at replacing the paper-based and standalone systems with centralised internet based technologies continue in numerous nations, including Zimbabwe [5, 9, 10]. This network revolution within developing nations is also supported by the high proliferation rates of wireless internet access [11]. Health systems in developing nations seek to leverage these network infrastructural developments to achieve better healthcare for citizens and to improve the working conditions for public servants. Furthermore, as will be demonstrated in this study, health systems strengthening projects lead infrastructure development efforts within the domain. The domain consisting of a multiplicity of stakeholders such as policy makers, donor organisations, researchers, civil servants, developers and private interests [12]. The evolutionary path of health information systems is therefore determined by events that are not only specific to the implemented technologies but also originate in these organisational structures and the corresponding interactions [5]. The strengthening of the health information systems in developing nations is therefore considered as a complex socio-technical concern requiring systems thinking approaches to resolve [13]. The large scale nature of health systems development programs also entails their characterisation as information infrastructures [14]. This differentiates them from the smaller information systems projects that have fewer 'moving parts' and are limited in their temporal and spatial reach.

We will now continue by providing a review of information infrastructures literature for comparative purposes, paying attention to the different approaches that actors engage to resolve their concerns within the evolving socio-technical system. The methodological approach adopted in the study is given in the materials and methods section, after which we provide an analytical description of the evolution of the information infrastructure in the results section. Finally we conclude by discussing the practical and theoretical contribution from the study.

1.1   Information Infrastructure

An Information Infrastructure has been defined as "a shared, open, heterogeneous and evolving socio-technical system consisting of a set of IT capabilities and their user, operations and design communities" [15, p. 4]. Typical information infrastructures are the internet (15), health information systems [14, 16], public sector ICT architectures [7], and online collaborative environments [17]. These are to varying degrees, shared, open and contain numerous differentiated and interconnected parts and are therefore heterogeneous. Furthermore, they are constituted of IT capabilities distributed among their users, operations personnel and designers. A key to understanding the evolution of infrastructures is the installed base [7]. An installed base is the pre-existing and current state of a system and can be discovered and experienced as resistance or inertia during periods of change [15]. This shows that an information infrastructure is relational to the people and practices which it supports and it can not be known without them [18, 19].

The evolutionary trajectory of an information infrastructure emerges from the resolution of the tension of whether a chosen path can initially accommodate the needs of an installed base on one hand, and whether it can be adapted to the needs of a growing user base on the other [15, 16, 20, 21]. Tension arises due to the multiplicity of actors engaged in infrastructure development activities since what is often posited as the best design by others often falls short in the context of implementation, requiring innovation to appropriate to local contexts [22]. These issues are more pertinent in the "global village" where initiatives designed abroad find themselves in local settings, a process which has been called glocalisation [23]. The resolution of the tension between the local and the global is a key process for the emergence of infrastructure [19]. A tension has also been identified between the technical and social view of information infrastructures [19]. It is when these tensions are resolved that an information infrastructure emerges [12, 19].

Shaping the Evolution of Information Infrastructures.

Of critical importance in the area of health systems development, is shaping the evolutionary trajectory of an information infrastructure [12, 15, 24]. This is important given that the evolution of infrastructures is intrinsically path dependent [15]. Once a decision is made to adopt specific systems and the installed base is developed, it becomes difficult to reverse the unintended side effects due to potential lock-ins [24]. An example that is often cited is that concerning the adoption of the QWERTY key-

board, which has become a de facto standard. Even if the Dvorak format of keyboard is espoused to be more efficient, it remains difficult to implement under current conditions due to the dominance of the QWERTY layout [25]. The paradox is that path dependence is also desirable due to the security of continuity it provides to organisational life [26]. Due to these seemingly conflicting attributes, an information infrastructure is therefore considered as a complex phenomenon. It grapples with intended goals and emergent unexpected consequences [26]. These shape its actual trajectory in practice and research suggests that the result is a high rate of unmet expectations [19, 27]. To tackle this reality, studies on the suitable approaches that can be adopted to harness complex environments are widespread in the information systems discipline [12, 28].

1.2   Macro Intervention Strategies

A primary approach for shaping public sector information infrastructures is standardisation. This entails bringing together stakeholders from government, the private sector, civil society, international agencies and research institutions to collaborate in the standardisation process [7]. These agencies have been recognised as prominent in shaping the evolution of ICT infrastructure in developing nations [12]. However, their engagement has also been recognised as problematic since the domain of their operation has a political character [29]. For instance in a study of health systems in Guatemala, Silva and Hirschheim [30] demonstrate how a health systems program was terminated as soon as one political party lost elections in the nation. The reason provided in this study (ibid) was that the health program had failed to alter the deep structures, that is the political culture that had become entrenched due to agreements made to end a civil war that had lasted for more than three decades. While such a case is unique, it remains that organisational networks are scenes where the negotiation of power occurs and infrastructural decisions are made [29].

1.3   Micro Intervention Strategies

While decision making is typically a concern for those in the realms of management, users and developers of systems adapt numerous strategies to cope with their corresponding challenges [22]. Concepts that have emerged in understanding how activities at this level shape infrastructure are bricolage, improvisation and articulation work [16, 22]. Bricolage has been aptly defined as "the ways that individuals and groups borrow from existing cultural forms and meanings to create new uses, meanings and identities" [31]. Improvisation is a related concept that emphasises the momentary and timely aspects of reacting to emergent challenges [22]. Articulation work however, is differentiated from the concepts above in that it does not presume that that actors have "much control to stabilise the meanings and purposes of technologies" [31].

   A characteristic which enables investigation of information infrastructure is that it is invisible except when undergoing design or has broken down [19]. When breakdown of infrastructure is imminent, articulation work ensues to cope. Articulation

work has been defined as the work that enables other work [32]. Articulation work is therefore considered as infrastructure work [19]. There are different forms in which articulation work can be observed during breakdown such as 'making do', 'worka-rounds' and 'institutional rearrangements' [32]. The activities that ensue when infra-structure breaks down are occasions for innovation [16], and are seen by Ciborra [22] as important considerations in the formulation of strategies to develop information systems.

2   Materials and methods

The study was primarily conducted within the action research approach which is the dominant method within the global Health Information Systems Programme (HISP). There are a number of action research approaches identified in IS literature [33] and the specific method chosen in this study is informed by the networks of action ap-proach [21]. It emphasises the importance of collaborating with a diverse range of stakeholders in different organisations in order ensure the sustainability of an inter-vention [21]. The network of action approach does not prescribe procedures for data collection and analysis; hence a complementary method is appropriate to improve on the rigor of the study. To address this, the grounded theory method (GTM) was uti-lised. It is an inductive method which allows for the consideration of various data sources for the purpose of constructing substantive theory [34]. It offers a range of analytical procedures such as open coding, selective coding, theoretical coding and constant comparison [35]. The combination of the two methods to understand practice is not novel in the Information Systems discipline and this mixed approach has been named 'grounded action research' [34, 36]. The procedures of open coding, selective coding and theoretical coding were utilised on the data collected during the action research.

   The data utilised in the study was obtained from 8 qualitative interviews, 7 meet-ings with stakeholders, direct observation, project documents and by participating in conducting systems analysis. Field notes were the dominant method of capturing events. The participants included health information officers, information managers, program heads, donor agents and software developers. Constant comparative analysis was conducted on the data from 2 field work visits of 4-5 weeks each. Coding of data was conducted utilising nVivo software. The broad aim of the study was to discover the core concerns shaping the evolution of the information infrastructure understand how they are resolved by actors and develop theory on how they can be leveraged to improve outcomes. Categories generated through open coding were compared with other related codes and with concepts found in literature. Care was taken not to force concepts onto the data, and the principle of emergence of concepts from data was adhered to. Theoretical sensitivity was developed through a continuing literature re-view. The study is epistemologically critical and interpretive [37]. It is critical as it seeks to develop appropriate ideas to intervene to enable change and interpretive in that the authors acknowledge their involvement is implicated in the evolution of the information infrastructure.

3   Results

The MOHCW in Zimbabwe made significant progress in transforming its health information infrastructure enabled by a decision to change the decentralised paper and standalone software based information system to one that is centralised, integrated and web based. The health information system is organised into four levels, constituting the health facility, district, provincial and the national levels. The system had been based on a range of paper based registers implemented in all health facilities and collated on a monthly basis for reporting to the district level. At the district, the aggregate figures from the health facilities were recorded into a standalone 'Microsoft Access' based technology called DHIS 1.4. These were further aggregated upwards to the provincial and national levels through sending data files by email to the respective information officers. The entire process of sending data from the facility level up to the national level has been known to take up to a month, therefore affecting the timeliness of reporting. To circumvent this challenge, a weekly surveillance system was implemented using mobile technology, where all health facilities were provided with mobile devices as tools to report a limited amount of time critical health information. However, the MOHCW took a further step to implement a web based reporting system called DHIS2 in order to tackle the issue of fragmentation.

3.1   Sacrificing and Improvising

A key issue observed in Zimbabwe was the challenge of internet accessibility, from the level of district and below. Health workers from two rural hospitals and a district office visited within one district had been using wireless dongles which required that they performed data entry at midnight when internet access improved. This would be a form of articulation work, and one participant noted that this "sacrifice" was necessary. Another health worker also noted a challenge in obtaining a username and password to access the laptop for data entry into the system. This had occurred due to the fact that the health worker who had been trained for data entry into the system had since left the facility. Improvised in-house training had been arranged by nurses at the rural hospital to fill the gap. However, the laptop was lying idle due to a failure to obtain access privileges. With internet accessibility such a problem could have been resolved through remote desktop tools. This demonstrates the need to develop IT capabilities, so that such issues can be resolved locally. As noted by a manager: "*most of our personnel on the ground, that is the district health information officers ... their skills are limited in terms of what they actually know in IT*". This type of breakdown would require top management support and institutional rearrangement for sustainable repair.

3.2   Health System Development Network

The ministry was the key decision making body for the health information system intervention, which it implemented through an interorganisational network. A multiplicity of actors had been engaged in the development of the health information infra-

structure by the MOHCW. At the institutional level, the network was composed of donor organisations, academic institutions, private companies, health programs and consultancies representing local, regional and international interests. These organisations are pivotal in shaping the trajectory of the evolution of the infrastructure by providing financing, technical competencies, and other material and non material resources.

The network is engaged with the ministry in their different capacities, and being part of the installed base contributes to its inertia. Inertia arises due to challenges in collaboration among actors due to a lack of clarity on procedure. As one participant noted: "*you can not jump certain steps ... we can only engage other people to get on board [when] the system is fully running ... inasmuch as technology is ready, policy is not ready so you still have to go back to policy and check what are the policies governing these people?* ". Challenges in collaboration can further fragment interventions on the ground, increasing the work of health workers to keep up with information needs. For instance reporting online can be requested from facilities that have not had access to internet infrastructure, impacting on data quality. In one instance, it was observed that electronic devices that were acquired for acquiring co-ordinates to enable tracking of individual cases of Malaria where highly proprietary and could not be easily programmed to address cross platform needs. Given that the acquisition process had been initiated, it was not possible to reconsider the alternatives. Such issues highlight the importance of improved collaboration among the stakeholders and how the outcomes of the decision making process can increase the inertia of the installed base.

3.3   Implementation Strategies

A key strategy used to intervene in the information systems of the MOHCW, is engagement with top management for support. Decision making is centralised in the health ministry, making such engagement crucial for success. A project manager noted that they had earlier tried a bottom up approach and faced challenges. This also suggests that an adaptive strategy is important for a successful intervention. To adhere to formal protocol meant early planning, as noted by a participant: "*getting an IP address took 6 months ... so we had to start early*". A multi-stakeholder meeting to discuss HIS support could not take place due to concerns raised about protocol. This also showed that power was an issue among implementation partners. There also existed a conflict of interest which increased inertia of the installed base. In an instance, a data manager in one organisation lamented as to how he was failing to get access to information on the latest health facility list, a problem that affected the organisations ability to meet internal reporting deadlines and had been ongoing for months. Access to information in the ministry is centralised, and the level of access by external stakeholders is related to ones positioning in the network. A project head noted the importance of attending to '*low hanging fruits*' as a strategy for success in this context. A manager also noted the importance of knowing "*where you are going*", while others lamented slow progress due to collaborative inertia. Information officers interviewed highlighted that, it was not only an issue of power that caused some interven-

tions to flourish over others, it was how they assisted in alleviating concerns of the health worker. A key concern among health workers is the burden of balancing data entry in the numerous registers, and providing patient care on the other. Agencies that required increased data access and offered no direct incentives to reduce the workload of health workers faced a risk of failing to meet their objectives.

4   Discussion

In this study we find that while a bottom up approach to interventions is critical, engagement with the structures where power is negotiated is also important for success. The role of networks in shaping information systems projects in developing nations has been recognised in a study by Njihia and Merali [12] who studies the evolution of ICT provision in Kenya over a period of 42 years. They (ibid) develop a mechanism highlighting that certain changes to systems can lead to stasis or genesis. This supports the finding in this study that activities by actors in interorganisational networks can increase installed base inertia, particularly if they are fragmented, or reduce it through collaborative activity. It also confirms path dependence of information infrastructures, thereby demonstrating the network effects of decisions made by interorganisational network participants. The concept of donor dependence is of crucial importance here, since the activities they undertake can serve to entrench their interests in the installed base. One way that has been suggested to improve outcomes in information infrastructure projects has been to increase heterogeneity of actors in implementation networks, including those with diverse views into the process [15]. This should however be accompanied by the development of policy in order to reduce the advent of opportunistic behaviour [38].

Further work aims to develop the emerging conceptual model and to integrate the findings into the broader literature on information infrastructures. Issues that are of importance to further research include the development of strategies to improve collaboration in interorganisational networks, leveraging the installed base by paying attention to how implemented technology interacts with work practices, and institutionalising adaptive technology appropriation mechanisms. Specific consideration should also be given to the embeddedness of infrastructure in wider society, and the key issues that arise. Studies could do more to clearly demonstrate how the evolutionary trajectory of information infrastructure is located within the wider infrastructure of society. This would entail the development of substantive theories which are faithful to the contexts studied.

Acknowledgements

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II

INTERVENTION BREAKDOWNS AS OCCASIONS FOR ARTICULATING MOBILE HEALTH INFORMATION INFRASTRUCTURES

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ABSTRACT
This study investigates a mobile health project launched in Malawi and considers its sustainability in light of activities that occur in the pilot stage. It has been said that most projects of this nature fail during piloting hence it is pertinent to review the activities in this early stage. The study follows a grounded theory inspired research approach and is focused on the day to day breakdowns that occur in the pilot, what they reveal, and how the resolutions relate to the project's goals. It is found that when breakdowns occur, an articulation process to sustain the intervention becomes visible. Breakdowns can reveal tensions in the technical design and organisational context thereby offering opportunities for action in order that an intervention is sustained. The ensuing activity, for analytical purposes, is termed articulation work, and its variety and limitations are explained. In this study we discover two categories of articulation work, technological and human. Further to this, we argue that these two categories of articulation work can be further analysed into different dimensions, based on the levels of organizational involvement required to resolve them: (i) localised; (ii) multiple levels within a single organization; (iii) and multiple levels inter-organizational.

KEYWORDS: breakdowns, articulation work, sustainability, developing nations, intervention, grounded theory, information infrastructures, mobile health

1.   INTRODUCTION
There is a global drive to improve the Health Information Systems (HIS) of developing nations as it is recognised that they have a critical role to play in the provision of primary healthcare services (Braa, 2004). The initiatives are driven by the persistent concerns that current systems are collecting irrelevant information, the quality of data gathered is poor, there is duplication of efforts due to fragmentation, data is not received in a timely manner, and the information gathered is not used for decision making (Chaulagai et al., 2005; Lippeveld et al., 2000). However, designing and implementing health information systems to address these and other issues is a complex task. Numerous reasons have been given for this, such as the failure to change underlying organisational structures (Sahay et al., 2010; Silva and Hirschheim, 2007), a mismatch between adopted approaches and context (Cho et al., 2008; Puri et al., 2004) and the challenges of harnessing activities across networks of stakeholders with their diverging interests (Braa, 2004). In an effort to address these constraints, mobile technologies are espoused to have capabilities suited to the low resource contexts of developing countries (Sanner et al., 2012).

Mobile technologies have proliferated globally, with developing nations demonstrating exceptionally high adoption and growth rates (Sanner et al., 2012). The mobile device is useful for transcending the spatial and temporal limitations imposed by rural settings in poor countries. Healthcare delivery systems in these nations are thereby concerned with the increasing usage of this technology to ease the challenges they face (Asangansi et al., 2013; Chigona et al., 2012; Sanner et al., 2012; Shozi et al., 2012). However, as highlighted by Arnold (2003), mobile technology can behave in paradoxical ways which are not anticipated when it is introduced in organisational contexts. This evident paradox is

characterised as a mythological god called Janus who was cursed with looking forward and backwards at the same time. In our case, mobile technology was introduced with the goal of minimising the challenges of health work in situations of resource limitation, yet the maintenance of mobile technology is challenging in rural and under-developed urban locations where poverty is rampant. With such interventions, there is the risk that "*work routines are often destroyed and replaced with much less flexible and more expensive solutions*" (Berg, 1999, p. 96). In the broader context of human development, wherein health care provision is implicated, Escobar (2011) contends that the countries to which development aid is directed often have limited participation and control in rationalising the interventions. He concludes therefore that these interventions might themselves be implicated in the increase of poverty.

This study describes one such intervention in Malawi that was meant to extend the reach of the public health information system through the design and implementation of mobile technology based tools. It demonstrates how the micro-processes of domesticating mobile technology for the local setting are related to the broader context, implicating individuals, settings and resources far removed from the sites of implementation. We utilise the concept of 'information infrastructure' (Hanseth and Lyytinen, 2010) to illuminate the range of challenges and breakdowns that occur in implementing the technology. We further describe and categorise the articulation work that is undertaken to keep the project afloat and seek to surface the meaning of these activities for the sustainability of intervention. Through the use of these concepts we capture the broader socio-technical context of design and implementation of the system. Opportunity is an often overlooked aspect shaping the evolution of technology, yet it is implicit in the challenges that are faced. The study therefore conceptualises breakdowns, and the opportunities for articulation work that emerge along with the structural constraints determining the type of activities possible. More specifically, the study offers a multi-layered approach to discussing the nature of breakdowns, i.e. human or technical; levels of organization at which they might occur, and related implications on required articulation work and strategies to negotiate them.

1.1   Related Work

Given the tendency in IS research to overly focus on the potential of mobile technology, recent studies have called for a more holistic approach to mobile health implementation management, citing implementation failures, especially in relation to attempted scale-up efforts (Braa and Nielsen, 2013). Studies in large scale information systems have also narrowly focussed on the implementation aspects of technology separately from design (Pollock and Williams, 2008). Pollock and Williams (2008) bemoan the prevalence of what they term flat ethnographic studies, which seek to explain technology by looking only at the context of use at the expense of the broader socio-technical context in which they are embedded. To address these concerns, this study is conducted by researchers who engage with the varied breath of stakeholders in a technology implementation, from its designers to its users, across organisational and national boundaries, including its global context. The work contributes towards building an understanding on developing mobile systems meant to scale across multiple sites in different nations. It is also suited to address Pozzebon and Pinsonneault (2005, p. 125), who in discussing the implementation of generic software packages assert that the "*nature of the process by which global and local are negotiated is still poorly understood*". This persistent challenge necessitates the usage of a more encompassing socio-technical perspective, particularly the information infrastructural lens (Hanseth and Lyytinen, 2010), which is not common within the discourse on mobile healthcare technologies.In our study, we make the particular connection between articulation

work and the processes through which generic software comes to work across contexts and in local settings.

The study also pays attention to the perculiar context of Malawi, a developing nation facing unique challenges, thereby contributing to the broader discourse on IT and human development. Malawi is considered amongst the least developed nations, with a population growth rate that occurs in the foreground of a constrained infrastructural base. It consequently ranks poorly on global health indicators such as infant mortality rate and life expectancy. The health information system is highly fragmented thereby affecting the quality of the data that is used to make essential health decisions (Kanjo, 2012). Furthermore, while work in information systems has scarcely focussed on theoretical contributions, and has relied on existing concepts from sociology and other cognate disciplines, often in a descriptive manner (Matavire and Brown, 2011), our study makes a grounded theoretical contribution which is practically relevant to the context of research. In the following section, we proceed by providing a background of the theoretical concepts utilised in our research. After that, an outline of the chosen research method is given, including the analytical procedures used. A description of the case is then provided, followed by findings leading into the conclusion.

1.2   Breakdowns, Information Infrastructures and Articulation Work

Breakdowns in technology projects offer unique opportunities for understanding the context in which they are employed (Fischer, 2004). They also increase the visibility of stakeholders in an intervention and constitute interesting and overlooked sites of local innovation that may support acts of sustaining, extending and tailoring, as well as repurposing extant infrastructure (Jackson et al., 2012; Rosner et al., 2013). Breakdowns raise important questions about the fit and transformational role of a technology within an organisation. They become "*the basis for a much more detailed understanding of the relational nature of infrastructure*" (Star, 1999, p. 382). This means that breakdowns of technology can be useful in understanding the infrastructural context of their application. Infrastructure here is considered as information infrastructure, which is a socio-technical system of IT capabilities existing amongst stakeholders, including users and designers (Hanseth and Lyytinen, 2010). Since technological capabilities are constantly changing and stakeholders participation is fluid over time, an information infrastructure is also considered as evolving (Hanseth and Lyytinen, 2010). In the context of developing nations, the evolution of IT capabilities is not continuous but is punctuated by short periods of significant change with long periods of relative stasis (Njihia and Merali, 2013; Silva and Hirschheim, 2007). To explain the inability of a health systems intervention to be sustained, Silva and Hirschheim (2007) also note the importance of changing the underlying deep structures of organisations. In attempting to understand the underlying structures of systems, it is important to note that a defining feature of an information infrastructure is its invisibility, except during breakdown (Star, 1999).

Breakdowns are not a phenomenon that is unique to projects in under-developed contexts. According to Strauss (1988), p. 172, "*all projects have the potential for breakdown and repair; moreover, some degree of monitoring and rectifying of the fitting together of work is likely to be occurring at every phase of a project and at various levels of project organization*". What is unique therefore, are the idiosyncrasies of the context within which health information systems interventions occur (Puri et al., 2004); particularly in regards to issues that have been associated with under-development, that is the low literacy rates and poor access to electricity such as obtains in the case of Malawi. Breakdowns in the flow of activity are known, across differing philosophical traditions, to have the capability of revealing the nature of the world around, particularly the resources essential to the performance of a task (Jackson et al., 2012; Koschmann et al., 1998). A consideration of resources is elemental to the development of systems within the context of developing

nations, even as that might be, as in this case, constructed through a socio-technical lens. Looking at breakdowns in interventions has the benefit of allowing the analyst to look not only at the technology, but also at the activity for which the technology is implicated (Koschmann et al., 1998). When breakdowns occur, re-alignment of tasks, resources and agents is important in getting the project back on track (Baker and Millerand, 2007). This re-alignment can be in the form of "*making do*" or "*workarounds*" to get the project work to continue, or can be an occasion for "*institutional rearrangements*" (Strauss, 1988). Breakdowns emerge as an opportunity for building networks in the project's ecology (Mark, 2012). The management of breakdowns occurs through negotiation (Strauss, 1985). We demonstrate that, it is through choices available and decisions made in the event of breakdowns that intervention projects can be institutionalized in developing countries. In particular, we find articulation work being a dominant and approachable strategy for resolving breakdowns.

In the context of approaches that users adopt in stabilising technology within their context we find concepts like bricolage, improvisation and articulation work (Ciborra, 2002; Humphry, 2011). Bricolage is a concept that illustrates the collage created by users when they utilise seemingly useless bits and pieces of artefacts in their context to enable them to engage in routine work (Ciborra, 2002). The concept has been used to describe user activities in the appropriation of health technologies (Braa and Hedberg, 2002). In comparison, improvisation, while related to bricolage tends toward the consideration of activities that sustain routines in the face of the isolated and unexpected. Articulation work, on the other hand, is work that is usually unaccounted for in organisations yet it is critical to ongoing project activities. The concept refers to those tasks that are undertaken to facilitate the co-ordination of work. An important character of articulation work, in comparison to other concepts used in explaining the boundaries of information systems like bricolage and improvisation (Ciborra, 2002), is how it demonstrates the limited control that actors have in enacting routines within their context (Humphry, 2011). Articulation work, given its relationship to breakdowns, can be conspicuous since it brings a situation to visibility when re-alignment is possible or obstructive if no clear solution is available (Koschmann et al., 1998). In the service of workflow, the work of articulation is often assigned to specific organizational units, yet it is sometimes the case that these tasks are performed by people whose role is not primarily the maintenance of a technology, such as its users. Articulation work is also represented as invisible work since it is not visible except in instances of breakdown (Suchman, 1995). According to Star (1991) as referenced by Star and Strauss (1999), p. 10, '*articulation work*' is work that "*gets things back 'on track' in the face of the unexpected, and modifies action to accommodate unanticipated contingencies*". It refers to "*the specifics of putting together tasks, task sequences, task clusters -even aligning larger units such as lines of work and subprojects- in the service of workflow*" (Strauss, 1988, p. 164). Articulation work is a "*critical factor in information infrastructure building projects that involve multiple and diverse communities*" (Baker and Millerand, 2007). Infrastructure often requires articulation work to enable its continued functioning, as it contributes toward maintenance and transformation of novel technological offerings into quality systems that support everyday productivity (Bowker et al., 2010; Ribes and Finholt, 2009).

In our review of literature, particularly in the domain of health information systems, we have not found a study that elaborates the complex relationships between breakdowns, articulation work and information infrastructures. In the following section, we elaborate on the research method chosen for this study, provide an analytical case description, elaborate the findings and offer our analysis and discussion, rounding off with what it means for further work in the concluding section.

2.   RESEARCH METHOD
2.1   Research Approach

Primarily, the research is inspired by Grounded Theory Methodology (GTM) (Glaser, 1978; Glaser and Strauss, 1967). GTM is an inductive research methodology that gives primacy to empirical material by seeking to let the theory emerge and the data proverbially '*speak for itself*' (Alvesson and Sköldberg, 2009). Over time, the methodology has evolved into two distinct approaches, given the divergent paths taked by its originators. It has hence been a subject of contention, even within the information systems discipline (Matavire and Brown, 2011). Epistemologically, this research is interpretive and the researchers sought to obtain meaning from observations made in the data (Klein and Myers, 1999). GTM is rich in techniques for data analysis applicable to the social sciences and has been widely applied in interpretive information systems research (Matavire and Brown, 2011). Following GTM inspired techniques, preliminary concepts codifying the data were generated. Explanatory concepts were considered from a parallel literature review and integrated into the analysis. The usage of existing concepts to explain phenomenon in a grounded theory study is not in conflict with its original tenets (Glaser and Strauss, 1967). The reflexive usage of grounded theory methodology, without full adoption, is also widespread in social science research (Alvesson and Sköldberg, 2009). It is also a common approach within the Information Systems discipline (Matavire and Brown, 2011).The particular techniques from Grounded Theory Methodology (GTM) used were open coding, selective coding, theoretical coding and memoing with the overarching technique of constant comparative analysis applied. Open coding is the line by line analysis of documents like field notes, interview transcripts and recordings to identify categories in the data. Selective coding is the inclusion and exclusion of codes to enable theoretical focus. Theoretical coding is the integration of categories into sound concepts through making the relationships between them explicit (Matavire and Brown, 2011). Constant comparative analysis refers to comparing instances of concepts to others found within the data and literature in order to discover their dimensions or properties. Memos were also written to explore ideas which illuminated the empirical occurrences. It is important to highlight that the usage of grounded theory was merely analytical due to the constraints of applying the full methodology to a study of an ongoing action research project, where different actors work together despite the diversity of their research approaches. The analytical usage of grounded theory is common in information systems research (Matavire and Brown, 2011).

2.2   Data Collection and Analysis

While the mobile health system was piloted in Malawi starting from December 2011, this particular paper is developed from data jointly collected in the follow up stage with reflections on earlier activities. The second author has also been involved in the day-to-day running of the project from its inception. Field work was performed by both authors, within the context of a research pilot project, from April 2012 to May 2012 in a period of 6 weeks. Additional data was collected from interactions through to November 2012, making the span on data collection 8 months. The predominant qualitative data collection methods were observation, individual and focus group interviews. Email and SMS conversations highlighting the challenges of the project from its onset were also analyzed along with bug reports and processes for their resolution. Interviews with key personnel were also conducted. Five full day focus groups were organized in this period, with participants consisting of Statisticians, Health Surveillance Assistants, Statistical Clerks, Village Clinic Officers and Health Officers. Health Surveillance Assistants are responsible for collecting information within the community. Due to technical reasons, four focus groups have been considered in this analysis as shown in Table 1, below. Initial rigor in open coding generated a multitude of

concepts by "*running the data open*", however in later field notes, the approach was less open as concepts like articulation work were explored further. A literature review was undertaken to theoretically elaborate the codes. Focus groups helped to understand the challenges that the workers faced in their activities, mobile health technology usage, and on how the devices could be extended to support other aspects of their work. Field notes were the primary strategy for collecting the data and emergent ideas were pursued. Some interviews were also audio-recorded, with the permission of informants. Memos were used to reflect on observations, interview and theoretical ideas.

Table 1: Focus Group Participants

Focus Group	Health Facility Type	# of Participants	Designation
Group 1	Ministry of Health Headquarters	3	HMIS Management
Group 2	Health Centre	11	Health Surveillance Assistants (HSAs), Senior HSA, Statistical Clerk, Village Clinic Officers
Group 3	Health Centre	3	Health Officer, HSAs
Group 4	Health Area (A unit administering a collection of health centres)	2	Senior HSA, HAS

Some of the collected data was loaded into QSR-NVivo, a qualitative data analysis software which is compatible with grounded theory research (Hutchison et al., 2010). In particular, field notes and interview notes were loaded into QSR-NVivo, and open coded for categories. Memos were taken when ideas about the data came through discussion among authors and were also linked to the relevant categories in the software. It is through these discussions that the issue of articulation work was found to have strong explanatory power as pertaining to the issues arising and the desired outcome of the work, which is institutionalization of mobile technology in a healthcare setting. Detailed memos were also developed outside the software through an incremental memo sorting process as theoretical ideas were integrated with the discussion. QSR-NVivo was therefore not used extensively.

3.   CASE DESCRIPTION
3.1   Initial Organisation
This study was concerned with a mobile HIS pilot project initiated in Malawi to support the capturing of routine indicator data at health facilities administered by the Ministry of Health. At the time of the pilot, the ministry was engaged with the Health Information Systems Program (HISP), for which the authors are members, to facilitate migration from the standalone desktop based information system, DHIS 1.3, to the web based DHIS2. Data collection was done on paper registers at the level of health facilities, and these were sent for collation into DHIS 1.3 at the district level and further sent in electronic format to the national level. Numerous challenges therefore existed in sending data from the facilities by paper, particularly in the cases of rural health facilities where transport is scarce and road infrastructure is poor. It is in this context that the case for mobile data capturing at the level of health facilities was proposed, particularly since the DHIS2 software had mobile functionality integrated into it.

Work on the pilot started in late 2011, where strategies were formulated pertaining to how the hoped-for nationwide rollout would proceed. Discussions were held amongst key

members of the project team and relevant officials from the Ministry of Health, particularly members of the Central Monitoring and Evaluation Division (CMED). The project entailed the deployment of DHIS Mobile; a suite of mobile device based aggregate data capturing tools that utilize different technologies including internet browsers, Java (J2ME), and SMS. The J2ME mobile client runs on Java enabled phones and could be configured to use either SMS or internet traffic. The pilot in Malawi was undertaken for the J2ME and browser based DHIS Mobile solutions in 17 health facilities that fell under two of five health areas in Lilongwe district. Lilongwe city is the capital of Malawi, and the district encompasses some rural areas. The mobile J2ME and browser solutions in this case required GPRS connectivity to support data transfer between users and an online server. A monthly facility and a weekly disease surveillance report were chosen for the pilot. 20 Nokia C2-00 mobile phones were acquired from India based on a notable price difference in acquiring the devices from Malawi. Training was agreed for two representatives from each facility, where a requirement for at least one of them to be a statistical data clerk was made. Statistical clerks are employees of the Ministry of Health in Malawi whose responsibility is the management of health facility data. It was noted later that some facilities had no statistical clerks, and chose to fill the vacancy from the pool of Health Surveillance Assistants (HSAs) assigned to health facility catchment areas. In another instance, a data entry clerk who had been trained on the mobile technology had left the health facility, and no one had replaced him. This mobility was not an unusual scenario and often the health facilities responsible for supervising the work of HSAs can choose a replacement amongst them. The statistical clerk position was usually filled by school leavers, while the HSAs underwent additional training. A post-paid contractual arrangement was entered into with a mobile provider in order to ensure central bill payment and to permit cost analysis, specifically pertaining to data usage in line with research objectives. However, it was always envisioned that the project aimed at addressing real challenges experienced at health facilities and its sustainability was a stated and motivating goal.

3.2 Breakdowns

3.2.1 Mobile Device and Server Configuration

As the organisation and functionality of the intervention emerged, configuring mobile devices for the mobile network was initiated. This included the purchase of SIM cards, applying internet connectivity settings, creating data entry forms, installing the J2ME client, creating user names, and testing. It is during this early stage that the conceptualised intervention started to face problems, initially that the India acquired phones were not compatible with the host mobile network. The devices could not be configured for data packet access using configuration files from the service provider. Technical discussions ensued where a range of specialists were engaged to configure the devices to work in Malawi. This was not fruitful because of the persistence of the device and network conflict. A decision was made to acquire a different local model of devices which had been confirmed to be configurable within this context. While this was ongoing, training had to be re-scheduled, to the chagrin of participants. Configuration of the online server instance to be used for the pilots progressed much slower than expected, as efforts depended to a significant extent on a resource team, resident in Blantyre, some 300 km away. Coordinating tasks with the team proved to be more challenging than anticipated. Face-to-face meetings with the system administrators were difficult to arrange which was exacerbated by prevailing nationwide fuel shortages at the time of implementation.

3.2.2   Mobile Service Provider Interactions

Earlier in the project, a post-paid subscriptions package with the mobile service provider had been selected. Insomuch as this arrangement permitted central administration of phone subscriptions and access to data usage summaries for research, it posed some challenges. With post-paid subscriptions, the available package meant that voice calls had to be capped to avoid excessive bills. This limited the capacity of phone users. With pre-paid subscriptions the phone users would have had the option of purchasing additional phone credit from numerous sale points. Furthermore, issues with 'packed up' SIM cards or call service unavailability arose for some users. The chosen service provider also delayed in refreshing call credit at the beginning of each month. The challenges proved difficult to resolve because of the organisational setup within the provider. The contact persons were service personnel who depended on their colleagues in the provider's IT department to resolve the pilot project's technical concerns. There was limited direct contact with the IT personnel, which made it challenging to resolve critical technical issues. Interactions with the contact persons revealed that they lacked authority to push for resolutions from the provider. For instance, at one point the mobile provider contact had to call an IT person and ask for an explanation as to why it had taken long to cap voice calls as agreed. The request was refused, yet the issue was subsequently resolved; after five months of piloting had elapsed.

3.2.3   Mobile Application Usage for Data Entry

The conversation below, between one of the authors and a participant enrolled in the pilot, demonstrates some of these challenges:

UserX: "My number is ... am unable to SMS, make or receive calls" (17 October 2012)

UserX: "Just want to remind you about my issue...my number is ...Am unable to SMS, make or receive calls" (18 October 2012)

Author: "I have presented the issue to [mobile service provider]. I am waiting for their feedback" (18 October 2012)

UserX: "Evening, the [mobile service provider] people have not rectified my problem...unable to call or SMS...pliz assist"(5 November 2012)

       All the messages from UserX were forwarded to our contact person, for action. Such challenges could be minimised with the use of pre-paid cards as they can be acquired from vendors countrywide. Modalities to switch from post-paid mode of subscription to pre-paid were initiated. A sticky point is the management of the allocation of Internet data bundles for participants. The mobile service operator had no service that allowed subscribers to share data bundles. There was a need to push call credit to the devices which recipients needed to manually convert to data bundles. Another challenge is that the cheaper data bundles targeted, had limited validity periods, a day in most cases. There were ongoing negotiations for a solution with the mobile service provider. While longer term strategies to resolve these problems are preferred, it is also important to highlight an occasion where users articulated a resolution. The pilot was also designed to compare usability between the J2ME and browser based clients in low resource settings. All participants were trained in the use of the browser based solution while a group from one Health Area received additional training in the use of the J2ME client. During the process of data entry in the latter group, when the J2ME client experienced connectivity problems, some participants shifted to the browser based application. This is important since it creates the possibility to install multiple clients on user devices such that they can shift from one to another to resolve breakdowns.

3.2.4   Ministry of Health Project Coordination

As previously noted, piloting was started in a period during which the Ministry of Health was attempting to migrate from a desktop-based DHIS1.3 to the internet and central server based

DHIS2 solution. The pilot project was utilising an online national DHIS2 server, but the Ministry of Health Central Monitoring and Evaluation Division (CMED), which was at the centre of the proposed migration efforts, was yet to shift from DHIS1.3. There was no seamless metadata, data element and indicator export functionality between DHIS1.3 and DHIS2. The implication of this is that all district health offices in Malawi, including our pilot district were required to send their data to CMED in a DHIS 1.3 compliant format. Although CMED intended to move to DHIS2, they lacked financial and technical capacity to push the migration forward. For example, the Ministry of Health Headquarters had a single IT officer in their hierarchy, whose focus was not on the national health information system. It was found that the bureaucracy in applying for the creation of a new IT position in the Ministry hampered the efforts. Therefore, migration of data from DHIS1.3 to DHIS2 was dependent on the DHIS team in another city. Financial support for the migration was dependent on multiple implementation partners, with their own timelines and organisational arrangements to adhere to. Each external donor agency or parallel program had its own organisational priorities, which did not uniformly represent the problems on the ground. For instance, in one scenario, 18 districts had multiple donors willing to support ongoing HIS efforts, whilst the other 10 districts had none at all. Donor organisations only operated within certain districts that they had targeted to achieve the greatest impact according to their internal organisational goals. Thus, while the goal is integration of data processes, spatial fragmentation still persists due to uneven distribution of HIS resources. To counter such challenges, some working groups were put in place by the Ministry of Health and its partners. For example, a Monitoring and Evaluation (M and E) Technical Working Group was mandated to establish appropriate standards for integration. Within the working group, a mHealth forum with the membership of the various organisations running mobile interventions in the health sector of Malawi was established after the pilot was started. It is through this forum that key questions about the sustainability of projects could be negotiated. For instance, a key concern that arises in the design of technology for health is, if it works, "*who is going to pay for it*"? The mobile devices need airtime to be enabled for data access on a regular basis and it was therefore anticipated that negotiations with mobile providers can occur at the level of the Technical Working Group.

3.2.5   Global Development and Local Requirements
At the time of implementation, the DHIS Mobile platform used was rapidly evolving to support varying requirements from the parent project's multiple implementations in various countries. This introduced instabilities in the platform. For example, at one point, in upgrading to a newer DHIS2 server instance, it was discovered that compatibility with a mobile J2ME reporting client supported by the previous version had been lost. This was temporarily resolved by backwardly synchronising server instance releases with available mobile client releases, which was satisfactory. This scenario presented shows an instance where the issues in Malawi were similar to those in other locales, hence the speedy resolution. DHIS Mobile software was developed by an international team of software developers, with most core developers resident in Vietnam and some key project leaders, responsible for coordinating developer tasks, based in Norway. It was therefore challenging to adequately relay localised software requirements between the implementation team in Malawi and the global team in Vietnam and Norway. In cases where urgent resolution of bugs was needed, given the limited technical skills in the ministry, local workarounds would likely address the problems timeously. There existed communication challenges in forwarding local requirements to the global development team and coordinating their resolution. A member of the global team aptly characterised this through the remark: "*to be honest we didn't understand the request until now*"; months later.

3.2.6   District Office System Access

In the case of mobile HIS data entry, data is transmitted from mobile devices into the central server. This is problematic for data quality as all the intervening checks necessitated through the paper-based system are leapfrogged by the mobile technology and central server architecture. In DHIS1.3, data was entered in a database on the local machine at the district level, archived, and sent via email to the health statistics office at the national level. In one instance, a participant at the district office, would enter the data offline after receiving the paper reports, store the file archive on a memory stick, and go to an adjacent office block where an internet connection existed to send the data. Internet connectivity related challenges were also experienced at national level in attempting to retrieve these files. With mobile data entry at facility level, it is important for the district offices and the national level to have stable internet connection in order that they may verify and confirm the entered data. Furthermore, health workers at the facility level also needed mechanisms through which they could access reports on the submitted data in order to improve on its quality. During the pilot, data dongles were provided, a situation which required manual monthly airtime top up. Asides from this, the participant officer also continued to receive paper reports from facilities that were not part of our pilots, for entry into the DHIS 1.3 system. A district officer therefore had to reconcile the data entered onto the online DHIS2 server, using mobile phones, with the data in DHIS1.3, before sending data for the district to the national level in the archive format. This was an inconvenience which was expressed clearly as an untenable situation. At the time of writing this paper, the situation had improved after CMED and most districts in Malawi, including Lilongwe had shifted from DHIS 1.3 to DHIS2. The shift made it easier for the district participating in the DHIS Mobile pilots to manage data reporting through a combination of paper-based registers and DHIS Mobile-supported reporting, as now all data was maintained under one central server.

4.   ANALYSIS AND DISCUSSION

It is realized that the basis for the pilot to be permitted within the Ministry of Health of Malawi was to attempt to address the numerous challenges encountered in the flow and proper use of data in line with local and global requirements. Malawi is considered as a least developed nation, a measure which demonstrates its marginality in the provision of basic services like education and healthcare to its people. Hence simply put, it is breakdowns in the healthcare delivery infrastructure that permit this innovation process to occur in Malawi. Our own intervention, centred on the DHIS Mobile technology, was geared towards addressing the challenges posed in monitoring health indicators from across the country. We saw in this research that though technology typologies might assist in the conceptualization of solutions for developing nations as described by Sanner et al. (2012), technology fit and sustainability can only be the result of a continuous articulation process within the context. This articulation work is conspicuous where users find their own solutions to the challenges, and obtrusive where unsustainable mechanisms are enacted to solve the challenges. Such mechanisms, in this case, manifest in donor dependency to resolve problems. We find that chosen solutions interacting with persistent structures in the intervention can result in breakdowns. This also means that the choices that are also made in the event of breakdowns have a similar causal and conditional impact on future failures and successes as they affect the problem and decision space.

4.1   Breakdowns and their Articulation

In Table 2 below, we see situations where breakdowns occurred in the intervention, and how they were resolved. The goal was to eventually have a design which was robust and could operate within Malawi, with aligned external dependencies. In this study we discover two

categories of articulation work, technological and human. Technological articulation pertains to technical work that is done to ensure the work of mobile data entry gets back on track. Human articulation pertains to the work of formation of temporal networks of action among actors to address breakdowns. We also see the challenges of designing mobile HMIS technology for developing countries, with Malawi categorised as least developed (UN, 2011). The systems designed in global domains, face challenges that are understood in event of localised breakdowns. Articulation work is used as a strategy to overcome these challenges. However, it is recognised that articulation work is not enough to sustain interventions, even what is here termed human articulation. In the research context we see the peculiar case of the formation of the mHealth forum, which we argue is articulation work, in the form of organisational rearrangement. Kanjo et al. (2009) who also conducted their study on the HIS in Malawi recognise that stakeholder buy-in alone was not enough to get a system to be institutionalised, and therefore recommend that flexible standardisation is key to HIS success. However, it is important to realise that such institution wide approaches require higher level negotiation processes which are relatively inaccessible to many m-health initiatives. This research recognises and considers the essence and possibility of a multi-level approach to institutionalisation.

Table 2: Breakdowns and their Articulation

	Articulation Work	
Breakdown	**Technological Articulation**	**Human Articulation**:
Failed mobile device and server configuration	Phones hurriedly replaced, and the pilot training affected.	Negotiations with network operator and project sponsors led to a realisation that the local mobile provider involvement should start early.
Limited mobile services from provider as we deal with marketing agent.	Mobile data capping remained problematic. Usage trends and alternative packages were analyzed in the billing statements so as to determine future re-arrangements.	More strategic partnerships with local mobile provider could provide leverage in negotiating packages.
Failed SIM cards.	SIMs collected from mobile service operator and delivered individually to remote facilities. Mobile software configurations reapplied and tested.	Negotiations on SIM ownership to provide incentive for mobile device maintenance among users.
Missing mobile system Functionality	Making do with the available features while awaiting changes.	Engagements with the global team to consider requirements from case and improve responsiveness to local concerns.
Limited system access from District Health Office	Manual dongle top up. Assistant statistician needed to enter data from new system into old.	Negotiations for full migration from legacy system to new system.
Mobile client application failures	Users chose browser client when J2ME client failed.	Negotiating the building of redundancy into the intervention by training users on multiple

		clients.
Erratic internet connectivity in Central health statistics office.	Awaiting connectivity solutions proposed by different stakeholders.	Advocating to stakeholders for a sustainable solution. Developing resident capacity to manage implemented solutions and provide support to users.
Delays in attending to user queries by mobile service provider	Making do with current limited services.	Frequent follow ups on queries raised with provider. Lobbying with other organisations doing mHealth, through the Malawi mHealth forum, for a unified voice to gain more bargaining power.

From the case presentation and Table 2, above, it is evident that resolution of local technology breakdowns can be achieved at individual level, across different levels within an organization, and across organizational boundaries (within or across countries). However, where interventions are part of a larger infrastructure setup it is often the case that networking across organizational levels and across organizations in necessary to resolve breakdowns. In this study, articulation work that requires collaboration across multiple levels includes efforts to resolve: mobile telephony subscription; replacement of failed SIM cards; migration from DHIS 1.3 to DHIS2; DHIS2 server configuration; and failed attempts mobile device configuration, for the set of phones purchased in India. Consequently, the two identified categories of articulation work, technological and human, can also be analysed from other dimensions based on the levels of organizational involvement required to resolve them: (i) localised (individual or location where breakdown occurs; single point of end-user support) ; (ii) multiple levels within single organization (multi-level and intra-organizational); (iii) and multiple levels cross-organizations (multi-level and inter-organizational).

A challenge is found in motivating local and global stakeholders into more structured and sustainable inter-organisational arrangements. A significance of the multi-dimensional analysis of articulation work presented above is that it may help interventionists anticipate the amount of effort and coordination required to address breakdowns in a mobile health project. Coupled with an obvious need for coordination that emerges when multiple stakeholders require mobilization to address breakdowns is the issue of jurisdiction. Particular stakeholders tasked with the resolution of breakdowns might not be in a position to influence the trajectory of required articulation work across organizational boundaries. When this occurs, there might be need for preliminary work, such as development of work relationships, to take place in order for required articulation work relating to identified breakdowns to take place. However, building stable work relationships across organizational levels takes time. The DHIS Mobile pilots could have benefited from such an analysis in dealings with the mobile service provider, where resolution of issues agreed upon with points of contact depended on other IT personnel the project team was hardly in contact with. Implications of buying mobile phones outside the context of implementation, under which the DHIS Mobile project team could not readily access the vendors, when problems emerged, could also have been weighed more carefully. Going forward, such an analysis also creates an opportunity for those implementing mobile health systems to anticipate the amount of work introduced in negotiating the development of more sustainable organizational arrangements that can outlive current intervention activities.

Meanwhile, articulation work remained as the dominant strategy to keep the intervention afloat. Infrastructure work frequently entails ongoing articulation work to permit continued functioning (Bowker et al., 2010). Quite often, failures in information systems

projects in developing countries are due to limitations in technological and human infrastructure (Heeks, 2002; Manda and Sanner, 2012; Semaan and Mark, 2011). In our work, we demonstrate through an ongoing project the low level strategies that are employed to resolve these challenges, and we find articulation work occurring technologically and organisationally. By analysing our research in this manner, we also see the possibility for breakdowns being used as opportunities for the building of both technological and human infrastructure. We also see the challenges that can arise if breakdowns are tackled in isolation, as similar challenges exist in other projects within the context of developing nations.

It is critical that efforts to develop necessary technical and human infrastructure take on board key stakeholders and also look beyond individual project arrangements. It has been noted that project-centric interventions often collapse when interventions end (Lehmann and Sanders, 2007; Sanner et al., 2012). However, unlike individual project arrangements, which are often short-term, infrastructures evolve over long periods of time. This necessitates the presence of more persistent individual and organizational arrangements to transition novel solution offerings into stable technologies that support productivity (Ribes and Finholt, 2009). It is against this background that key players within the Malawi HIS landscape, such as the Ministry of Health (through CMED) and the team coordinating the shift from DHIS 1.3 to DHIS2 had been engaged from the onset. At the same time, engagement of multiple stakeholders, especially across organizational boundaries, must be approached with caution, as this can introduce significant coordination overheads, which may slow down the resolution of breakdowns. All the same, the strategic negotiation of breakdowns across stakeholder groups is a key process in designing mobile technologies that address both immediate and long term concerns for sustainability (Mark, 2012; Ribes and Finholt, 2009).

5.   CONCLUSION

This study demonstrates that mobile intervention in developing countries entails the development of local work routines at multiple organisational and interorganisational levels to support the introduced technology. In some cases, this is done with the resources embedded in the context, while in others users have to rely on the continued support from the interventionists. In either case, we see that sustainability of intervention is an evolutionary process which entails the constant adaptation of human and technical resources necessary for the continued use of introduced technology. Given the limited infrastructure in the context of this study, articulation work is employed to keep the project ongoing and it takes on the peculiar form that provides suggestion to the sustainability of the intervention. Two varieties of articulation work are discussed in this work, which are human and technical. Participants employ technical and human resources in the environment based on their local knowledge to sustain the work. The organisational structure is altered in that new connections are sought when breakdowns occur. This is illustrated in the human articulation aspects where diverse interactions are employed to address a breakdown. In technical articulation, we see problematic parts being replaced and rearranged by participants to enable the intervention to continue. In this context, we realise that rigid systems will be expensive and not easily integrated into the contexts as users will not be able to recover from breakdowns resulting in failure.

Breakdowns can manifest at various levels within the organizational hierarchy, or manifest across organizations shaping an implementation. In our case, this includes stakeholders within the Ministry of Health, users, implementation partners, the mobile service provider, the project support team in Malawi, and the global development partners. Breakdowns can be localised, such as those within the Ministry of Health, or manifest in cross-organisational relations. The latter is evidenced in how breakdowns within our mobile

service provider, with regard to addressing issues impacted the pilots, showing the boundaries of articulation. The varied nature and extent of breakdowns has an implication on the type of articulation work required to resolve them. For example, breakdowns requiring the mobile service provider to cooperate are much harder to resolve considering that they are beyond control thereby temporally becoming external contingencies. We also find that breakdowns are occasions to alter the organisational and technological structure of the project as evidenced in the formation of the mHealth forum.

In future work, we aim to continue to develop a theoretical framework that is useful in the design of mobile HMIS solutions. From our analysis we see that designing for articulation is a useful strategy for developing HIS in developing nations. Our work also enables us to consider the role and timing of strategies that can be employed to improve outcomes in information infrastructure interventions, such as the the long-now of information infrastructure design (Bowker et al., 2010; Ribes and Finholt, 2007, 2009) The long-now perspective is concerned with building information infrastructures to address present and emergent demands, with an emphasis on decisions taken early on in the intervention as having consequences for the sustainability of the intervention. In paying attention to the relevance of the totality of socio-technical arrangements, which lead to breakdowns or their resolution, this paper underscores the importance of the information ecology (Nardi and O'Day, 2000) within which mobile HMIS solutions are constructed. Our work also points to the inter-organisational character of localised interventions. They demonstrate how the local can be intricately tied into activities that occur across organisational and national boundaries. Understanding the nature and sustainability of such relationships is a key aspect in ensuring sustainability. It was recognised that interorganisational relations have a key role in enabling nations to develop suitable technologies for development (Njihia and Merali, 2013). The study also raises question about the approaches that are suitable for investigating technologies in complex organisational settings such as that which is illustrated in the case. It is important to adopt approaches that illuminate the multiple levels of the phenomenon and the varied relations that are implicated in developing technologies for low resource contexts. Grounded theory methodology has the character of following the data from the setting closely, with fitting categories for explanation. The role of literature in such studies is often contested, however we demonstrate in this work that the adoption of the principles of the methodological approach is not in conflict with existing theoretical concepts. However, the difficulty of adhering to the methodological tenets of GTM means its application, particularly within the broader context of an action research project which is guided by specific practical outcomes, remains contentious. Despite this, it still remains that the field would benefit from research that aims to develop theory that is faithful to the context. Studies that illuminate the difficulties and approaches used in practice will be informative to the discourse.

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III

FROM CO-OPTATION TO PRODUCTION: RISK IN HEALTH INFORMATION SYSTEMS IMPLEMENTATION AND DEVELOPMENT

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Abstract: In this paper we discuss the production of space in the arena of development of a server environment meant to host a new technology, which is the DHIS 2 software in Zimbabwe. Emerging technologies developed and implemented with the goal to integrate fragmented health information systems require robust and scalable server infrastructure offered in environments of reliable internet connectivity. We analyse the legacy space, that is decentralised and running standalone applications, as needing transformation to a new space with a centralised server architecture. We pay attention to the activities among the diverse stakeholders engaged in the production process as key to understanding the implementation. The process undertaken in order to develop the requisite new relationships to meet these demands is considered as the 'production of space'. Using this conception, we find that there are asymmetries between the co-opted space of donor agencies, the representations of space inscribed in the technology and the material lived context of the health information systems change intervention which severely impact on the production of space. We thereby present perspectives through which challenges of complex large scale and generic technology implementations can be understood and interventions sustained.

Keywords: production of space, integrated health information systems, architecture, materiality, intervention, co-optation

1. INTRODUCTION

Increased access to the Internet in Africa, particularly due to the rapid roll-out of mobile networks, has presented new opportunities for the development and implementation of health information systems (Matavire & Manda, 2014; Sanner, Roland, & Braa, 2012). Many governments have chosen to leverage this infrastructure to develop integrated data warehouses for the storage and dissemination of their data (Braa & Sahay, 2012). The District Health Information Software (DHIS 2) is a generic open source and Internet-based technology that many of these nations have chosen in order to address this concern (Braa & Sahay, 2012). This technology runs on a central server and creates the possibility for health workers at all health facilities with internet connection to capture routine data for surveillance of health indicators across regions. The challenge is that the techno-organisational development necessitated by the implementation of this software does not occur on a tabula rasa. There is a pre-existing configuration of society, organisation, politics and technology in these spaces which is often called the installed base (Hanseth & Lyytinen, 2010) on which novel techniques need to be applied to produce the 'new' spaces of production for the technology (Lefebvre, 1991). This study focuses on server infrastructure development in the context of Zimbabwe, where pre-existing arrangements constrained the production of a space for the appropriation of the DHIS 2 technology.

To understand the challenges, it is essential to give an overview of the dominant structures characterising this domain. Many developing countries have adopted the World Health

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Organisation's (WHO) Sector Wide Approach to Health Development (SWAp) in the hope of resolving the numerous challenges they face within their public health systems. These challenges include shortages of funding, poor infrastructure and limited human resources (Braa & Sahay, 2012). The adopted Sector Wide Approach (SWAp) is "*a sustained government-led partnership with donor agencies and the civil society in-which sector-wide interventions are applied to an expenditure framework and national implementation system for the health policy*" (Taderera, Madhekeni, Zhou, & Chevo, 2012, p. 159). Accordingly, a key component of the SWAp in Zimbabwe is to pool donor resources within the Ministry of Health and Child Care (MOHCC) in order to coordinate activities aimed at strengthening the national health information systems. Increasingly tense relationships between the government of Zimbabwe and numerous agencies involved in the healthcare sector led donor organisations to channel money, not through the pool of funds, but directly to Non-Governmental Organisations (NGOs) and United nations agencies such as the United Nations Development Program (UNDP) and United Nations Children's Fund (UNICEF) among others (Taderera et al., 2012). Research suggests that billions of dollars are channeled through these organisations toward the diverse interests of the involved stakeholders based on the premise that they are less corrupt and more accountable than despotic African regimes (Gary, 1996). There is consequently a persistent highly fragmented environment of multiple donor programs, siloed information systems (Braa & Sahay, 2012) and possibly, a weakened state (Gary, 1996).

This situation contributes to the production of data of low quality which is neither used, nor adequate for decision making (Hotchkiss, Aqil, Lippeveld, & Mukooyo, 2010; Lippeveld, Sauerborn, & Bodart, 2000). Consequently, there is a drive to replace legacy systems, with integrated and internet based solutions. There is also a drive to increase ownership of these systems in the government given the unsustainability of prior interventions. This task is complex, and is either characterised by high rates of failure or, at least, largely unmet expectations. Research to account for these complexities has however been largely trapped within a micro-meso-macro conceptualisation of the phenomenon serving the different 'professional concerns' of the researchers. For instance, there is a predominance of institutional level analysis, and the application of institutional theories to account for the challenges faced and failures experienced (Asangansi, 2012; Sahay, Sæbø, Mekonnen, & Gizaw, 2010; Sanner & Sæbø, 2014). On the other hand, micro perspectives highlighting the strategies employed by users in 'domesticating' technologies for local use have also found a consistent place in the discourse (Asangansi et al., 2013; Heeks, 2002; Matavire & Manda, 2014). Few have undertaken to develop explanations that transcend these dichotomies. In this regard, "*pursuing alternative perspectives on, and ontologies of, technology may be especially important and valuable*" (Orlikowski, 2010, p. 127). In our analysis, we have discovered emergent fit between the phenomenon, and conceptions of Lefebvre (1991) on 'production of space'. Numerous studies have highlighted the value of spatial analysis in information systems research which they rightly contend is often taken for granted as demonstrated by the paucity of such studies (Czarniawska, 2004; Jorgensen & Sorensen, 1999; Kaniadakis, 2012; Sahay, 1997). We look to Lefebvre (1991), and his concept of 'production of space' to theorise the process through which the server infrastructure in the Zimbabwe health ministry emerges from, and necessitates the formation of, new relations. We see that to run the technology, a decentralised architecture and its spaces need to transition to a centralised architecture with the requisite spatial rearrangements. However, misalignments between the conceptions of planners, necessary competencies and daily realities of users constrained the emergence of the new infrastructure.

2. THEORETICAL BACKGROUND

2.1. Production of Space

A key challenge that motivated Lefebvre (1991) to present the concept of production of space was the dominance of the object-subject distinction in philosophy and social science. This,

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according to Lefebvre served a discourse that propagated and increased the gap between the mental and the social. Marxism transcended these dichotomies by providing a theory and methodology which related the physical, mental, and social aspects of life. However, unlike many of his contemporaries in the French Communist party, Lefebvre viewed Marx historically and dialectically.   Marx's categories of analysis, particularly the economic analysis of commodities and social relations were limited by the time and place of his writing.   For Lefebvre, the increasing importance of urbanization and space and its effect on everyday life was simply not visible to Marx at that time. He was thus not able to adequately address the challenge presented by new developments in the productive forces of society giving rise to a '*new mode of production which is neither state capitalism nor state socialism, but the collective management of space*' (Lefebvre, 1991, p. 103). This discussion of Lefebvre (1991), dovetails with an increasing awareness in information systems that the distributed nature in which software is now developed, implemented and used calls for spatial conceptions of the phenomenon (Kaniadakis, 2007; Pollock & Williams, 2008). The concept of 'production of space' can therefore provide greater analytical insight into these spaces of technology development, implementation and use. Despite this shared awareness, very little has been done to utilise these ideas in technology studies, a gap we aim to fill in this paper.

Lefebvre (1991) posits a tool, the spatial triad, in order to uncover the process of production of social space. Within this tool are what he refers to the moments of production of space which are 'spatial practice', 'representations of space', and 'representational space'. Lefebvre (1991, p. 38) notes that "*the spatial practice of a society secretes that society's space, it propounds and presupposes it, in a dialectical interaction*". Spatial practice, also referred to as perceived space, foregrounds the relationship between a space and its use and can be understood by looking at the varying competencies that make up a society. For instance, the hospital as a space engenders visions in the mind of the practice of doctors, nurses and their patients of using that space. Similar analogies can be demonstrated for markets, stadia, malls, and other spaces demarcated for specific practice. Representations of space are the conceptualised spaces and these are related to techniques which produce artifacts such as maps, plans, models, and designs of a space (Lefebvre, 1991). Representations of space, also known as conceived space, are linked to "*tools, methods, systems, discourses, models, images, and strategies which are engaged in the materialisation of ideas*" (Carp, 2008, p. 134). Finally, the third in the conceptual triad of Lefebvre (1991) is 'representational space', which is also known as lived space. Representational spaces "*are those places that evoke an unusually deep sense of meaning*" (Carp, 2008, p. 135). Lefebvre (1991, p. 33) posits that representational spaces embody "*complex symbolisms, sometimes coded, sometimes not, linked to the clandestine or underground side of social life, as also to art*". If coded, representational spaces could be monuments, memorials, churches, art forms and other such structures which are found in social space. Having expounded the conceptual triad as such, it is important to note that it is to be considered in a holistic and concrete manner if the concept of 'production of space' is to be grasped. Consequently, Lefebvre (1991) thinks of the elements of the spatial triad as 'moments' in the production of space.

2.1.1. Placing Technology in Space

Having introduced the concept of production of space, it is important to bring to the fore the 'place'' that information technology has in this process. According to Smith (2008), advances in information technology differentiate and enhance co-operative labour between workers distributed in space, something which is of vital importance to capital by virtue of its reduction of the costs of production. In particular, "*the obsolescence of old technologies and the rise of new ones, so vital to capitalism, is simultaneously the transformation of old spatial structures into new ones*" (Smith, 2008, p. 128). New information technologies therefore, at least partially, account for changes in the spatial relationships of production. Lefebvre (1991) also notes that space is both a product and is itself a means of production. This means of production, and the

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product, can not be separated from the "*productive forces, including technology and knowledge, or from the social division of labour ... or from the state and the superstructures of society*" (Lefebvre, 1991, p. 85), and also, perhaps, from nature. The production process itself implies mediation, that is the application of a technique to move from the 'raw material' to the product (Lefebvre, 1991).

2.1.2. Health information systems strengthening space

Pollock and Williams (2010, p. 540) assert that the healthcare sector has "*the largest and most complex organisational structures*". The healthcare space of nations considered as developing is particularly complex in that it is populated by multiple donor agencies and programs with vertical reporting systems (Braa & Sahay, 2012; Lippeveld, Sauerborn, & Bodart, 2000; Taderera, Madhekeni, Zhou, & Chevo, 2012). The state has increasingly co-opted donor agencies in order to support service delivery in the areas of healthcare, education etc (Gary, 1996). Co-optation refers to a scenario where one group uses the space of another, in areas where interests meet, in order to achieve its own objectives. Lefebvre (1991) provides the example of the earlier and enduring use by Christians of buildings which had originally been set aside for other public activities as its cathedrals as a successful case of co-optation. This co-opted space is the dominant space in health information systems interventions where policy, strategies, plans, architecture, standards, technologies, and funding mechanisms are agreed upon among diverse stakeholders (Braa, Monteiro, & Sahay, 2004). The space of health information systems strengthening is consequently constituted of actors of varying competencies, from the local level of health workers, to the global level of multilateral and unilateral agencies. Furthermore, many of the actors are actual users of the health information systems that are implicated in this space and interventions are driven by their acceptance of the systems in their contexts (Braa & Sahay, 2012).

3. RESEARCH APPROACH

Overall, the study was conducted within the action research tradition (Davison, Martinsons, & Kock, 2004). Since the aim of the study was to generate an explanatory theory of the development and implementation of a generic software in a local setting, for which action research is not fully equipped (Baskerville & Pries-Heje, 1999), it was supported by techniques from the grounded theory methodology (Glaser & Strauss, 1967; Matavire & Brown, 2013). A particular technique that was used for theoretical elaboration from the methodology was the 'constant comparative method'. This implied the continuous and reflexive movement between data, theoretical codes and literature in search of both gaps in literature and relevant conceptual formulations which were faithful to the empirical material. This was supplemented by discussions among the co-authors on the implications, fit and suitability of alternative conceptions of the phenomenon under study. Early stages of the study were largely inductive, yet latter stages focussed on the emergent theoretical conception and its applicability in explaining the data.

3.1. Research Context

The research context concerns an initiative by the Ministry of Health and Child Care (MOHCC) in Zimbabwe to implement an Internet-based routine health information system from early 2012 to late 2013. The study was exploratory, with initial visits organised to get insight into a relatively concealed process and later visits being organised with specific interventions in mind. The study presented a unique opportunity to study the implementation of the system from prior to a decision to adopt the system, through to piloting and rollout to more than 60 districts in the nation. The global context of the development and implementation of the generic DHIS 2 software that was being implemented by the MOHCC also presented a unique phenomenon of enquiry. The authors were involved with the project at the numerous levels, from having access to developers and sponsors based in the north, to interacting with implementation partners and

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government officials at the numerous levels of the MOHCC and across organisational boundaries in Zimbabwe. The study was concerned with understanding this ensemble of people, organisations, artefacts and practice and developing explanatory theory on the development, implementation and use of generic software.

3.2. Data Collection

Following the action research method of learning by doing, actors across organisational units, in and outside the health ministry, were engaged to identify and resolve the various challenges that were being faced in adopting and implementing the DHIS 2 technology. Up to 24 interviews were conducted with health staff from the facility up to the national level and across organisational boundaries. These were with 7 directors, 2 programmers, 2 provincial officers, 6 district health information officers, and 7 health facility workers. Interview questions were focused on understanding the health information system from the perspective of the different actors at the multiple levels, identifying problems and collectively designing interventions to resolve them. Observation of health information staff was done in their work settings and in training sessions arranged in order to understand work practices and facilitate the transition to the new system. This paper focuses on the area of server infrastructure which was a critical component to the system, and for which engagement with the authors intensified in the 6 months from June 2013 to December 2013. During this period, two field visits were organised, the first with two of the authors of this paper and the second with all three. In particular, a training workshop for IT staff in the ministry of health in order to build capacity around the server infrastructure, which had almost completely been neglected in the roll-out of DHIS 2 was organised. During this training, a participatory risk analysis exercises with the IT staff was conducted. The aim was to understand the risks around the deployment of the system and to collectively design interventions to resolve them.

3.3. Data Analysis

The data collected, and activities for each day were developed into comprehensive field notes. The field notes were in turn developed into more palatable reports which were shared with the MOHCC, training participants and partners. Using these reports, plans for further intervention were developed with feedback from the numerous stakeholders, both 'local' and 'global'. Information and documents collected in the research were kept confidential, stored on local machines and also backed up on virtual machines. The study occurs in a complex domain where knowledge claims are tested in practice, and where the subjects of research can speak out against science. The scientification of society or socialisation of science is often considered in itself as a unique characteristic of emerging global phenomenon (Nowotny, Scott, & Gibbons, 2001). Consequently, participants in the study were to varying degrees involved in analysing the phenomenon. We were involved in diagnosing problems, and solving them in a practical setting. Our interventions were judged as essential by the participants and constituted ongoing analysis. The authors also discussed on the key areas on which the phenomenon could be theorised. After numerous cycles, the authors agreed on the relevance, fit and explanatory reach of Lefebvre's (1991) ideas on the 'production of space'.
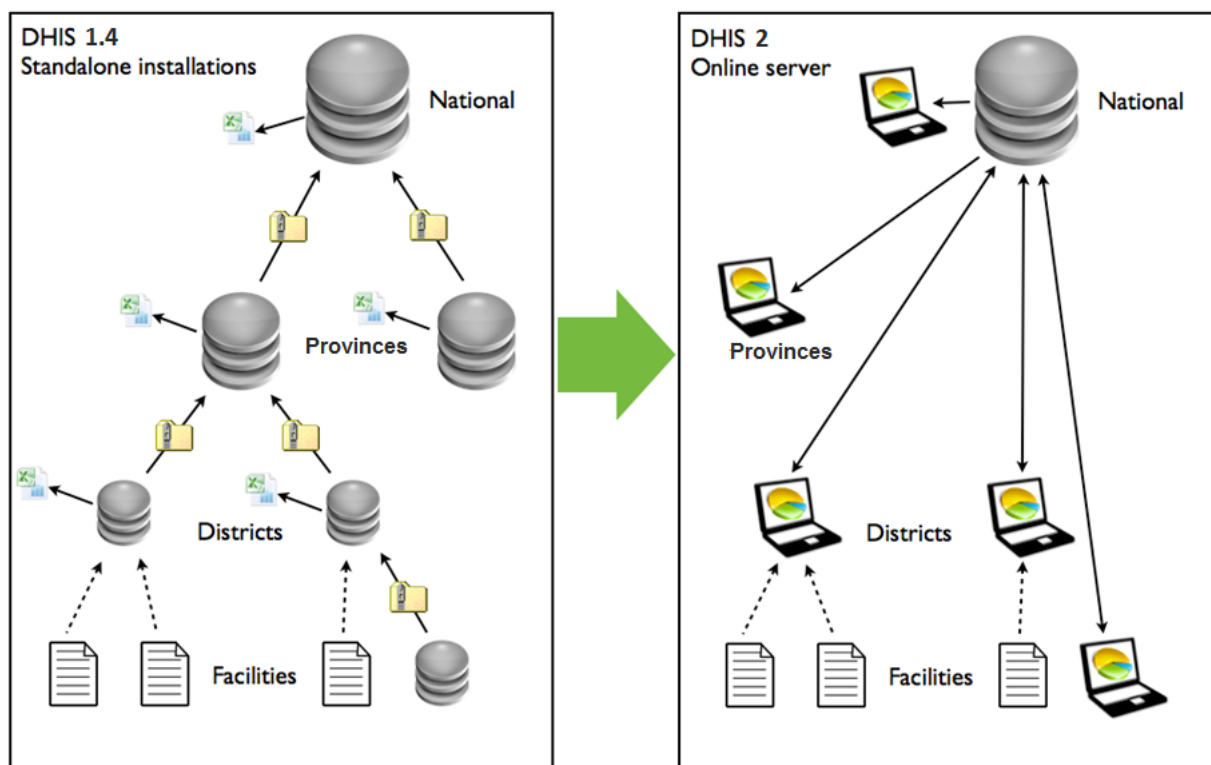
4. RESEARCH CASE

Zimbabwe is a country in Southern Africa which was in 2012 struggling to emerge from a serious political and economic crisis characterised by hyperinflation and abandonment of the national currency. As a nation, it obtained independence from British colonial rule in April 1980. It underwent a number of socio-economic and political transitions culminating in the imposition of sanctions by its western allies at the turn of the millennium. During this period, a hyper-inflationary environment was experienced as foreign currency reserves were depleted, lines of credit were closed and donors scaled down their initiatives in the country. It is also during this period that the public health system struggled and collapsed, exacerbated by an exodus of skilled

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professionals such as administrators, health information officers, doctors, and nurses to other countries. Prior to the crisis, Zimbabwe's health information system was considered the best in the Southern African region, given that the nation had been developing it since its attainment of independence, buoyed by a vibrant educational system. However, the economic crisis reversed many of the gains made, affecting the individual, social, economic and political fabric of the nation.

A key development in the nation is the ultimate increased involvement with the international donor community. Civil society in the nation had also become politically polarised, and trust in the governments' ability to implement programs had ceased. A result was that, international funding for key sectors of the economy, such a healthcare, was channelled through parallel systems. This led to the proliferation of program specific silos which received funding on behalf of their areas of interest such as malaria elimination, Prevention of Mother to Child Transmission (PMTCT), AIDS, TB and health systems strengthening. However, in spite of these challenges, the nation set forth to establish a vision for the development of its health systems after 2008. The year 2008 is significant, as it marked the zenith of socio-economic decline in Zimbabwe, leading to the forced transition of the nation to a government of national unity, which lasted until 2013. The nation also adopted a multi-currency regime to mitigate the effects of inflation. Civic society was increasingly co-opted into the government at all levels and donor agencies found themselves in strategic positions across the board as government sought re-engagement with the international community. A national health systems strategy was developed, whose aim was "*first to provide a framework for immediate resuscitation of the health sector and second, to put Zimbabwe back on track towards achieving the Millennium Development Goals*" (MOHCW, 2009a, p. 1). The 'Zimbabwe Health Information System Strategy' was also developed, given the necessity to develop the '*information building block*' of the overall health system.

4.1. Development of the Health Information System

To address the increased burden of disease and health service demand for increased data availability, the ministry had piloted the routine National Health Information and Surveillance (NHIS) system in 1985 and rolled it out in 1988 (MOHCW, 2009b). In 2004, this system had been recognised and awarded the title of best health information system in the region. Due to changes in technology, and given a new strategic direction of the unity government, and in collaboration with South African Health Information Systems Programme (HISP SA), an access based District Health Information System (DHIS 1.4) was piloted and introduced in 2010, replacing the NHIS system. DHIS 1.4 is a standalone system based on Microsoft Access technology. The system was successfully implemented by ZimHIS, a donor supported US agency, in partnership with the MOHCC and other international donors. Persistent calls for wider data availability and system integration of HIS, in line with the health strategy, are key drivers that led the MOHCC to a pilot of DHIS2 technology, which followed in December 2012. DHIS2 is a generic web based repository for tracking service indicators collected by healthcare providers used in over 50 countries and developed at the University of Oslo. The possibility of the system to interoperate with other technology through its application programming interface (API) made it a good candidate in the MOHCCs pursuit of a 'unified health information system'. The transition from DHIS 1.4 to DHIS 2 is as represented in Figure 1, below. Using the DHIS 1.4 technology, data was tallied daily and summarised periodically on paper at health facilities by nurses. These were sent to the administrative level for entry into the DHIS 1.4, by the District Health Information Officer (DHIO). They would in turn collate the data from other facilities, compress it and email, or send via memory device, to the next level. The process would be repeated at the provinces, with the data emailed to the national level.

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Figure 1. Spatial Representation of transition from DHIS 1.4 to DHIS 2

The nature of the DHIS 2 technology also implied new relationships with the global community, particularly those based in Oslo, besides the need for a robust server infrastructure in the MOHCC headquarters. Furthermore, this implied engaging other stakeholders such as the government's internet service provider, and a team of programmers based at an organisation which was housed at a local university (varsIT) in order to bridge the gap between its global development and local users. ZimHIS, had the limited capacity of a single developer but had the strategic advantage of being housed in the MOHCC headquarters and being responsible for the day to day maintenance of DHIS 1.4 technology, among numerous other health information tasks such as capacity building. The MOHCC had limited IT personnel within its ranks, and consequently co-opted ZimHIS for support and maintenance. varsIT also provided complementary support to the MOHCC, particularly in developing and implementing the human resources information system. Other programs such as AIDS/TB and Malaria were not only running their own HIS, within their vertical IT Units, but were engaged in processes of procuring new technology from countries such as Tanzania and Ethiopia. The University of Oslo had been engaged to support integration of these systems through the DHIS 2 technology which was developed through its Health Information Systems Program (HISP). In particular, the national malaria control program started a project with HISP to develop mobile tools for monitoring cases in rural facilities. The legacy routine health information surveillance technology DHIS 1.4, being based on a Microsoft Access database, was maintained on desktop computers by the health information officers at the different levels of the health system, which are patient care level, health facility level, administrative level, and the national and international level. It is important to note that another health program, ZimRBF had also implemented DHIS 2 in Zimbabwe almost 12 months prior to the MOHCC, albeit in its own silo and with uneven success. They utilised the services of private consultants based in Tanzania, a fact which could not discount a need for local support. Later a local intermediary was given the task to address the day to day challenges that arose.

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5. FINDINGS / DISCUSSION

The risk analysis exercise revealed that Internet infrastructure at the national level was highly problematic, particularly as regarding a limited capability at this level to support the server. The network within the building was unsegmented and unmanaged and shared by hundreds of users, many with misconfigured machines. For most of the working day the network (including the single internet link) was saturated with unexplained and unmonitored traffic. The physical state of the server room was also poor, with insufficient air-conditioning, inadequate power supply and accumulated technological waste around. There was almost absolute reliance by the MOHCC for technical support on a single developer from the co-opted ZimHIS, coupled with an inadequate backup process and the absence of a disaster recovery plan raising the risk of data loss. There was no framework to engage consultants, vendors and partners, such as non-disclosure agreements. There were no available agreements with equipment vendors for the equipment that had been obtained. Co-opted agencies had uneven power relations foregrounding politics of controlling this server space at the expense of the production of the system. Due to limitations in skill, and weakened decision making capabilities there was also limited technical support coming from the IT unit. A solution proposed was for ZimHIS to mobilise resources in order to support a vacant IT director position in the MOHCC, thus increasing decision making capabilities in the unit. However, this had political connotations in this space. The IT Unit had a different reporting hierarchy, distinct from the health information unit thereby presenting challenges for support of the 'new' systems within the information unit. Sanctions on the country posed a risk for the security of the system given that the nation could not obtain certificates for encrypting data which are often provided by US and western agencies.

Organisation of server infrastructure development, while constituting the backbone of the implementation and rollout of the system, was given scant attention. The focus was on networking the country and while large amounts were used to lay fiber cables to all districts, funding for the server and its connection to the network outside the MOHCC headquarters was more or less forgotten. Web and server based technologies were not well known in the MOHCC, nor among donors or implementing actors who saw the 'server' as the container of the data and therefore something they needed to control. Among them were numerous ideas as concerning the hosting of the server, including hosting in the MOHCC headquarters despite inadequate infrastructure, increasing connections into this building, hosting in a main hospital, utilising local private cloud solutions or selecting international cloud hosting. This lack of understanding and politicisation of technology, as actors sought to occupy this 'empty' space, led to the sub-optimal configuration and implementation of the system which had an impact on the performance of the system since improved connectivity at the facility level would not matter if the server was unavailable. A district information officer noted that this impacted on his ability to retrieve reports when they were requested by executive staff. Prior to the implementation of the DHIS2 system, addressing technical challenges had been managed in a distributed manner by health information staff at the district, provincial and national level with limited support provided by ZimHIS. The new system represented a spatial shift to a stronger technical core unit, something only partially considered in plans and the production of this space proved difficult in practice.

6. CONCLUSION

Introduction of new information technologies and changes in the technological setup account for changes in the spatial relationships of production. Analytically, and utilising Lefebvre's (1991) conception of production of space, changes in productive relationships should be seen at the levels of spatial practice, representations of space and the representational spaces. These correspond in our case to the co-opted donor driven spatial practice, a representation of space inscribed in the DHIS 2 architecture replacing the older technology, and representational spaces of users of the technology which are changing with the shift to the new mode of production. The

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dominant space of donor organisations led by the MOHCC decided upon the adoption of the DHIS 2 technology, and its representations of space. The representational spaces of users at the district were the subject of the rollout of a fibre optic network enabling them to enter data into the DHIS 2 system, while there was a conflict between the representational spaces of users at the national level and the representations for server infrastructure in the technology. While before, each district managed their own technology relatively independently, in the new central server based paradigm, they would suddenly all have to rely upon a centralized production set-up: a totally new technological space was being generated in conflict with pre-existing representational spaces. Due to lack of initial knowledge, the first approach focused on control of, rather than mastering of the technology.

We have seen that in the production of the space of the Zimbabwe health information system, there are contradictions between the mental, social and physical moments or dimensions of space. The shift in the technology design and architecture (from decentralised district 'servers' towards a central internet based server) has not been fully understood in terms of its organisational consequences, nor has it been properly catered for in terms of its material consequences.   IT management structures and physical data centre infrastructure need to be co-produced with technology architecture but these have each proceeded at their own pace and according to the demands, interests, constraints and priorities of different actors. We have seen how the resulting misalignments are a source of risk for the ministry which need to be identified and managed. It is our view, based on the findings described here as well as elsewhere, that a broad spatially oriented approach to capacity development and security management is a useful way for the state to approach the discussion on clouds, data centres and hosting of web based information systems in the public sector. We see that the production of space perspective is useful in demonstrating the material aspects of web based technologies like DHIS 2. Technology that is Internet based comes inscribed with 'representations of space' which need to be produced in context, yet are sometimes taken for granted by the stakeholders concerned, including intermediaries engaged in implementation and development of the systems. This study shows that the spatial aspects of implementation of technologies in countries having limited infrastructure need to be foregrounded in order that these system meet their objectives. While the pre-existing arrangements in many African nations show significant degrees of co-optation, proper understanding of this space can lead to the sustained 'production of space'. The production of space as a historic "extrusion" also creates new voids, contractions and continuous opportunities for co-optation, domination and appropriation by different external and internal interests. This study has demonstrated the practical significance of the 'production of space' perspective in analysing complex spaces of technological development. The scope of the work of Lefebvre is broad, and hence we see this as presenting opportunities to current IS discourse. In particular, recent perspectives which seek to discuss the materiality of technology will benefit from this body of work.

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IV

Health Information Systems Development : Producing a New Agora in Zimbabwe

Abstract

The study develops a socio-spatial theoretical explanation of the process of appropriation of a health information system in the Ministry of Health and Child Care in Zimbabwe. The explanation is based on ideas on the social production of social space by Henri Lefebvre and emergent spatial theories in the Information Systems discipline. Using this conceptualisation it was possible to relate multiple levels and perspectives through which a generic software based health information system was adapted. The study demonstrates how struggles for control around different aspects of the system such as the server shaped appropriation of the technology. Through the theoretical framework, we see how powerful actors with diverse interests develop representations of the system that are injected into user spaces as new practices emerge. There is a difficulty in meeting user needs at once, given the diversity of needs and actors, however health ministries, although weakened, occupy a strategic positions in producing representations of space and can shape appropriation of the technology. Open source technologies, such as implemented in this study, carry with them cues that emerge from their communities which if appropriated by these ministries, can aid in meeting some health information systems strengthening goals.

Introduction

Given the distributed development, implementation and use of generic software solutions, spatial theories have been increasingly adopted to explain the phenomenon (Pollock &

Williams, 2008). A paradox characterising the proliferation of generic technologies is that they should be able to address local concerns while at the same time being used in increasingly diverse contexts. The appropriation of these technologies in local contexts consequently implies the cooperation of diverse actors wielding diverse interests. This is no less a necessity in health information systems strengthening initiatives being undertaken in developing countries. Many such nations are adopting generic health information software in order to integrate their hitherto fragmented systems (Braa & Sahay, 2012). Given that for the given contexts the generic technologies being implemented represent new modes of production which are not fully accounted for in extant literature, it is important to continue to develop theories that faithfully explain the phenomenon (Kaniadakis, 2007; Markus & Silver, 2008; Sanner, Manda, & Nielsen, 2014). This is also given the high failure rates of IT intervention that have been reported in this context (Heeks, 2002). To contribute to development in this direction, the exploratory research questions pursued in this study were, (i) in what analytical context does the appropriation of a generic and open source health information system unfold, and (ii) utilising this analytical view, how can the transformatory goals of adopting the such systems in developing countries be realised?

This study was conducted within the Ministry of Health and Child Care (MoHCC) in Zimbabwe. The MoHCC was migrating from a hybrid standalone technology and paper based national routine health information system to a leading edge Internet-based integrated health information infrastructure developed around the open source and generic District Health Information Software (DHIS 2) as illustrated in Figure 1 below. The generic DHIS 2 software had been adopted by health ministries in the region such as in Zambia,

Malawi, Mozambique and South Africa, and also as far afield as some states in India and South America. This was in line with global initiatives that sought to improve the health information system building block within health ministries in developing countries (Braa & Sahay, 2012).
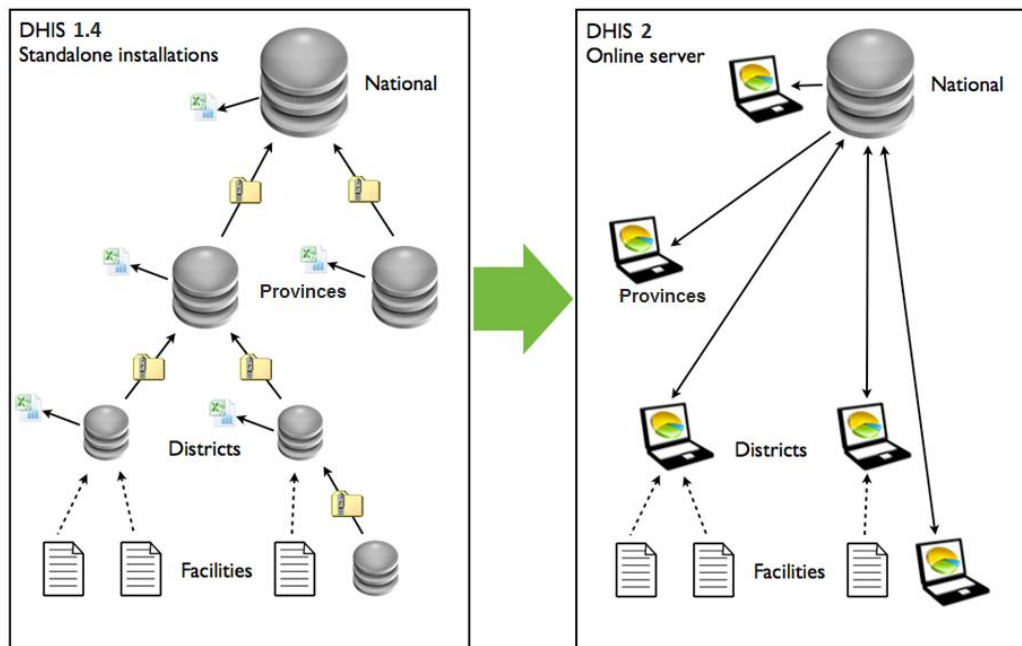
Figure 1 Change in architecture from DHIS 1.4 to DHIS 2

Recent years have seen increasing research on the global development, implementation and use of large scale generic software technologies, also known as information infrastructures (Hanseth & Lyytinen, 2010; Pollock & Williams, 2010). State institutions, such as health ministries with their characteristic fragmented systems and complex organisational structures, have been engaged in the development of policies, strategies, architectures and standards in order to leverage the proliferation of these technologies (Braa & Sahay, 2012; Pollock & Williams, 2010). This necessity is magnified in developing countries, also called the Global South, where the rapid rollout of Internet infrastructure and mobile technologies has

surfaced a ready and unexploited market for technological innovation (Gomez, 2013; Graham & Mann, 2013; Sanner, Roland, & Braa, 2012). Additionally, the success of nations such as India and Kenya in not only consuming but also producing information systems related services has enriched the discourse on information technology and development (Avgerou, 2010; Graham & Mann, 2013; Madon & Sahay, 2001). Research has therefore moved beyond considering the use *and* production of software as inherently antagonistic, since understanding their mutual interpenetration is now deemed as integral to sustained appropriation within given contexts (Madon & Sharanappa, 2013; Pollock & Williams, 2008).

Studies have increasingly looked at the information systems phenomenon in developing countries by analysing the political context of its implementation (Njihia & Merali, 2013; Silva & Hirschheim, 2007). Gagliardone (2014) has introduced the concept of 'technopolitics' in order to demonstrate how adoption and adaptation of some information technologies in Ethiopia was mediated by political forces. This is aligned with Sahay and Lewis (2010) who note that health information systems can be perceived as tools used by the state to render legible the complex processes related to disease in society, therefore serving the needs of the state in relation to society. The challenge of balancing between 'good' and 'bad' appropriation of these technologies is source of failure for many interventions in developing countries. Bad appropriation here would be the adoption of a technology to serve powerful interests in relation to users interests. Silva and Hirschheim (2007) posited that it was the failure to change 'deep structures' which accounted for the failure of a health information systems project in Guatemala. Deep structures are constituted of beliefs and values, services and technology, the distribution of power and organisational arrangements (Silva &

Hirschheim, 2007). However, to say technology is political without capturing the material basis which ought to provide an analytical view of the source and content of this politics has proved insufficient.

To understand the implementation, development and use of these information technologies, other researchers have utilised analytical concepts from the natural sciences, particularly complexity science (Merali, 2006; Njihia & Merali, 2013). Within this stream there is a discourse that sees information technologies as Complex Adaptive Systems (CASs) (Braa, Hanseth, Heywood, Mohammed, & Shaw, 2007; Hanseth & Lyytinen, 2010). Complex Adaptive systems are those that "*change and reorganise their component parts to adapt themselves to the problems posed by their surroundings*" (Holland, 1992, p. 18) . For instance, to enable appropriation of information technology in developing countries Braa et al. (2007) have suggested that there is need to create attractors which are regions towards which the complex adaptive systems evolve. These attractors are 'actor networks' which are flexible in that they respond to changes in the environment (Braa et al., 2007, p. 400). While this conception highlights the necessity to develop networks for information systems to be sustained, the content of these networks and their potential to be used to dominate the users, including their material basis, are not issues adequately addressed by the formulation.

Kaniadakis (2007, p. 74) articulately notes that "*with the gradual appreciation of the distributed and networked character of innovation, spatial concepts that capture and embrace spaces within which social and economic relations and processes of innovation are formulated … are extremely important*". Spatial theories have two primary benefits, the first

being that they enable an understanding of the interconnection of activities distributed in space and time within a single project. Secondly, they transcend theoretical ideas which have traditionally privileged either action or institution in their description of information systems phenomenon. However they have their drawbacks, the major one being the difficulty of using time and space as a frame for techno-organisational analysis (Sahay, 1997). This study attempts to bridge this divide, and to address concerns arising from prior conceptions of this phenomenon. It does this by demonstrating that the the development, implementation and use of a generic information system is shaped by a political dialectic between domination and appropriation which unfolds in social space. Furthermore, it shows how conceptions from Lefebvre (1991) on the 'production of space' can be useful in providing an understanding of how generic health information systems fail to attain their transformatory goals. Finally, basing on such findings, it is possible to craft strategies which assure that the developmental goals of these technologies can be met.

The next section develops the theoretical conceptualisation; in particular, a background to the emergent spatial conceptualisation. Within this section, the concepts of the 'agora of techno-organisational change', 'production of space' and 'reappropriation' are discussed in terms of how they fit into explaining a contemporary information systems phenomenon. The third section describes the research approach, including the data collection and analytical techniques that were utilised. The research case is presented in the fourth section after which the fifth chapter focuses on the findings. Finally, a concluding section presents a discussion of the findings along with their relevance, implications and opportunities for further work.

Theoretical Framework

Importance of Space in Information systems change

Due to emergent patterns of globalisation, also observable in developing countries, the context in which technological change occurs has been increasingly problematized (Robertson, 2012). For instance, to account for the distributed activities in the global development of the HDTV standard Jorgensen and Sorensen (1999) propose that their context be considered as an "*arena of development*". This is defined as "*a metaphor for the cognitive space where political, social and technical performances related to a specific technological problem takes place*" (Jorgensen & Sorensen, 1999, p. 411). To account for similar phenomenon within practice oriented studies, Monteiro and Rolland (2012) have introduced the concept of 'trans-situated use' to explain how the local use of an information system implicates users distributed in time and space. Additionally, Pollock, Williams, D'Adderio, and Grimm (2009) have introduced the '*extended situation*' as a concept to understand how contemporary IT support emanates from spaces in different time zones across the globe. While these studies provide different perspectives to understand contemporary information technologies, they offer limited explanations to account for the interwoven nature of generic information technology development, implementation and use. In addressing this gap, Pollock and Williams (2008) have posited the Biography of Artefacts framework (BoA) which is elaborated on below.

The Biography of Artefacts framework

According to the biographies framework, generic technologies such as the SAP Enterprise Resource Planning (ERP) system, have been shaped and developed at the multiple places in

which they have been implemented and used, each site making an inscription on the artefact which determines its current and future form. This history of the ERP technology, starting from the early days where it emerged from Manufacturing Resource Planning (MRP) systems, to its current state, where it is used in multiple industries and nations, forms the biography of the artefact (Pollock & Williams, 2008). This also includes the emergence of best practice communities such as that led by Gartner around ERP, and the global distribution of experts customising the systems for local use. This work by Pollock and Williams (2008) sensitised the research on the necessity of a framework to account for development, implementation and use of generic technology within a globalised context. The challenge of this framework is that it is developed to account for technological project that is followed over a long duration in multiple use contexts, and is therefore insufficient for this work which tracks a single techno-organisational change instance over a shorter timeframe. However, to frame the socio-political context in which ERP choices are made, Pollock and Williams (2008) point to Kaniadakis (2007) 'agora' metaphor, a line of argument which is explored further below.

The Agora of Technological and Organisational Change

The space of development, implementation and use of generic technology has recently been considered as the 'agora of techno-organisational change' (ATOC) (Kaniadakis, 2007, 2008, 2012; Pollock & Williams, 2008). In ancient Greece, the agora was the focus of social and political life in Athens which, over time, was constituted of public buildings, walks, assembly areas, law courts, cemeteries, shrines and altars (Thompson & Wycherley, 1972). The development of its features occurred without a master plan, but rather emerged over time

with existing features being the basis for punctuated change activities signalling societal changes (Thompson & Wycherley, 1972). Relatedly, Espinosa and Harnden (2007, p. 402) define a new agora as a "*public sphere of enquiry and communicative action able to foster a new public and global citizenry of autonomous, conscious and socially responsible individuals and groups working for enhanced local and global welfare*".

Within information systems, the 'agora of techno-organisational change' (ATOC) refers "*to a marketplace for technological artefacts and expertise, but it is also a political arena where actors negotiate and pursue their interests and exercise power and control over the choices regarding innovation*" (Kaniadakis, 2008, p. 4). It is "*an alternative concept seeking to integrate multiple levels of analysis in exploring and understanding innovation as it takes place in the space between local [techno-organisational] change instances and the global knowledge economy*" (Kaniadakis, 2007, p. 75). It is a 'multidisciplinary space' in which the designers, implementers, and users of an organisational technology potentially interact to conceptualise, design and intervene in information systems change initiatives (Kaniadakis, 2007; Pollock & Williams, 2008). It is also an arena where actors accumulate power and is therefore a site for clandestine and sub-rosa activities (Grisot, Thorseng, & Hanseth, 2013). However, while the ATOC offers a suitable framework for description of context where generic IS phenomenon unfolds, it is argued here that it does not provide sufficient analytical leverage to deal with the developmental context in which this study occurs. To address this limitation, it was essential to complement the 'agora' concept with the formal conceptual basis for socio-spatial analysis as developed by Lefebvre (1991).

The Production of Space Perspective

According to Lefebvre (1991, p. 129), "*social relations of production have a social existence to the extent that they have a spatial existence; they project themselves into a space, becoming inscribed there, and in the process producing that space itself. Failing this, these relations would remain in the realm of pure abstraction – that is to say, in the realm of representations and hence of ideology: the realm of verbalism, verbiage and empty words*".

A key motivation for Lefebvre (1991) in positing the 'production of space' perspective is an observed shift in modes of production from the more localised ones to the globalised production of goods and commodities. In particular, he noted the emergence of a '*new mode of production which is neither state capitalism nor state socialism, but the collective management of space*' (Lefebvre, 1991, p. 103). Consequently, he demonstrated that a space of production such as the agora was itself a product, and therefore sought to uncover the underlying principles through which it emerged. To Lefebvre (1991) social space was therefore constituted of a spatial practice, representations of space and representational spaces which were shaped by political struggles. Lefebvre (1991) referred to these aspects of social space which are implicated in its production as a spatial triad.

Lefebvre's Conceptual Triad

The conceptual triad of Lefebvre is composed of *spatial practice*, *representations of space* and *representational space*. These three elements constitute what he called the moments in the production of space, dealing with different but interrelated qualities of socio-spatial reality. Spatial practice is defined as the relationship between a space and the uses of that space, and is 'secreted' by the social activities of actors that inhabit the space (Carp, 2008;

De Vaujany & Vaast, 2013; Lefebvre, 1991). For instance, a programmer in an open source software project will keep a version of the code on his local computer and follow certain rules in committing his work to the main repository hosted on a remote server as part of that community's spatial practice and through that participate in producing the space. Representations of space emerge from a dominant space through the activities of planners, architects and other privileged actors whom use their areas of expertise to conceptualise the relationship between the structure and use of a space (Lefebvre, 1991). Representation of space can be architectural designs or frameworks inserted into a user space. The third of the triad, representational space is the lived space of users and inhabitants which is pervaded by signs, art, symbolisms and beliefs and partly escapes the grasp of representations yet is a subject to them. Produced space is shaped through a dialectical process, such as through the struggle between domination and appropriation (Lefebvre, 1991).

Appropriation and Domination of the Agora

The appropriation of a space is concerned with the process of making a space "*one's own*", that is its adaptation to a some specific needs (De Vaujany & Vaast, 2013). Since no production of space occurs *tabula rasa*, appropriation is therefore concerned with the reorganisation of pre-existing spatial configurations to suit the needs of a group and is synonymous with changes in technology, a force of production (Lefebvre, 1991; Smith, 2008). On the other hand, dominated space is a space that has been "*transformed – and mediated – by technology, by practice … [where] in the best circumstances the outside space of the community is dominated, while the indoor space of family life is appropriated*"

(Lefebvre, 1991, pp. 164 - 166). An understanding of appropriation is not complete without showing whom appropriates what and for whom (Lefebvre, 1991).

As described prior, the agora is the site at which the struggles amongst different actors as relating to a technological offering occur. A key aspect of health information systems strengthening in developing countries is to develop an appropriated space in which users, implementers, practitioners and designers of a technology have sustainable interactions (Braa et al., 2007). The 'agora' can therefore be appropriated or dominated, moreso in relation to user needs which are often subject to powerful interests (Lefebvre, 1991). It is clear that borrowing the concepts of Lefebvre (1991) on the production of space it is possible to understand the appropriation of IT artefacts as a process of appropriating space. In particular, it is possible to understand how choices made by actors produce and shape the Agora of Techno-Organisational Change. The next section will elaborate on the methodological approach adopted in this study before exploring the empirical basis of the presented ideas.

Research Methodology

This study was conducted with the strategy of generating theoretical insights through a case study approach (Eisenhardt, 1989). Data on the case was gathered through participation in a techno-organisational change process and analysis was conducted through the selective use of techniques from grounded theory methodology. A core grounded theory technique utilised to generate theoretical insight on the case was the 'constant comparative method' which emphasises a continuous literature review parallel to data collection and analysis (Matavire & Brown, 2013). Furthermore, given the nature of the phenomenon under study,

it was essential to conduct the research at multiple organisational levels, and also across organisational boundaries (Braa, Monteiro, & Sahay, 2004; Hitt, Beamish, Jackson, & Mathieu, 2007). This is important in order to go beyond the 'micro' vs 'macro' dichotomy, and also to enable a more holistic view as to why certain strategies and interventions fail in one context in comparison to another.

The initial research design was constructed as an exploratory action oriented study aimed at developing theoretical insights around the integration of health information systems within the health ministry in Zimbabwe. The 'unit of analysis' of the study was the productive relationships that emerged during the development, implementation and use of the DHIS 2 technology in the health ministry. Even as it is difficult to delineate the boundaries of such multi-level and cross-organisational phenomenon, the focal unit as defined above was adequate. Relevant theoretical constructs emerged as the data was interrogated during comparative analysis. The case was selected somewhat serendipitously based on the opportunity it presented to observe and theorise a techno-organisational change process from its adoption through to adaptation. Furthermore, the chance to study the phenomenon in Zimbabwe, a nation which had been going through a turbulent socio-political transition, presented a unique theoretical sample.

Data collection and analysis

Data was collected during a 3-year period of research, from February 2012 to February 2015. During this period, 5 field visits were organised, with the total period spent on the ground exceeding 6 months. During these field visits interviews were organised with stakeholders. The researcher participated in more than 12 meetings at multiple levels of the

health information system, was engaged in observation of work practices and contributed to planning and execution techno-organisational interventions. An excess of 34 interviews were conducted in the study, 7 with program directors, 3 with system developers, 3 with provincial officers, 9 with health information officers, and at least 12 with health facility workers responsible for data collection. The interviews ranged from open to semi-structured and lasted at least 30 minutes each. The focus of the interviews was on understanding the techno-organisational practices of health information workers and their challenges in order to design interventions to remedy problems. The predominant method for recording was field note taking, while some sessions were voice recorded with permission from participants. Field notes are "*an ongoing stream of consciousness commentary about what is happening in the research, involving both observation and analysis*" (Eisenhardt, 1989, p. 539). The taking of field notes enabled the constant comparative method of simultaneous data collection and analysis to be integrated into the study (Eisenhardt, 1989; Matavire & Brown, 2013). Official documents such as strategies, plans, and other government publications were also reviewed in order to understand the research context. A number of photographs were also taken at the multiple levels of the health system.

Data analysis revolved around five aspects with different levels of abstraction, (i) the writing up of field notes (ii) the generation of conceptual codes (iii) the development of reports on interventions to share and obtain feedback from stakeholders (iv) application of the constant comparative technique from grounded theory and (v) a continuous in depth literature review (Eisenhardt, 1989; Matavire & Brown, 2013). Early on in the study, the

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generation of conceptual codes was performed using the NVivo qualitative analysis tool. Utilising this software, conceptual codes around inter and intra organisational collaboration emerged early from the data as can be seen in Figure 1 below. The study oscillated between inductive coding based on data and deductive analysis to search for and identify suitable concepts and research gaps within literature. During the process, memos were developed as a basis for developing the research for publication.

**Figure 2: Screenshot of NVIvo demonstrating emergence of conceptual codes**

The primary technique of data analysis was the constant comparative technique from Grounded Theory methodology (Glaser & Strauss, 1967). The basic tenet of the technique is to simultaneously conduct data collection, coding and literature reviewing in order to generate concepts that fit the substantive area being studied (Matavire & Brown, 2013). Opportunities to discuss and clarify emerging ideas with the peers in the research community were taken as ideas emerged (Eisenhardt, 1989). The use of analytical techniques from Grounded Theory without adopting the methodology wholesale is widespread in Information Systems research (Matavire & Brown, 2013). It is however

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important to note that this partial application of the techniques is criticised for eroding theoretical emergence by those who follow what is termed the classical grounded theory (Van Niekerk & Roode, 2009). However, this classic approach is also criticised for being highly formulaic (Eisenhardt, 1989). The concepts from Lefebvre (1991) were found to have emergent fit in explaining the phenomenon considered in this study.

Case Study : DHIS 2 in Zimbabwe

Study Setting

The study was conducted in Zimbabwe, a landlocked Southern African nation which is bordered by South Africa, Botswana, Zambia and Mozambique. The health information system in the Ministry of Health and Child Care (MoHCC) in Zimbabwe, which in 2004 was given an award for being the best in Southern Africa (MOHCW, 2009), is a stabilised institution with a delineable legacy traceable up to the earlier days after the nation's independence in 1980 (Sanders, 1990). A national health information system was piloted in 1985, and rolled out in 1988. After this, a joint evaluation by the World Health Organisation (WHO) and the MoHCC was organised in 1999 following which further improvements were made. The legacy of the early health information system is seen in the entrenched information practices among nurses at health facilities, where statistics and catchment area maps were displayed on walls even in the most remote clinics, see Figure 2 below. The health information system was decentralised and paper based, with health facilities across the nation having a mandate to manage their own data and make decisions.
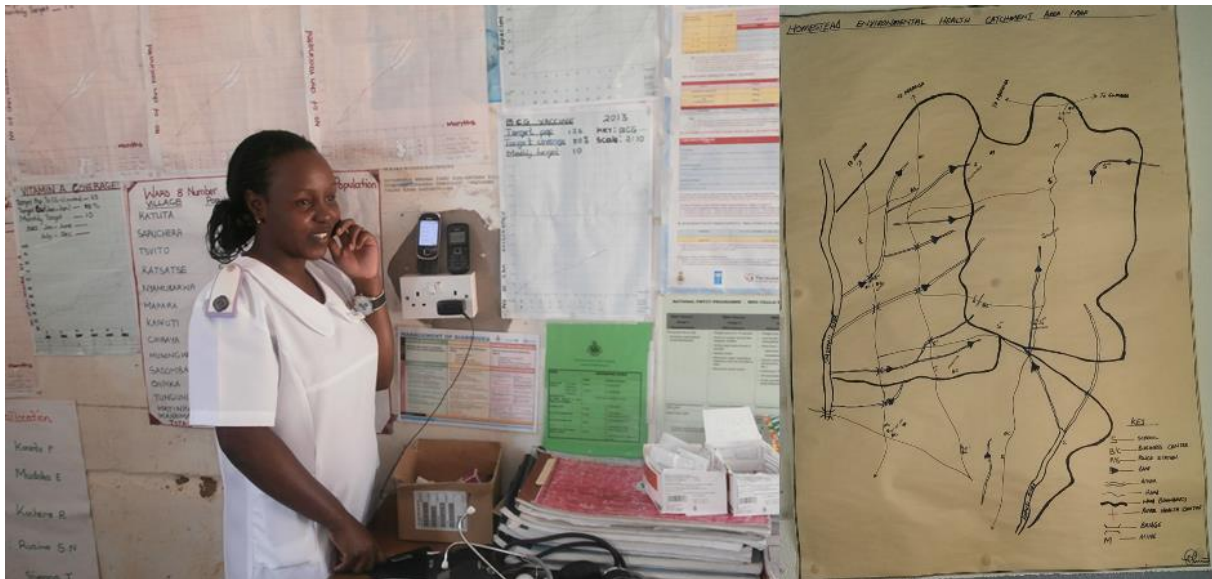
Figure 3: A nurse at a rural facility with analytical charts. Catchment area maps in another facility (right).

Over time, the offices of district, provincial and national information officers were introduced in order to facilitate the flow of data from the health facilities. Health information systems courses were also introduced at the local polytechnic to improve the capacity of the information officers. These earlier developments were largely eroded during a period of hyperinflation which led to mass outmigration of health information staff and the collapse of the national health system between 1999 and 2008. Given the shrunken economy, related loss of faith in the state and sanctions by many western nations, international agencies began to channel limited resources for health services through politicised donor agencies. This exacerbated the fragmentation of the health system with some programs which had more generous donor arrangements developing their own vertical reporting systems with little standardisation and in parallel to the weakened national HIS. However, positive socio-economic changes precipitated by the abandonment of the local currency in 2008 prompted the government to chart a new way in regards to

developing an integrated health information infrastructure as enunciated in the health information and health systems strategies that emerged in 2009.

Zimbabwe's health information system is constituted at health facility, district, provincial and national level. There is also the village health worker level which reports community data to the facilities. There were over 1500 public health facilities, in over 60 districts within 10 provinces in Zimbabwe during the time of the study. Many of these facilities suffered from poor infrastructure, which is road, electricity, and internet connectivity. At the health facility level, data is collected on all patient encounters and entered into relevant, and sometimes disease specific, paper-based registers by health workers. Tally sheets are used to keep count of disease incidents, and these are summarised into the standardised monthly reporting forms for submission to the higher levels. At some large health facilities, data clerks were employed to enter data into electronic formats. At the district hospitals District Health Information Officers (DHIOs) had the role of collating and analysing data from their areas. DHIOs entered the paper-based data from respective areas into the legacy District Health Information Software version 1 (DHIS 1.4) and presented it at periodic district executive meetings. After analysis and approval, the data was further sent by email to the provincial level in a compressed and standardised format where it was received by Provincial Health Information Officers (PHIOs) and the process repeated, this time submitting to the national level.

After aggregation, cleaning and analysis the national officers shared the data with partners such as the World Health Organisation (WHO), donor organisations supporting the public health system, health programs, researchers, and the top decision makers in the MoHCC.

While this process unfolded, sometimes taking over 2 months, disease specific health programs had their own data, systems, technologies, and officers, from facility up to the national level. Despite the obvious burden this exerts to health workers, who are responsible for collecting all this information to meet program needs, there is an administrative burden at the central level on how to make sense of these data flows.

Development and Use of DHIS 1.4

Prior to using DHIS 2, and since 2010, the MoHCC was using the standalone DHIS 1.4, a Microsoft Access based database that it rolled out to the district, provincial and national levels and in large hospitals where there was access to electricity and potential internet connectivity through wireless dongles. Healthcare facilities were still using paper reports which they physically transported to the district offices for entry into DHIS 1.4 as illustrated in Figure 1. The standalone DHIS 1.4 system was relatively easy to install from compact discs and maintain utilising information officers at the different levels. A set of forms, corresponding to the standardised routine paper reporting formats at the health facilities were customised into the system. These formats change occasionally due to shifting priority areas in the MoHCC, and also due to external requirements from global agencies. The process of standardising data entry formats into what is called a 'minimum data set' for efficient information exchange and customisation of DHIS 1.4 required the support of external actors, since the MoHCC had limited internal capacity. Consequently, the system was customised, rolled out and supported by the donor aided health information systems project, ZimHISP which was co-opted for the task by the MoHCC, with limited specialised support coming from the application's developers in the South African Health Information

Systems Program (HISP SA). ZimHISP had a single programmer who was also responsible for other health information systems in the MoHCC. For instance, the organisation had also introduced a mobile phone based reporting system based on the FrontlineSMS platform to enable the reporting of weekly notifiable disease data to the national level from all health facilities. At this point, ZimHISP can be seen to have appropriated the development and maintanance of the health information system. Consequently, the ministry's information system space was now partly dominated by ZimHISP who, according to the perspective of some staff in the MoHCC, "*were getting all the benefits*".

Adoption of DHIS 2

The MoHCC decided to implement the DHIS 2 technology in Zimbabwe in early 2012. Firstly, DHIS 2 is internet based and requires health information officers to have a more robust internet infrastructure to access its features. Consequently, additional donors emerged on the stage committing resources to roll-out a fibre optic internet backbone to district health offices, and satellite technologies (VSAT) for some remote facilities. ZimHISP was strategically positioned in the MoHCC to be a focal implementation partner to donor agencies and the University of Oslo. However, ZimHISP had limited knowledge of the new system and only had one programmer. Furthermore, they were receiving funding from a foreign government agency which had its own interests in the implementation, and potential conflicts with other actors. However, they accepted the role of implementation partner, and undertook to customise the DHIS 2 system for the MoHCC as they had been doing with DHIS 1.4. The ZimHISP programmer attended DHIS 2 capacity development courses in India and Kenya in order to improve his skills on the system. 1300 laptops were

also purchased and were rolled out simultaneously as health information officers and data clerks from large health facilities were trained on the new system. This was despite the limited computer literacy of many officers, especially in the rural areas where some laptops were found stowed away. The DHIS 2 technology is also developed in as open source software in a global context. Effort was made to develop a local team which included MoHCC representatives which could participate in the global development of the system. For instance workshops were organised with donor agency representatives, IT staff from MoHCC programs and from the IT unit.

Integration of Vertical Malaria System

A core reason for adopting DHIS 2 was to develop a system that could integrate data flows from the different programs. A vertical donor supported malaria pre-elimination program had been facing difficulties and had limited support for developing and integrating its systems with the national HIS. This led to the initiation by the University of Oslo of a project to develop a DHIS 2 integrated system for tracking patients across program stages based on the Android mobile device operating system. The key requirement was for health workers to be able to conduct follow up visits of positive cases to the households in order to stop further transmission of the parasite. This implied the ability for health workers to capture data including GPS coordinates of breeding sites and homes on the Android devices while offline, which could be synchronised once internet connectivity was available. A Master student at the University of Oslo was given the task to demonstrate that it was possible to do through the DHIS 2 system's health program module called 'Tracker'.

To begin with, the malaria pre-elimination project had been ongoing in the MoHCC and was largely paper based. An international donor agency (HealthAccess) had initiated a software development project to capture data on proprietary PDAs and had piloted it in the relevant province with the malaria control program. Many issues had arisen with this project, primarily the expense of the highly proprietary GPS devices at a cost over 1000 US dollars per unit which was difficult to justify. Also HealthAccess project continued in the direction of a fragmented program specific system which was not in line with the MoHCCs strategy to integrate their systems with DHIS 2. Consequently, the development capacity of the University of Oslo, the demonstrated fit of the DHIS individual records module, the operational GIS module already built into DHIS 2, and the attraction of widely available Android mobile devices justified professional development of the project. The project was generating broader interest with other donors seeing the fit of the platform to their use cases in different countries. Consequently, the project was 'globalised', with more requirements coming from other donors, particularly international agencies, leading to the employment of full time programmers, and change in the focus from Zimbabwe. A University of Zimbabwe software development project (UZDev), observing these shifts also sought to participate in the development of the system, however hesitantly. HealthAccess also engaged their regional and global partners to explore participation in the global development of the application in order to roll it out to the Southern African region.

A 'pre-pilot' of the system was conducted by visiting health facilities in the pre-elimination province of Matabeleland South. In this stage it was found that the primary users of the system, Environmental Health Technicians (EHTs) had competency with Android devices

which they often owned themselves. The EHTs also had charts and maps on their walls in order to track the distribution of malaria cases and provide treatment as seen in Figure 4 below. The pre-existing system was based on a set of paper based registers some of which were filled out in fours for each encounter and sent to the district, provincial and national levels. Using an Android based system would mean data would go directly to a central server from the site where the incident was detected. When the system was completed, it was customised for the malaria program in a workshop with key representatives from the MoHCC in order to develop local capacity.
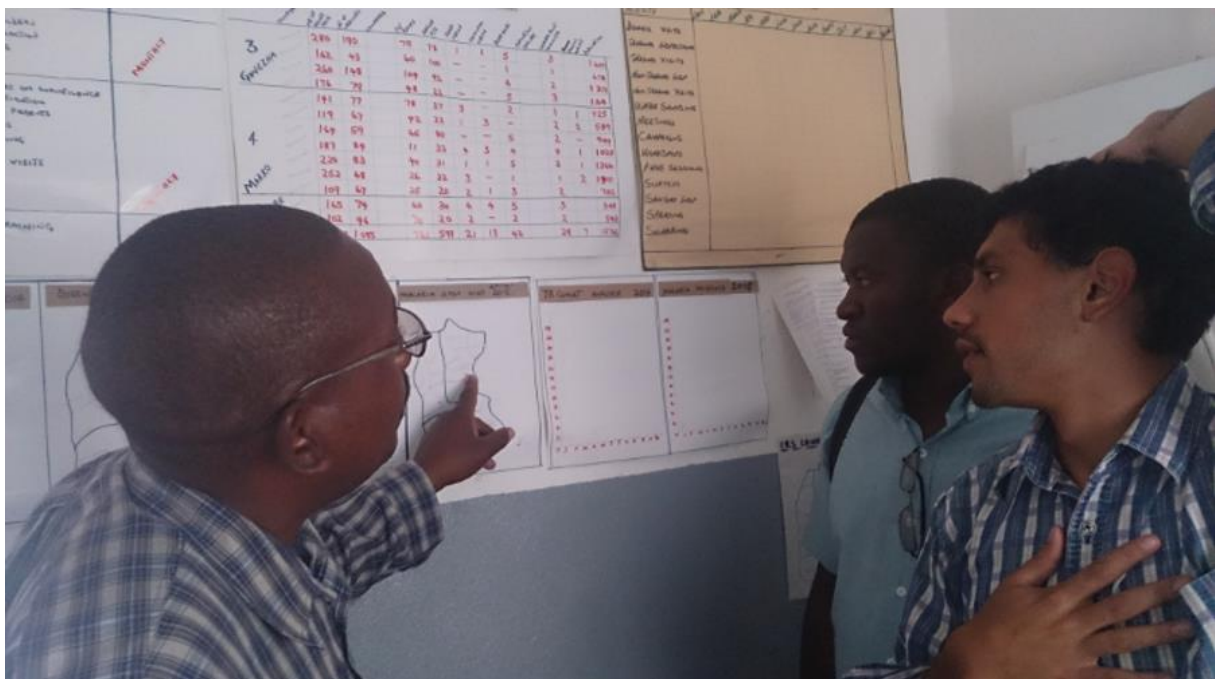

Figure 4 An Environmental health technician showing incidence of malaria in catchment area

Developing Local Support

The health informatics program at the University of Zimbabwe (UZDev) was an organisation that had prior to the pilot of DHIS 2 in Zimbabwe been responsible for the development and implementation of a Human Resources Information System (HRIS) for the MoHCC. UZDev

was home to at least 5 expert Java programmers, and had a constant flow of student interns who could number a dozen. A project by the University of Oslo was initiated in order to enrol the organisation so they could provide local and regional programming support for DHIS 2. However, without an immediate financial incentive and with their pre-existing interests in the MoHCC, it was hard to motivate them to redirect their activities. Furthermore, some scepticism about the suitability of their participation was raised by the MoHCC, since there was no specific agreement to assure their continued support. ZimHISP which was the main source of capacity had limited capacity, and also were not cooperating at the system development level with other stakeholders given diverse interests. For instance, there were delays in providing access to partners who could assist in customisation, server maintenance and programming.

It was particularly difficult to promote a cooperative development approach by developing a local team since ZimHISP was not working well with other actors who could have been interested in developing a local DHIS 2 community. Furthermore, there was minimal support sought from the mailing list with only a handful of emails being sent in over 3 years that the project was unfolding. Within the MoHCC, software development capacity was absent, with the IT Unit which should have coordinated the development tasks depending on ZimHISP. In fact, the entire project budget literally ignored support to the MoHCCs IT Unit. Key challenges in this unit included the vacancy of the IT director position and the limited capabilities of its technical staff. Consequently, some challenges experienced by users were often unresolved for long periods, particularly given the lack of clear procedures and poor communication channels. This had the effect of causing delays in achieving set milestones as

decisions of cooperative development were often politicised with actors pursuing their diverse interests.

The Politics of Servers

With DHIS 1.4 stakeholders such as the national statistics agency would physically approach the health information unit to request copies of sections national data relevant to their work. If the office was closed, and health information staff were not available, it would not be possible to get the data. Furthermore, in order to conduct field visits and trainings, the national health information unit would travel with the national data server given as well that they did not have any laptops. In migrating to DHIS 2, a web based system, emphasis was placed on distributing laptops and rolling out internet infrastructure to the district and provincial offices while connectivity at the national level was not changed particularly due to the contested nature of the new server architecture. Key stakeholders such as the government internet service provider, DHIS 2 experts, the IT unit, server experts, and potential partners in the donor community were largely from the development process around the server. The challenge was that there was no policy to control access to the system and the default position was to withhold these permissions to partners. Over time, the senior national health information officer was given 'super user' privileges to access the DHIS 2 software itself, but access to the physical server and the back end was still largely controlled by ZimHISP.

With the previous version of DHIS 1.4, the server was controlled by the information unit and ZimHISP at the MoHCCs headquarters, both of whom had limited capacity for the new infrastructure. Consequently the server for the new technology was hosted in the same

building with the MoHCC, see Figure 5. This was an old machine with low specifications, and it was running on an unmanaged network with very limited bandwidth. The argument was that the MoHCC wanted to develop its own data centre and could not allow the server to move from the building. Furthermore, debate of hosting any of the data on the cloud was simply not entertained. Over the period of the study, the server experienced unreasonable downtime, and was moved from building to building within the government complex, changing IP addresses, at the expense of the users of the system. For instance, users would only find out that the server is not up or changed address through their own personal networks with the DHIS 2 team.

Figure 5 National server room hosting new DHIS 2 system on one of the machines

Discussion of Findings

Conceptualising the Agora of Techno-Organisational Change

We see that when technology emerges in a context, spatial changes occur to enable its adoption and use. The 'new' space that emerges with the implementation of generic information systems has been called the 'agora of techno-organisational change' (ATOC) (Kaniadakis, 2007). The ATOC is the arena where actors and stakeholders interact and make choices regarding a technological problem. Generic software systems are characterized by their ability to be customized to meet the needs of diverse users. With DHIS 2's adoption in the MoHCC, a diverse set of actors, with users on one hand and designers on the other, including the multiplicity of participants such as intermediaries who have private and public interests in the system need to collaborate to ensure successful appropriation. New practices emerge as diverse physical and social spaces are appropriated for the information system. At the planning level, actors adopt strategies to adapt the technology without disrupting the status quo through the development of specific representations of the technology. The level of planning is constituted of diverse actors representing local and global interests. At the user level, strategies are also developed to integrate the technology into their work life albeit with difficulty for many health workers who have limited to no computer literacy. The emergence of this ATOC resonates with Lefebvre's (1991) argument that changes in the modes of production should be accompanied by changes in space if they are to be more than meaningless rhetoric. This is also in line with the assertion by Smith (2008, p. 128) that "*the obsolescence of old technologies and the rise of new ones, so vital to capitalism, is simultaneously the transformation of old spatial structures into new ones*". The

struggles around the appropriation of this space by the different actors pursuing their interests demonstrates the potential for groups to dominate user spaces.

Appropriation of the Agora

Gagliardone (2014) considers the struggles that occur when different actors attempt to appropriate a technology in order to meet their individual objectives as technopolitics. In particular, Gagliardone (2014, p. 7) notes that technopolitics "*accounts for how policy makers often perceive technology as an extension of their plans and ambitions, rather than as a neutral tool that responds to functional imperatives*". In this work we show how technopolitics around DHIS 2 is inherently a spatial struggle which was centred on appropriating a fragmented agora. We can see that while the state and partners were focussed on the technopolitics around the server, little progress was made in strengthening this backbone of the system. This aspect would have benefited from a decisive MoHCC which could have committed to the development of a stable hosting arrangement around which the users and other programs could be integrated and participate in the agora. The MoHCC's leadership in this arena was constrained by the weak position they had in terms of knowledge and resources meaning they had to be subjected to the interests, representations and timeframes of sponsors and other partners. This challenge of weak leadership of the DHIS 2 based information system was contrasted to the strong culture of data collection and analysis that was evident in most health facilities and other representational spaces such as district offices.

As a consequence of the challenges in developing the server space, the ability of the system to meet end user needs was constrained. At the facility level, only district hospitals and

large rural health centres had the technology injected into their spaces. In some facilities which were sufficiently developed, it was possible to see how the technology had been integrated into work practices. In particular at the district level, many officers could retrieve data from the system and share it with their executive members. However, similarly to the DHIS 1.4 technology, the district information officers were still responsible for receiving paper reports from the facilities in their areas and entering it into DHIS 2. This demonstrates that a representation from the old technology was merely persisted in the new system. The development of representations of space which are more faithful to the opportunities offered by the technology, such as its ability to be accessed through mobile technology can go a long way in ensuring the agora is appropriated by users. This could also reduce the burden of district health information officers of entering data from all facilities in their catchment area. With the establishment of courses to support the development of the skills of these information officers it will be possible to see the emergence of a new agora appropriated by its users.

A strategy for developing representations that are faithful to the representational spaces in the MoHCC is the possibility to leverage mobile technologies. The MoHCC was already using a mobile reporting system for weekly rapid disease notification. The system was successfully appropriated by the users who could address day to day breakdowns in the system, a process that has been referred to as 'appropriation work' (Draxler & Stevens, 2011). As noted, there are challenges for users in many of the smaller health facilities, particularly in rural areas, when it comes to utilising laptops. In the case of the malaria program, an Android based system was developed by the University of Oslo to support the collection of

facility and community data. While such innovations can go a long way in diminishing spatial barriers, studies show that their local appropriation should not be taken for granted as it still implies alignments across organisational boundaries (Matavire & Manda, 2014). There are breakdowns in mobile technology, a need for recurring payment of services and the development of internal procedures to account for the hardware in an organisation in order to appropriate this technology. Critically, these mobile systems still depend on a central server infrastructure which as has been shown can be an arena of intense struggles. Consequently, the threat of user spaces being dominated are not diminished by mobile devices especially given the weak structures in the MoHCC which are dependent on external donors. Appropriation of the agora should be a key objective when adopting health information systems lest the developmental objectives be neglected and old efficient systems and practices such as found in the representational spaces in the MoHCC be needlessly eroded.

Conclusion

The theoretical framing developed and presented in this study is useful for gaining an understanding of how diverse actors involved in the development, implementation and use of a generic information technology in the health sectors of developing countries appropriate space. Earlier studies have looked at the need to develop networks across organisational boundaries and the importance of attractors such as flexible standards for their development (Braa et al., 2007). However, such studies have been criticised for taking the material basis of information systems for granted and also for not adequately dealing with the influence of powerful actors (Kaniadakis, 2007; Timmermans & Berg, 1997). The

theory presented in this study sensitises researchers and practitioners to the socio-spatial context of health information systems appropriation in developing countries and consequently how these technologies can be leveraged to achieve desired organisational change. The conceptualisation adopts Lefebvre's (1991) 'production of space' perspective which enables an understanding of the interrelationships between the politics of software representations, historical user spaces and the development of new practices. This study contributes to the handful of studies that have utilised the views of Lefebvre (1991) to understand organisational phenomenon (for examples see: De Vaujany and Vaast (2013) and Wasserman and Frenkel (2011)). It also contributes novel ideas to the emergent literature in information systems which is involved in developing spatial conceptualisations. More studies utilising the ideas could enrich the theoretical foundation of information systems research, particularly in developing countries where novel insights can be drawn. Lefebvre's (1991) conception is particularly relevant to developing countries given that it emphasises the necessity of approaches for appropriation in the face of domination by technologies and their practices. Comparative analysis with other cases can contribute to the continued development and refinement of the ideas presented in this study.

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