Research Article

Health Information Systems Development: Producing a New Agora in Zimbabwe

Rangarirai Matavire

University of Oslo, Norway

Abstract

This study is concerned with implementation of the District Health Information Software (DHIS 2) system in the health ministry of Zimbabwe. The open source software is used in numerous developing nations, with its development coordinated by the University of Oslo in Norway. The study theorizes the process through which the globally developed and used software technology becomes part of daily life in the developing nation. A sociospatial theoretical explanation of the process of appropriation of the software is developed. The explanation is constructed through a concatenation of ideas on the social production of social space by Henri Lefebvre and emergent spatial theories in the information systems discipline. Using this conceptualization, it was possible to relate multiple levels and perspectives through which the system is adopted and adapted. This is achieved by linking the spaces of decision making, social practice, and everyday use within which the struggles to appropriate the technology ensue. Using this perspective, it is possible to improve the understanding of the generic software phenomenon and thereby craft interventions through which the technologies can be successfully appropriated in developing nations.

Introduction

The increasingly distributed development, implementation, and use of generic software solutions has been problematized in information systems research (Pollock & Williams, 2008). *Generic software* is a class of information systems that can be used in diverse settings and is developed in such a way that it is customizable to meet local needs. The appropriation of these global technologies in local contexts implies the cooperation of diverse actors holding potentially conflicting interests. This is a challenge within health information systems–strengthening initiatives being undertaken in developing nations (Braa, Monteiro, & Sahay, 2004). These nations are known to have fragmented systems that are paper-based and politicized which produce data of poor quality (Braa & Sahay, 2012). The broader context of such generic technology implementations that reflect the emergence of new modes of production is not fully accounted for in the extant literature (Kaniadakis, 2007; Sanner, Manda, & Nielsen, 2014). To contribute to theory development in this direction, the exploratory research questions pursued in this study were: (1) How can we understand and explain the process of appropriation of a generic health information software system in a developing country context? and (2) How can the development objectives of adopting these technologies in such contexts be better realized?

This study was conducted within the Ministry of Health and Child Care (MoHCC) in Zimbabwe. The ministry was until recently called the Ministry of Health and Child Welfare (MoHCW). The MoHCC was migrating from a hybrid paper and decentralized database system to an open source, centralized database and web-based district health information software (DHIS 2; see Figure 1). In practice the DHIS 2 system was integrated with legacy paper-based systems despite a goal of full automation. The generic DHIS 2 software had been adopted by health ministries in nations of the region such as Zambia, Malawi, Mozambique, and South Africa and 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 systems (HISs) within health ministries of developing countries (Braa & Sahay, 2012).

To cite this article: Matavire, R. (2016). Health information systems development: Producing a new agora in Zimbabwe. *Information Technologies & International Development, 12*(1), 35–50.

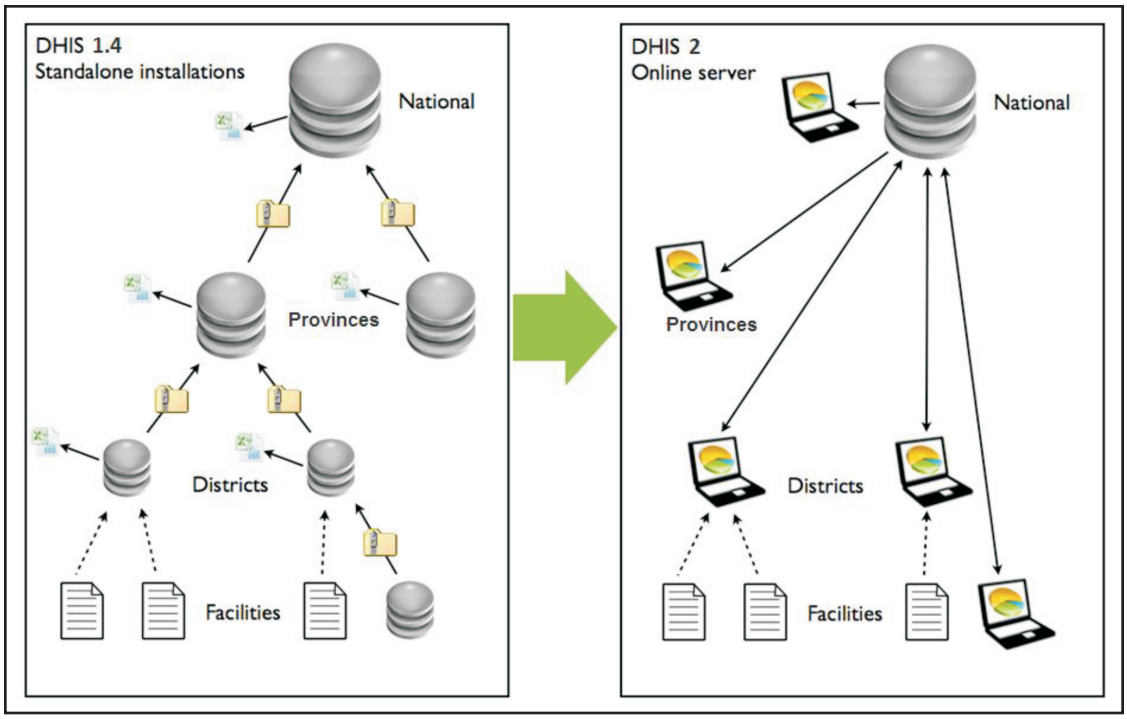

Figure 1. Change from the decentralized DHIS 1.4 to the centralized DHIS 2 system.

Health ministries worldwide have been engaged in the development of policies, strategies, architectures, and standards to shape the appropriation of systems such as DHIS 2 (Braa & Sahay, 2012; Pollock & Williams, 2010). The need for building internal capacity in the public sector to appropriate these technologies is magnified in developing countries (also called the Global South), where the increasing rollout of Internet infrastructure and mobile technologies has uncovered 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 two extremes of a scale, since understanding their mutual shaping is now deemed as integral to sustained appropriation within given contexts (Madon & Sharanappa, 2013; Pollock & Williams, 2008).

A number of studies have sought to theorize such contemporary information systems phenomena in developing countries. Silva and Hirschheim (2007) argue that these systems cannot be successfully appropriated unless the "deep structures" of politics and organization are addressed. Gagliardone (2014) has introduced the concept of "technopolitics" to demonstrate how adoption and adaptation of an information technology in Ethiopia was mediated by political forces. Sahay and Lewis (2010) posit that HISs should be perceived as political tools used by the state to render legible the complex processes related to disease in society. However, political process theories such as these, besides being fragmented and confusing (Kaniadakis, 2007), struggle with the antagonisms of structure versus agency, consequently failing to capture the unfolding phenomenon in an integrated way in which politics is a key but not defining factor. Other studies have employed analytical concepts from the natural sciences, particularly complexity science (Merali, 2006; Njihia & Merali, 2013). This is a field of inquiry in which natural systems such as organizing in ant colonies or unpredictable weather patterns provide metaphors for explaining phenomena which are not reducible to individual parts such as the evolution of the Internet (Hanseth & Lyytinen, 2010). Within this stream of literature, information technologies are often perceived as complex adaptive systems (CASs; Braa, Hanseth, Heywood, Mohammed, & Shaw, 2007; Hanseth

Table 1. List of Acronyms Used in this Paper.

ATOC	Agora of techno-organizational change
BoA	Biography of artefacts
CAS	Complex adaptive system
DHIS 2	District health information software
EHT	Environmental health technician
ERP	Enterprise resource planning
HIS	Health information system
HISP SA	South African Health Information Systems Program
MoHCC	Ministry of Health and Child Care
MOHCW	Ministry of Health and Child Welfare
NMCP	National Malaria Control Program
UNAgency	United Nations Agency
WHO	World Health Organisation
ZimHISP	Zimbabwe Health Information Systems Project

& 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 a need exists to create *attractors,* powerful stimuli that help shape how such CASs evolve. However, the broader socioeconomic context, assumptions about space and the potential of technologies to be used to dominate users are issues that have not yet been sufficiently explored. The preceding views therefore offer a fragmented perspective on the IS change phenomenon.

In addressing such concerns, 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 concepts 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 phenomena. However, they have drawbacks, the major one being the difficulty of using time and space as a frame for techno-organizational analysis (Sahay, 1997). This study attempts to bridge the divide and address concerns arising from prior conceptions of information systems appropriation in developing countries. It shows how conceptions from Lefebvre (1991) on the "production of space" can be useful in providing a better understanding of the generic HIS phenomenon in developing countries. Finally, and as will be demonstrated, it becomes possible to craft strategies that ensure the developmental goals of these technologies can be met. Table 1 lists the acronyms that are used in the paper.

The next section develops the theoretical conceptualization; in particular, it provides a background to the emergent spatial perspective. The third section describes the research approach, including the data collection and analytical techniques that were employed. The research case is presented in the fourth section, after which the fifth section focuses on the discussion. Finally, a concluding section presents the findings, along with their relevance, implications, and opportunities for further work.

Theoretical Framework

Significance of Space in Information Systems Change

Due to emergent patterns of globalization, also observable in developing countries, the broader context in which technological change occurs has been increasingly problematized (Robertson, 2012). For instance, to account for the spatially distributed work involved in the development of a high-definition television (HDTV)

standard, Jorgensen and Sorensen (1999) propose that the broader context be considered as an *arena of development,* defined as "a metaphor for the cognitive space where political, social and technical performances related to a specific technological problem takes place" (p. 411). To account for this global IT phenomenon within practice-oriented studies, Monteiro and Rolland (2012) have introduced the concept of "trans-situated use," which is helpful in explaining 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 for understanding contemporary information technologies, they offer an inadequate account of the broader socioeconomic space, where information technology development, implementation, and use unfold. In fact, where the concept of space is explicitly used, it is scarcely defined. In trying to address such gaps, Pollock and Williams (2008) posit the Biography of Artefacts (BoA) framework, elaborated on below.

The Biography of Artefacts Framework

According to the BoA framework, generic technologies such as enterprise resource planning (ERP) systems are shaped and developed at the multiple places where 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 when it emerged from manufacturing resource planning systems to its current state, where it is used in multiple industries and nations, forms the biography of the artefact (Pollock & Williams, 2008). This involves the emergence of best-practice communities such as that led by Gartner around ERP and the global distribution of experts customizing the systems for local use. The work by Pollock and Williams (2008) sensitized the research on the necessity of understanding the historical trajectory of a technology as key to explaining its local adoption and evolution. The challenge of this framework is that it is developed to account for a technological project that is followed over a long period of multiple-use contexts and is therefore insufficient for this work, which tracks a single techno-organizational change instance over a shorter timeframe. However, to frame the local socioeconomic spaces in which ERP choices are made, Pollock and Williams (2008) point to Kaniadakis' (2007) "agora" metaphor, a line of argument which is explored below.

The Agora of Technological and Organizational Change

The space of development, implementation, and use of generic technology has recently been considered as the "agora of techno-organizational change" (ATOC; Kaniadakis, 2007, 2008, 2012; Pollock & Williams, 2008). In ancient Athens, the agora was the focus of social and political life, which, over time, came to be 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, rather, emerging over time triggered by social changes and revolutions (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-organizational change* 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-organizational] 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 organizational technology potentially interact to conceptualize, 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). While the ATOC offers an improved understanding, the space remains largely undefined except by focusing on its contents. Furthermore, the ATOC is conceptualized as subjective, given the focus by Kaniadakis (2007) on the diverse "viewpoints" of the actors. To address this limitation, it was essential to complement the agora with the formal conceptual basis for sociospatial analysis as developed by Henri Lefebvre (1991).

The Production of Space Perspective

According to Lefebvre (1991),

> 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. (p. 129)

A key motivation for Lefebvre (1991) in positing the production of space perspective is an observed shift in modes of production from more localized modes to a globalized 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 Kaniadakis' agora was itself a social product. Lefebvre (1991) sought to uncover the process of production instead of simply enumerating the contents of a space. This process could be revealed through understanding the spatial practice, the representations of space, and the representational space of the society. Lefebvre (1991) called these "moments" of the productive process a "spatial triad."

The Spatial Triad

Lefebvre's *conceptual triad* 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 sociospatial reality. *Spatial practice,* or *perceived space,* 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 supermarket has its own spatial practice, with specific areas set aside for grocery carts, fresh vegetables, beer, cereals, cash registers, entrances, and exits. *Representations of space,* or *conceived space,* emerge from a dominant space through the activities of planners, architects, and other privileged actors who use their areas of expertise to conceptualize the relationship between the structure and the use of a space (Lefebvre, 1991). Representations of space can be architectural designs, plans, or frameworks inserted into user spaces. The third piece of the triad, *representational space,* or *lived space,* is the space of users and inhabitants and is pervaded by signs, art, symbols, and beliefs. It partly escapes the grasp of representations, yet it is their subject. Social space is shaped through dialectical processes such as through the struggle between domination and appropriation (Lefebvre, 1991). For instance, a local supermarket owned by a cooperative and selling local produce could be considered as appropriated, while an international chain store importing all its products can be considered as dominated.

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 specific needs (De Vaujany & Vaast, 2013). Since no production of space occurs tabula rasa, *appropriated space* is therefore concerned with the reorganization of preexisting 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 incomplete without showing who appropriates what and for whom (Lefebvre, 1991).

As described earlier, the ATOC is the space in which global technological offerings make their way into local contexts. A key aspect of HIS implementation in developing countries is sustainable appropriation (Braa et al., 2007). It is reasonable to posit that by 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 the ATOC. In particular, it is possible to understand how, through the spatial triad, the agora of techno-organizational change is produced. The next section elaborates on the methodological approach adopted in this study, after which the research explores the empirical basis of the work.

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-organizational change process, and analysis was conducted through the selective use of techniques from grounded theory methodology. A core grounded theory technique that sensitized the generation of theoretical insights on the case was the constant comparative method, which emphasizes a continuous literature review parallel to data collection and analysis (Matavire & Brown, 2013). Furthermore, given the nature of the context, it was essential to conduct the research at multiple organizational levels and across organizational boundaries (Braa, Monteiro, & Sahay, 2004; Hitt, Beamish, Jackson, & Mathieu, 2007). This was important in order to go beyond the micro- vs.-macro dichotomy and enable a more holistic view of the ATOC.

The initial research design was constructed as an exploratory action-oriented study aimed at developing theoretical insights around the integration of HISs within Zimbabwe's health ministry. The study's unit of analysis 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 multilevel and cross-organizational phenomenon, the focal unit as defined above was necessary to enable emergence. Relevant theoretical constructs emerged as the data was interrogated during comparative analysis. Selection of the case was serendipitous, based on the opportunity to observe and theorize a techno-organizational change process from technology adoption through adaptation and use. Furthermore, the chance to study the phenomenon in Zimbabwe, the author's birthplace and a nation undergoing a turbulent sociopolitical transition, presented a unique theoretical sample.

Data Collection and Analysis

Data was collected over a three-year period of research, from February 2012–February 2015. During this period, five field visits were organized, with the total time spent on the ground exceeding six months. The researcher participated in more than 12 meetings at multiple levels of the HIS, observed work practices, and contributed to planning and execution of technological interventions. More than 34 interviews were conducted during the study: seven with program directors, three with system developers, three with provincial officers, nine with health information officers, and at least 12 with health facility workers responsible for data collection. The interviews ranged from open to semistructured and lasted at least 30 minutes each. The interviews focused on understanding the techno-organizational practices of health information workers and their challenges in designing remedial interventions. The predominant method for recording was field note taking, while some sessions were voice recorded with participant permission. 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). Taking 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 to understand the research context. A number of photographs were taken at multiple levels of the health system.

Data analysis occurred at different levels of abstraction through (1) writing up field notes, (2) generating conceptual codes, (3) developing reports on interventions to share with and obtain feedback from stakeholders, and (4) performing a continuous in-depth literature review (Eisenhardt, 1989; Matavire & Brown, 2013). The generation of conceptual codes was performed using the NVivo qualitative analysis tool. Using this software, conceptual codes around inter- and intra-organizational collaboration emerged from the data (see Figure 2). The study oscillated between (a) inductive coding based on data and (b) deductive analysis to search for and identify suitable concepts and research gaps within the literature. During the process memos were generated as a basis for developing the research for publication.

The central technique for 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, code, and review the literature to generate concepts that fit the substantive area being studied (Matavire & Brown, 2013). As ideas emerged, opportunities to discuss and clarify them with peers in the research community were used (Eisenhardt, 1989). The use of analytical techniques from grounded theory

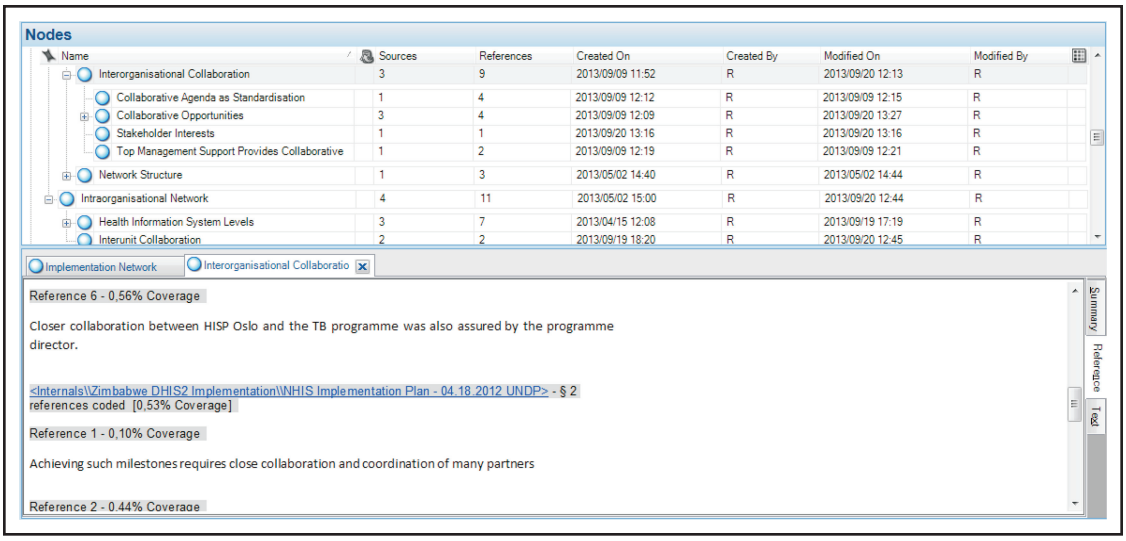

Figure 2. Screenshot of NVivo, displaying emergent conceptual codes.

without adopting the full methodology is widespread in information systems research (Matavire & Brown, 2013). It is important to note that this partial application of the techniques is criticized for eroding theoretical emergence by those who follow what is termed the "classical grounded theory approach" (Van Niekerk & Roode, 2009); however, this approach is criticized for being highly formulaic (Eisenhardt, 1989). After numerous iterations in which concepts such as "articulation work," "interorganizational networks," "evolution," and "information infrastructures" were compared with the data for relevance, the concepts from Kaniadakis (2007) and Lefebvre (1991) were found to have emergent fit and the broad conceptual reach necessary to explain the phenomena considered in this study.

Case Study: DHIS 2 in Zimbabwe

Study Setting

Legacy of the Health Information System

The study was conducted in Zimbabwe, a landlocked Southern African nation bordered by South Africa, Botswana, Zambia, and Mozambique. The HIS 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 stabilized institution with a delineable legacy traceable to the early days of the nation's independence gained in 1980 (Sanders, 1990). An HIS was piloted in 1985 and rolled out in 1988. After this, a joint evaluation by the World Health Organisation (WHO) and MoHCC was organized in 1999, following which further improvements were made. The legacy of this early HIS is seen in the entrenched information practices among nurses at health facilities, where statistics and catchment area maps were maintained and displayed on the walls of even the most remote clinics (see Figures 3 and 4). The HIS is decentralized and paper based, with health facilities across the nation mandated to manage their own data and use it to make decisions.

Over time, district, provincial, and national information officers were introduced to facilitate the data flow from health facilities to the various stakeholders. HIS courses were introduced at a polytechnical school to improve the capabilities of the information officers to deal with the increasing demands for information. These early developments were largely eroded during a period of hyperinflation (1999–2008), which led to mass outmigration of health information staff and the collapse of the national health system. Given the shrunken economy, the related loss of faith in the state, and the sanctions by many Western nations, international agencies began to channel limited resources for health services through donor agencies. This exacerbated the

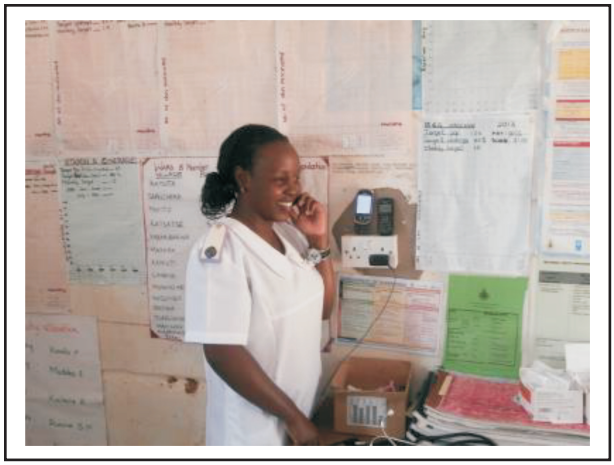

Figure 3. A nurse at a rural facility with analytical charts on the wall.

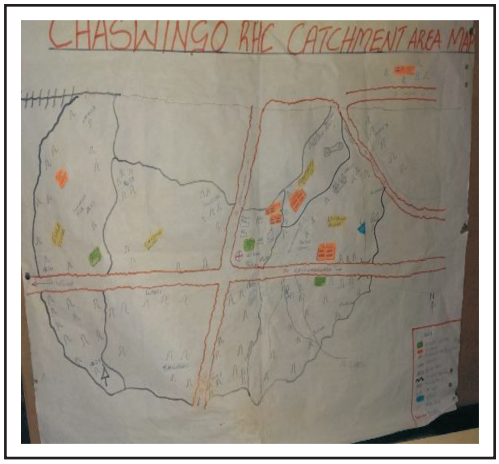

Figure 4. A catchment area map in a rural health center.

health systems' fragmentation, as some programs with more generous donor arrangements developed their own vertical reporting systems, with little standardization and running in parallel to the weakened national HIS. However, positive socioeconomic changes precipitated by the 2008 abandonment of the local currency prompted the government to chart a new course with regard to an integrated HIS (MOHCW, 2009).

Structure of the Health Information System

Zimbabwe's health information system is constituted at the local health facility, district, provincial, and national levels. There are more than 1,500 public health facilities in more than 60 districts within Zimbabwe's 10 provinces. Many of these facilities have poor infrastructure such as roads, electricity, and Internet connectivity. At the health facility level, data is collected on all patient encounters and entered into relevant paper registers by health workers. Tally sheets track disease incidents, which are summarized into standard monthly reporting forms for submission to the higher levels. At some large health facilities, data clerks enter data into electronic formats. At the district hospitals, district health information officers are tasked with collating and analyzing data from their areas. Before DHIS 2, these information officers entered the paper-based data from their respective areas into the legacy district HIS software version 1 (DHIS 1.4) and presented it at district executive meetings. After analysis and approval, the data was emailed to the provincial level in a compressed and standardized format, where it was received by provincial health information officers and the process was repeated, this time submitting the data to the national level.

After aggregation, cleaning, and analysis the national officers shared the data with partners such as WHO, donor organizations, and top MoHCC decision makers. Meanwhile, disease-specific health programs had their own data, systems, technologies, and officers. Despite the obvious burden this exerted on health workers, who were responsible for collecting all this information to meet program needs, there was also an increased burden at the central level with regard to rationalizing these data flows.

The DHIS 1.4 Agora

Prior to using DHIS 2 in 2013 the MoHCC used DHIS 1.4 from 2010, a Microsoft access–based database, which it rolled out to computers at the district, provincial, and national levels. It was also deployed in large hospitals, which had access to electricity and the Internet through wireless dongles. Healthcare facilities were largely still using paper reports, which they physically transported to the district offices for entry into DHIS 1.4. The standalone DHIS 1.4 system was relatively easy to install from CDs and maintain for information officers at the different levels. A set of forms, corresponding to the standard routine paper-reporting tools used at the health facilities, was customized for the system. These forms are known to change occasionally due to shifting disease priority areas in the MoHCC as well as the external requirements of global agencies. The process of

standardizing data entry forms to collect only essential information for efficient exchange and the corresponding customization and rollout of the system required the support of external actors. Consequently, the system was customized, rolled out, and supported by the donor-aided HIS project, ZimHISP, housed in the MoHCC and based in the United States, with some specialized support coming from the application's original developers in the South African Health Information Systems Program (HISP SA). ZimHISP had a single programmer, who was responsible for supporting most of the HISs. Funded through its U.S. office, ZimHISP paid the salaries of some MoHCC officials in key areas. Together, they introduced a mobile phone–based reporting system, built 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 was responsible for the development and maintenance of the health information system in the MoHCC. According to the perspective of an informant, ZimHISP "[was] getting all the benefits" from funding agencies, affecting the project's original commitment to build the MoHCC's capacity.

Producing the DHIS 2 Agora

The MoHCC decided to implement the DHIS 2 technology in early 2013. Firstly, DHIS 2 is Internet based and requires health workers to have a more robust Internet infrastructure to access its features. Consequently, GlobalFund, a Swiss-based donor engaged in strengthening the HIS, committed the needed funding. GlobalFund contracted a local United Nations Agency (UNAgency) to be its procurement partner and project manager. Two local Internet service providers were contracted to roll out a fiber optic cable–based Internet network to district health offices. Satellite technologies were chosen for some remote facilities and districts. ZimHISP was strategically positioned within the MoHCC building to be a key implementation partner. The University of Oslo, as coordinator of the software's global development, was also contracted to provide quality assurance for the implementation. ZimHISP's single programmer had a limited understanding of the new system. Furthermore, the major funder was a foreign agency that had its own interests in the implementation and potential conflicts with other actors. Despite these different agendas, ZimHISP accepted the role of implementation partner and undertook to customize the DHIS 2 system for the MoHCC as it had been doing with DHIS 1.4. The ZimHISP programmer attended DHIS 2 capacity development courses in India and Kenya to improve his skills.

UNAgency purchased 1,300 laptops, rolled them out to health information officers and data clerks at large health facilities and trained them on DHIS 2. This was in a context of limited computer literacy among health workers in the MoHCC. A senior manager within the MoHCC stated:

> 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 . . . IT skills themselves among the health workers involved in data collection and transmission. You know, like I mentioned earlier, IT skills were not part of our formal training in the health sector.

Efforts were made to develop a core local team, including MoHCC representatives, who could participate as developers, implementers, and users in the global DHIS 2 community. Workshops were organized to develop capacity with donor agency representatives and IT staff from the MoHCC. This was problematic for GlobalFund, which aimed to develop capacity inside the MoHCC and not indirectly through ZimHISP. Furthermore, there was a concern over the leadership of the technology change process, with a senior informant exclaiming that the MoHCC could not take responsibility for failures as it did not control "funding for operationalizing the [plans]."

The DHIS 2 Android Development Arena

A core reason for the MoHCC's adoption of DHIS 2 was to develop a system that could integrate data flows from several vertical programs. Integrating program systems was challenging, given the diverse agendas of the implementing partners. However, an opportunity arose to enroll the National Malaria Control Program (NMCP) into the agora. The NMCP needed a system for following up malaria patients to their households to stop further transmission of the disease. This required functionality able to capture data, including GPS coordinates of malaria parasite breeding sites and patient homes while offline in remote areas. Data would then be sent to

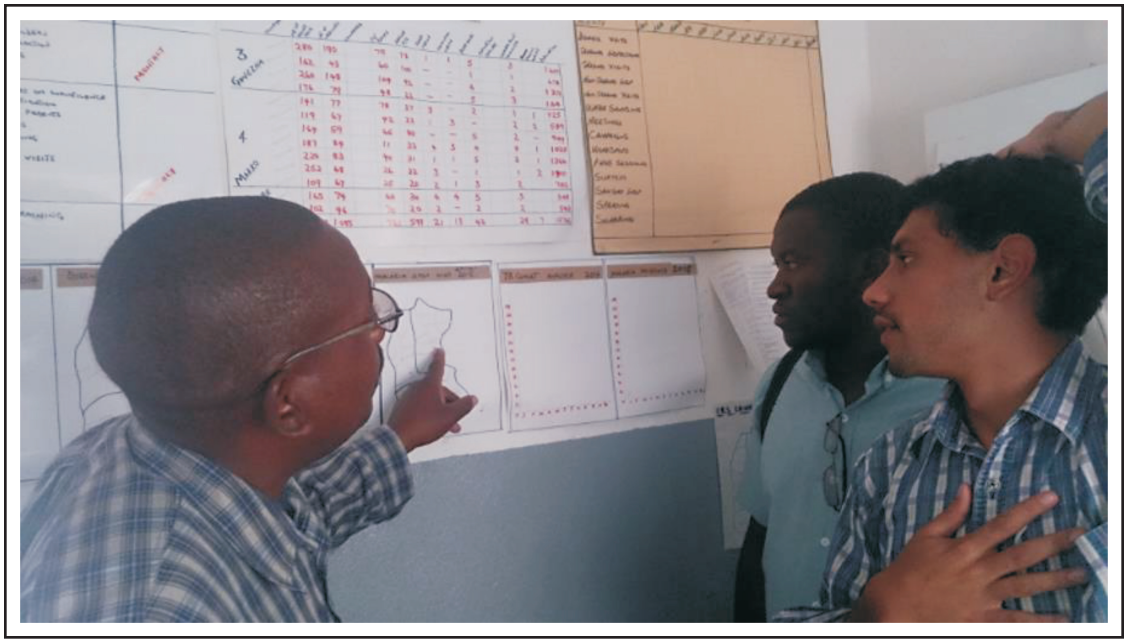

Figure 5. An EHT shows sites where malaria cases originated in his catchment area.

the national level and integrated with the DHIS 2 system when connectivity was restored. A donor and implementing partner, MalariaDonor, had previously initiated a software development project to capture data on proprietary PDAs and had piloted it in one province with the NMCP. Many challenges had arisen with this initiative, including the expense of the proprietary GPS devices, which cost over US$1,000 per unit. The project also represented a program-specific information system, which did not feed into DHIS 2. Consequently, HISP Oslo became involved in developing an Android operating system–based software with MalariaDonor and the NMCP sponsored by GlobalFund. This was originally a graduate student project to test the feasibility of meshing with DHIS 2.

HISP Oslo's involvement can be attributed to a number of factors coming together such as the preexisting DHIS 2 patient tracker module, the operational GIS module already built into DHIS 2, and the reasonably priced Android mobile devices (compared to the expensive GPS devices). A local HIS initiative at the University of Zimbabwe, UZDev, was approached to support the development activities. In response it offered office space to the Norwegian graduate student. The agreement was that he would transfer system capacity to UZDev to enable local development and support. However, in sum, UZDev's greatest contribution was to offer office space as it was not committed to the effort. Meanwhile, it was found that the system's primary users, environmental health technicians (EHTs), were competent with Android devices, which they often owned themselves. The EHTs also had charts and maps on their office walls that tracked the distribution of malaria cases and patient treatment (see Figure 5). The preexisting system was based on a set of paper registers, some of which were filled out in quadruplicate for each malaria encounter and sent to the district, provincial, and national levels. Using an Android device, these forms could be eliminated as data went directly to a central server from the site where a positive case was detected.

As the pressure to deliver the Android solution persisted and funding permitted, a programmer was hired on a month's contract to help with the task. During this time it was discovered that a HISP Oslo team based in Vietnam and the Philippines was developing an interface for Android applications and DHIS 2. The Zimbabwe team, consisting of the programmer, the graduate student and this author, decided to build on this work since the source code was freely available. Within a month, a stable version of the Android application was released. However, this success led to increased interest from other projects in the DHIS 2 community. HISP Oslo decided

Figure 6. National server room hosting the new DHIS 2 system on one of the machines.

to take over the development by employing the programmer on a longer term contract. The Zimbabwe project was at risk as there was uncertainty in the MoHCC given the new direction taken by HISP Oslo. However the programmer assured the implementers that he would maintain a focus on Zimbabwe. In his own words he noted, the "malaria project is the key priority at the moment, and I have tried to express this several times." However, in practice, software development was now controlled in Norway with additional programmers being employed at the University of Oslo. UZDev, with its programming capacity, was failing to catch up and soon disappeared from the playing field. New relationships and players had emerged in the agora, shaping the Zimbabwe project.

Appropriation of the Server Arena

With the distributed DHIS 1.4 system, national data was located in an offline database physically hosted in the office of the HIS unit within the MoHCC. This carried implications for data access. For instance, stakeholders such as Zimbabwe's statistics agency would physically approach the health information unit to request copies of sections of the national data relevant to their work, but if the office was closed and/or the health information staff was unavailable, the data would be inaccessible. To cite another example, if the national information unit staff from the MoHCC was conducting field visits and training, they would travel with the desktop computer hosting the national database, especially given a lack of access to laptop computers. However, with the migration to the web-based DHIS 2 system, the national health information officers lost this control as the database moved. The system was now hosted in the MoHCC's server room under the control of ZimHISP and the ministry's incapacitated IT Unit (see Figure 6). In addition, emphasis had been placed on distributing laptops and rolling out Internet infrastructure to the district and provincial offices, while connectivity at the national server room did not change.

A new contest had emerged in the agora around appropriation of the server. Key stakeholders such as the MoHCC information unit staff, the government Internet service provider, DHIS 2 experts, the IT unit, server

experts, and potential partners in the donor community were largely excluded from the process of developing and customizing the server. A contributing factor was the absence of a policy defining access control. As ZimHISP was strategically placed in the MoHCC, it was able to withhold permission from other partners and constrain the collective development of the server. Over time a senior national health information officer was given front-end "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. The system was running on an old server and an unmanaged network with limited bandwidth. The argument for not using an established organization for hosting was that the MoHCC wanted to develop its own data center and could not allow the server to move from the building. Unlike the development arena of the Android system, the MoHCC was clear on the need to host the system internally. Debate over hosting data on the cloud was not entertained. Those interviewed cited security fears and general best practices, yet it was clear the politics of appropriation had intervened. Over the period of the study, the server was moved from building to building within the government complex, changing IP addresses, at the expense of system users. This space was largely controlled by ZimHISP, which kept an arms-length relationship with the Oslo team. Often users and other stakeholders would only find out that the server was not up or had changed its address through informal networks.

Discussion

According to Lefebvre (1991), if the production of space perspective fails to grasp the concrete, then it fails as an analytical model. It was highlighted in the forgoing sections that many conceptions of information systems phenomena fail to account for such material aspects. Furthermore, these conceptions fail to provide a framing for multiple levels of contemporary information systems, which this study aims to overcome. In this study, a spatial theorization is presented called "producing the agora." The agora in this case is the space through which a global process of technology development and use is instantiated in a local context. The agora is defined not as a container of things and products, but itself a product produced through the tripartite interaction of its spatial elements. These elements, or moments as Lefebvre (1991) calls them, are perceived, conceived, and lived space.

The Perceived Agora (Spatial Practice)

Lefebvre (1991, p. 33) notes that the spatial practice of a society "embraces production and reproduction and the particular locations and spatial sets characteristic of each social formation." As demonstrated, there has been an evolution of the spatial practice in the agora based on the different HIS technologies that have been adopted. Earlier systems were defined and developed in-house within the MoHCC. With DHIS 1.4, ZimHISP was co-opted into the MoHCC space with the help and support of donors. This co-opted space within the MoHCC headquarters was the locus of HIS development. ZimHISP was able to extend this co-opted agora by working with HISP SA and filling vacant positions in the MoHCC for which they provided funding. Through this produced space, ZimHISP was able to roll out the DHIS 1.4 system and support the implementation of a mobile HIS at all public health facilities. The spatial practice therefore consisted of the co-opted ZimHISP space, its U.S. office, HISP SA, the HIS unit of the MoHCC, district offices, large hospitals, and health facilities. With the emergence of DHIS 2, a new spatial practice emerged, involving ZimHISP, the MoHCC, the University of Oslo, GlobalFund, UZDev, MalariaDonor, and the NMCP program. This new perceived agora constituted a spatial practice that linked places more globally distributed into the day-to-day activities of the health worker at a rural health facility.

The Conceived Agora (Representations of Space)

Conceived space is that of planners and those who develop projects to intervene in space and modify it (Lefebvre, 1991). The DHIS 1.4 system can be seen as a representation of space, which intervened in the agora to modify it. The technology was developed in South Africa, and consequently, ZimHISP engaged South Africa as a partner in the project thereby modifying the spatial texture of the agora. Technology representations are not the same and, consequently, they intervene and shape the agora in different ways. Besides the technological artefact, other representations intervene to shape the space through which the technology is adopted.

These representations can be in the form of decisions, or plans and can sometimes be as subtle as emails which contribute to shaping the spatial texture, such as the health systems strategy that emerged in the MoHCC after the 2009 collapse of the HIS. It is important to observe that the chosen representations, or technologies in this case, can be appropriated and reflect back onto the dominant space from lived spaces, a dominant space which tries to maintain its own dominance. This reflection can be unexpected and itself be a source of conflict. It is these struggles which shape the agora, as some aspects of the technology are accepted easily such as DHIS 2 development in Norway, while others such as cloud hosting are rejected. In the case of Zimbabwe, the conflict around the server presents an interesting phenomenon where a representation is injected into lived space, yet it looks back to the space of conception that it tries to modify. This seemed shocking to agora actors who were focused on improving connectivity at the districts without thinking of improving the Internet connection at the MoHCC headquarters, a central space in the agora. DHIS 2 has representations embedded within it that are carried by the community as best practices and inserted into the agora. The DHIS 2 representations promote a new centralized server space, although the agora has not fully changed to reflect this, with politics emerging such as they did around the issue.

The Lived Agora (Representational Space)

Lived space is the space of the users, and this must be included in any conception of the ATOC if it is to be a concrete reality. A specific lived space, which is central in any discussions of systems in the MoHCC, is the space of the rural health facility. "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). In the rural health facility, a place where patients come, history is relevant and paper records rule. There are other representational spaces, such as the district hospital, where information officers often work. These are the spaces the agora seeks to appropriate, but, as Lefebvre notes, escape attempts to complete rationalization. Paper is still a key medium for the storage and dissemination of information, a state of affairs unlikely to change without a struggle. Some rural health centers visited in this study did not use the laptops they were given. Instead, they kept them stowed away, with one MoHCC partner noting that after a while, they disappeared completely: a failure of the productive process. With DHIS 1.4, the system was rolled out as far as the district level, and this representation did not directly intervene in the representational spaces of most rural health facilities. These facilities often lack electricity and depend on low-power solar cells. The DHIS 2 intervention left this area largely untouched and merely followed in the tracks of DHIS 1.4, reaching the district level only, except with the DHIS 2 Android project. The DHIS 2 software representation has intervened indirectly through the preexisting weekly disease mobile system rolled out by ZimHISP to collect data from facilities. However, the system largely relies on monthly paper reports from facilities, traveling to the district office for entry into DHIS 2. A tendency of some actors in the agora is to seek to dominate these lived spaces with technology. There was no shortage of frameworks, architectures and technologies being presented to the ministry in order to shape the agora.

Dominating and Appropriating the Agora

The agora as a whole is a space which some actors will seek to dominate in the pursuit of their own interests. It constitutes a productive force which can be reappropriated, for instance, to seek political ends, make a profit, or push an agenda. The world over, there is never a shortage of people or agencies that seek to dominate others. This domination can also be pursued through architectures which are produced by a knowledge which seeks hegemony (Lefebvre, 1991). This means choices in technology can be made, and often are, in order to pursue the interests of a powerful group. The development arena within this agora was dominated by HISP Oslo, which depended on the productive and reproductive forces of Norway as a developed country. This is exemplified in the Android project, which failed to produce a development arena in Zimbabwe, a space consequently dominated by HISP Oslo. On the other hand, a struggle between appropriation and domination ensued around the server, an arena dominated by the co-opted ZimHISP. The MoHCC, with its limited capabilities, also had an interest in not losing control of the server. According to the conception of Lefebvre (1991), dominated space and appropriated space may in principle be combined—and, ideally at least, they ought to

be combined. But history—which is to say the history of accumulation—is also the history of their mutual separation and antagonism. The winner in this contest, moreover, has been domination. (p. 166)

Conclusion

This study has presented a theoretical framing of the process by which a generic technology makes its way into a local setting. While previous studies have looked at such phenomenon through different perspectives, such as political theory, natural science, and other sociological theories such as Actor-Network Theory, this study argues that these formulations offer a fragmented view. In addressing the weaknesses of previous conceptualizations, a discourse on space has emerged in the discipline. However, these studies largely perceive space as a container (sometimes an empty one) of social actions and fail to provide an adequate elaboration of what they mean by the concept. This study extends these ideas and integrates the theoretical formulation of the nature of social space by Henri Lefebvre with state-of-the-art spatial concepts in information systems as presented through the agora by Kaniadakis. Using this formulation it was possible to bring together places distributed in time and space into a single framework. It enabled the researcher to understand the political struggles that ensue in the process of appropriating a generic HIS and how these shape the spaces in which the technology emerges and is used. Using these ideas enables a broader view of IS change phenomena and intervenes through choices of technology and its artefacts, thereby improving on successful appropriation. The framework produced by the concatenation of concepts is termed "producing the agora." It is hoped that practitioners and researchers can find meaning in these ideas for their relevant contexts to equip them for strategic intervention. It also sensitizes practitioners in the discipline to understand the far-reaching consequences of their technology choices. This study has been a grounded one, meaning the concepts in this study can be further refined as more contexts of such types of phenomena are incorporated. In addition, Henri Lefebvre's conceptualization is dense, and continued development in this direction will be fruitful for information systems researchers. Other spatial conceptions must also be considered to enrich the discipline. ■

Acknowledgments

Thanks to the reviewers of this article for their insightful and useful comments. Thanks also go to the Zimbabwe Ministry of Health and Child Care for the opportunity to do the research. Finally, thanks to the editors.

Rangarirai Matavire, PhD student, Information Systems, University of Oslo, Norway.
matavirer@gmail.com

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