OPEN GENERIFICATION
The case of District Health Information Software

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To my dear family
# TABLE OF CONTENTS

LIST OF FIGURES .................................................................................................................. III

LIST OF TABLES .................................................................................................................... IV

ACKNOWLEDGMENTS .......................................................................................................... V

ABSTRACT .............................................................................................................................. VI

CHAPTER 1  INTRODUCTION ............................................................................................... 1

1.1 Motivation ......................................................................................................................... 1

1.2 Research problem area .................................................................................................... 2

1.2.1 Why generic technology? .......................................................................................... 2

1.2.2 Research questions ....................................................................................................... 5

1.3 Theoretical perspective .................................................................................................... 6

1.4 Research approach .......................................................................................................... 7

1.5 Contributions .................................................................................................................. 8

1.6 Thesis outline .................................................................................................................. 9

CHAPTER 2  RESEARCH CONTEXT ....................................................................................... 10

2.1 Healthcare in developing countries .................................................................................. 10

2.2 HIS in developing countries ............................................................................................ 12

2.2.1 Hospital based systems ............................................................................................. 15

2.2.2 Aggregate reporting systems .................................................................................... 16

2.2.3 mHealth systems ....................................................................................................... 17

2.3 HISP and DHIS2 ............................................................................................................. 19

2.3.1 The birth of HISP and DHIS in South Africa .............................................................. 20

2.3.2 Scaling beyond South Africa ..................................................................................... 21

2.3.3 Transition to generic DHIS2 ..................................................................................... 22

CHAPTER 3  LITERATURE REVIEW ...................................................................................... 26

3.1 IS innovation in developing countries: addressing the technology-context mismatch .... 26

3.1.1 Transfer and diffusion of technology: from developed to developing countries .... 27

3.1.2 Social embeddedness: in the context of a developing country ................................ 30

3.2 Design for multiple contexts .......................................................................................... 32

3.2.1 Balancing between global and local ........................................................................ 33

3.2.2 Generification work .................................................................................................. 34

3.2.3 Generative design and FOSS innovation .................................................................. 37

3.3 Scaling: as a means of expansion and spreading ........................................................... 41

3.3.1 Mechanisms of scaling ............................................................................................ 43

3.3.2 Scaling and generification ......................................................................................... 46

3.4 Design at the organizational field level ......................................................................... 47

3.5 Summary and proposed conceptual framework ............................................................. 49

CHAPTER 4  RESEARCH APPROACH .................................................................................... 50

4.1 Research paradigm: my personal orientation ................................................................. 50

4.2 Research methodology: studying generification process ............................................. 52

4.2.1 Action research ......................................................................................................... 53

4.3 Data collection ............................................................................................................... 58

4.4 Data analysis ................................................................................................................. 62
CHAPTER 5  RESEARCH FINDINGS

5.1 SUMMARY OF RESEARCH PAPERS

5.1.1 Paper I: Interplay of institutional logics and implications for deinstitutionalization: Case study of HMIS implementation in Tajikistan

5.1.2 Paper II: An Institutional perspective in shaping mHealth systems: Case from India

5.1.3 Paper III: Understanding design-use interaction: the case of name based HIS system in India

5.1.4 Paper IV: Scaling as a process of managing sociomaterial assemblage: cases about HIS in developing countries

5.1.5 Paper V: Open Generification: A Design Strategy for Health Information Systems in Developing Countries

5.2 SYNTHESIS OF RESEARCH FINDINGS

CHAPTER 6  RESEARCH CONTRIBUTIONS

6.1 THEORETICAL CONTRIBUTIONS

6.1.1 Open Generification – a conceptual framework

6.1.2 Implications of open generification

6.2 PRACTICAL CONTRIBUTIONS

6.2.1 HIS artifacts to support public health practices in developing countries

6.2.2 Strategy for designing generic systems

CHAPTER 7  CONCLUSIONS

REFERENCES

APPENDICES
LIST OF FIGURES

FIGURE 4-1: RESEARCH DESIGN AND TIMELINE ........................................................................................................56
FIGURE 4-2: ONSITE DISCUSSIONS AND OBSERVATIONS ..........................................................................................59
FIGURE 4-3: DIARY NOTES ...........................................................................................................................................59
FIGURE 4-4: DHIS2 REQUIREMENT ANALYSIS AND DESIGN ......................................................................................60
FIGURE 4-5: EMAIL DISCUSSIONS AND TRACING OF DESIGN MODELS .................................................................60
FIGURE 4-6: DHIS2 TRAININGS AND WORKSHOPS .....................................................................................................61
FIGURE 5-1: RESEARCH PROGRESS ..............................................................................................................................72
FIGURE 6-1: OPEN GENERIFICATION: A FRAMEWORK .................................................................................................78
FIGURE 6-2: CONTRIBUTIONS TO BODY OF LITERATURE (THE ITALICIZED BOLD ARE THE NEW ADDITIONS) .......88
LIST OF TABLES

TABLE 2-1: SUMMARY OF THE MAJOR HEALTH INFORMATION SYSTEMS IN DEVELOPING COUNTRIES .................................................. 14
TABLE 4-1: SUMMARY OF ACTION RESEARCH PROJECTS CONDUCTED .................................................................................. 57
TABLE 4-2: SUMMARY OF DATA COLLECTION METHODS ....................................................................................................... 61
TABLE 4-3: DATA ANALYSIS AT INDIVIDUAL PAPER LEVEL ..................................................................................................... 63
TABLE 5-1: RESEARCH PAPERS AND THEIR RESPONSES TO THE RESEARCH QUESTIONS ................................................................. 75
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ABSTRACT

This thesis presents an action research study into the design of generic health information system (HIS) based on District Health Information Software 2 (DHIS2) for the public health contexts of developing countries. As a core designer of the HIS and also engaged with its in-country implementations in different places, I take both “global” and “local” perspectives, to understand the challenges of design, implementation and their interplay. I contribute to debates on “generification” through articulating the concept of “open generification”. The thesis has also implication on strategies of information systems innovation in developing countries as well as mechanisms of scaling, in particular when transporting a technology that has worked in one context to multiple other contexts.

A practical motivation for this study is the endemic failures of HIS in developing countries, contributed significantly through “design-reality” gaps. Making generic design for multiple contexts or specific design for a particular context have both been deemed problematic, leading for calls for developing a “pragmatic balance”, although with little direction on how this can be achieved. Open generification is my contribution on how such a balance may be achieved, which is based on practical design guidelines at both the strategic and operational levels. Theoretically, open generification presents a conceptual perspective based on unpacking processes of building systems for both generic and specific based on principles of openness and collaboration. This depends on the configuration and interaction of social and technical elements at global and local levels. To facilitate this, the open generification framework suggests for mechanisms of embedding and disembedding. While open generification represents an ideal state, I also identify some potential distortions from this, and how they may be achieved. Supporting concepts of organizational field and scaling are used to build the open generification perspective. The concept of scaling helps to unpack processes of technology spreading and expansion in time and space while organizational field sensitizes to interdependent sectoral influences that shape the generification process other than suppliers and consumers. In this way, the thesis seeks to answer the following two guiding research questions: (i) how can we understand generic HIS design in the context of developing countries? (ii) what are appropriate strategies to help us design generic HIS that fits into the public health needs of multiple countries?

Methodologically, the study was conducted within the framework of the Health Information Systems Programme (HISP), which is an international project engaged in strengthening health data collection, analysis and management in many African, Asian and Latin American countries. Key activities in HISP are design, development and implementation of DHIS2, which I have taken a central stage as an action researcher. I conducted four different action research projects each analyzing processes of DHIS2 spreading, expansion, restructuring and architectural innovation in a generic fashion. Multiple qualitative data collection methods were used in the process. For data analysis, I followed inductive approach within the framework of interpretive IS research tradition. Findings from the data analysis are presented in five conference and journal papers. Practical outputs from my actions are mobile-enabled DHIS2 modules supporting practices of recording, tracking and reporting in rural healthcare organizations of multiple developing countries.
CHAPTER 1  INTRODUCTION

This thesis presents an action research study into health information system (HIS) design for the public health contexts of developing countries. In particular, the thesis investigates the challenges of designing generic systems as experienced from a “global” perspective and their implications on “local” level implementations in different countries. A key aim of the thesis is to understand these challenges and develop improved theoretical and practical perspectives that help to better address them. This introduction chapter presents an overview to the overall issues. The first section presents the motivation to undertake the research, and section two presents the broader research problem area and specific research questions targeted in the study. Following this, a brief description of the theoretical framework and research approach is provided in sections three and four respectively. Then section five outlines theoretical and practical contributions. Finally, section six presents a structure for the rest of the thesis.

1.1 Motivation

The primary motivation for this thesis is a research quest to analyze HIS design which emanates from both practical and theoretical concerns. The practical concern is failure of information systems (IS) in general, HIS in particular, in the contexts of developing countries, which the literature “manifests an acute anxiety about” (Avgerou, 2008, p. 37). A key personal motivation to look into this issue is a strong interest to contribute as someone from a developing country, trained as a computer engineer and working as part of a global team engaged in designing HIS solution for the public health sector of multiple developing countries.

The theoretical concern motivating the study is the interest to develop insights into processes of generic HIS design for the contexts of developing countries. I develop the concept of “open generification” building upon and extending the work on “generification” (Pollock et al., 2007) to theoretically understand processes of generic system design. While examining similar design issues, Braa et al (2007a) identified complexity as a key challenge. My study aims to contribute to this body of knowledge, identifying generic HIS design as one of the key challenges. The following section outlines why this indeed is a key challenge and in need of attention.
1.2 Research problem area

Many IS interventions in developing countries have been reported as either total or partial failures (see for example Avgerou & Walsham, 2000). Leading to the failures are the mismatches between design and reality (Heeks et al., 1999; Heeks, 2002; 2003), between cultural values of developed and developing countries (Rajapakse & Seddon, 2005; Soh et al., 2000) and also between assumed business models and realities (Yen et al., 2011). HIS interventions are no exceptions; they have suffered from design-reality mismatches (Heeks, 2006), technology-environment mismatches (Kiyan, 2007), problems of scalability and sustainability (Braa et al., 2004; Kimaro & Nhampossa, 2005), fragmentation (Chilundo & Aanestad, 2004; Jeppsson & Okuonzi, 2000), and inadequate capacity (Kimaro, 2006; Jayasuriya, 1999). Across these failures, a recurring theme is the use of artifacts designed in/for “western” contexts, often supported by donors, which do not fit to sociotechnical realities of developing countries on the one hand, and challenge of scaling and sustaining systems over time in an ever changing context on the other hand. This summarizes HIS failures from the use of a-contextual technology, which symbolizes the challenge to account the needs of multiple countries at the time of design. However, with research focused on identifying various dimensions of mismatch between technology and context at the hindsight of design, little has been investigated on how to approach design of generic systems that fit into the needs of multiple countries. My research investigates this issue.

1.2.1 Why generic technology?

Engaged with the investigation of the mismatch between technology and context in developing countries, existing literature has established two broad discourses of innovations – social embeddedness and transfer and diffusion (Avgerou, 2008). The transfer and diffusion discourse examines how artifacts designed outside the context of developing countries are brought to the context of developing countries through local adaptations and appropriations during implementation (Avgerou & Land, 1992; Bada, 2002). The social embeddedness discourse, drawing from the constructivist research stream, rejects those a-contextual artifacts and the notion of transfer by arguing for local cultivation and situated-design (Braa & Hedberg, 2002; Suchman, 2002). The overarching argument in the social embeddedness discourse is an approach for “IS innovation as a process embedded in local conditions of a developing country” (Avgerou, 2008 p.134).
However, a characteristic aspect of developing countries, also referred to as low resource countries with limited capacities, is their dependence on donors who tend to operate globally in multiple countries. In such situations, it is practically and economically prohibitive to perform independent and local design for each country (Braa et al., 2007b). Instead, it is required to have a pragmatic design strategy that strikes a balance between what to transfer globally and what to cultivate locally (Bjørn et al., 2009; Rolland & Monteiro, 2002). Striking a balance helps to achieve generic solutions that can potentially work globally for multiple countries. However, research still grapples with how to strike such a balance in efforts to develop a generic technology, which is a non-trivial challenge. There is a need to develop deeper insights into the act of finding the balance as well as design principles that move beyond general advices of being pragmatic, to actually how can this be done in situated settings. In particular, we need to better incorporate the very nature of the contexts, including capacities, both where generic artifacts are developed and implemented in global/local settings.

One emerging perspective to look into such issue of designing generic artifacts is the concept of “generification work” (Pollock et al, 2007) based on empirical work from the domain of enterprise resource planning (ERP) systems. The concept discusses vendors’ strategies for designing globally generic ERP artifacts intended to work for multiple customers. A basic element in the generification process is the segmentation strategy of vendors to answer the needs of only those customers considered commercially important. Those ranked less important “are pushed to the margins of the shaping process where they are not consulted or involved in design or evolution … what they could do with the system is policed” (p. 269). Instead of providing them a technology that fits to their sociotechnical settings, those considered less important are forced to fit into a technology that was designed for others. An open generification process, a strategy that helps develop a system that allows the establishment of fit to the sociotechnical realities of multiple users irrespective of their ranking, is the key perspective this thesis intends to advance.

My investigation on open generification also relates to my motivation to address problems of scaling mentioned above, because the success or not of scaling depends on the degree of generification (Sæbo, 2013). However, often, discussions of scaling are how a particular technology, resulted after some form of design effort, has failed to scale in the contexts of developing countries. With this, I see a tendency of treating scaling as an after design issue.
Instead, I look at scaling as highly dependent on design choices and strategies in particular on the degree of generification inscribed in the artifact. Drawing from this perspective, my intention is to further investigate the relationship between mechanisms of generification and processes of scaling.

1.2.1.1 Design for scalability

Closely related to generification and contributing to HIS failures is the challenge of scaling. The failures resulting from problems of scalability relate to the challenge of expanding and adjusting HIS solutions to make them work over time in particular settings and successfully spread them to multiple other settings (Braa et al., 2004; Kimaro, 2006; Sahay & Walsham, 2006). With scalability considered a prerequisite to sustainability (Braa et al., 2004), it becomes a topic requiring greater scrutiny, and both scaling and sustainability have been identified as important research topics (Walsham & Sahay, 2006; Walsham et al., 2007).

In the existing discussion of scaling, attention has primarily been on the material with little attention given to the social (for example, Monteiro, 1998) or in emphasizing the social while neglecting the material (for example Braa et al., 2004). A balanced and holistic understanding is further required as scaling necessarily involves both the social and the material. Braa and Sahay (2012) have also urged for a view of scaling not just in terms of boxes of technology taken from one site to another, but as the adoption of certain design strategies along the social and the material dimensions. The question then is what form of design strategy? In this thesis, I investigate this through open generification by looking for mechanisms of designing scalable HIS drawing from the emerging sociomaterial research perspective.

Scaling is also related to the problem of fragmentation, which is often associated with donors and their program specific funding (Chilundo & Aanestad, 2004; Jeppsson & Okuonzi, 2000). For example, think of a donor who is interested in contributing towards eradicating Tuberculosis (TB) in one country. Accordingly, this donor will direct resources to build an HIS artifact embedded in work practices, organizational structures and social processes pertinent to TB program. Assume things went smooth, and the technology-context match is established, and the country has a working system supporting the TB program. Then after a while think of another donor or for that matter the same donor, needing to support child immunization for the same country. This time, the donor will face a different set of data to collect and report, different work practices and probably different organizational structures.
and social processes reflecting immunization program. Then two paths exist for the donor. The first is to take out the existing TB system from its comfort zone and scale it to embrace realities pertinent to immunization so that it supports both programs, or the second path is to leave the TB system as it is but design a new system that works only for immunization. However, as pointed in the literature “[health] information systems have traditionally been designed as rigid, encoded systems … unable to accommodate … changes” (Shaw, 2009, p. 8); paving the way for the second path, and hence promoting fragmentation. This should not be surprising given the emphasis for embedding IS innovations in local settings (Avgerou, 2008; Suchman, 2002) and the problem closure approach of traditional system design practice (Gasson, 2003). This raises the need to understand design of generic, open and adaptive systems across time-space – across time in terms of expanding and adjusting the HIS to cope with emergent needs and sociotechnical realities of a particular setting, and across space in terms of spreading the working solution to multiple distinct settings.

The time-space perspective is important here as it enables for a more holistic and coherent understanding of IS design and implementation challenges (Sahay, 1997). If we look back to the challenges mentioned surrounding HIS activities – in a particular time-space, there are problems of technology-context mismatch and limited capacity to establish and support a system that works for multiple contexts and countries. If we somehow managed to reach a working system in time-space, then there is this constant and evolving interplay of the social and the material that awaits us on the face of the problems of sustainability, scalability and fragmentation across time-space. The aim of the thesis is, therefore, to understand these dynamics and articulate theoretical and practical perspectives that help us better address the problems that have overwhelmed HIS interventions in developing countries.

1.2.2 Research questions

Given the aim to understand the challenges and strategies of designing generic HIS, the research questions this thesis seeks to explore are:

**RQ1:** How can we understand generic HIS design in the context of developing countries?

**RQ2:** What are appropriate strategies to help us design generic HIS that fits into the public health needs of multiple contexts and countries?
Addressing these questions requires a research practice that “cross[es] the implementation line” (Leonardi, 2009). It requires a study that looks into the interplay between design and use across time-space with a focus on how different components of artifacts emerge and interconnect with work practices, organizational structures and social processes of multiple countries. Otherwise, when we study technology at the time of implementation “we de facto treat the technology that arrives as a black box because we usually do not know what its prior history may have been and, hence, why it arrives with its particular constellation of features” (Leonardi & Barely, 2008, p. 166). Failure to understand how the particular features emerge and interconnect with situated sociotechnical realities will put us in a disadvantaged position to conduct processes of generification and embrace new settings recurring on the face of the technology-context gap and challenges of scalability and its associated problems of sustainability and fragmentation.

1.3 Theoretical perspective

The theoretical point of departure in this research is the choice of design as the object of study. In the study, design is seen both as a product and as a process. Design as product is seen from the perspective of the ensemble view of technology (Orlikowski & Iacono, 2001) which accounts for the heterogeneous assemblage of the social and the material. As a process, design is seen as a set of activities through which the sociomaterial assemblage is established and evolved in time-space.

Clearly, both the product and process aspects of design are results of the context where artifacts are developed and implemented. In this thesis, where I have the interest of generic HIS that works for contexts of multiple countries, the issue of context receives a stronger level of scrutiny with an emphasis on the organizational, sectoral and wider national and international aspects (Avgerou & Walsham, 2000). As a result, multiple and broader institutional, political, economic, organizational and cultural factors come into play in shaping the product and process aspects of design. This clearly calls for a focus that goes beyond the interest of a single organization commonly seen in traditional system design practices. It requires for a broader level of analysis that accounts for the interplay of multiple organizations and associated interests. Addressing this, I adopt an organizational field level of analysis (DiMaggio & Powell, 1983), as it helps to develop a more structured and systemic
understanding of how technology is shaped by complex interdependent and sectoral influences (Chiasson & Davidson, 2005; Mignerat & Rivard, 2009).

In order to understand this shaping process in general, the internals of the technology product and the innovation process in particular, the study takes the perspective of the social shaping of technology (MacKenzie & Wajcman 1985; 1999; Williams & Edge, 1996) as the broader sensitizing theoretical device. Sociomateriality (Orlikowski, 2007; Orlikowski & Scott, 2008) is the other sensitizing perspective the study adopts to keep focus on the constitutive entanglement of the social and the material across time-space. Together, these perspectives help to reach a better understanding of generic HIS design in the context of developing countries.

With the interest to understand the design of HIS solution that works for contexts of multiple developing countries, the thesis also looks into practical concerns and pragmatic strategies for designing global and generic software artifacts. The discourses around generification (Pollock et al., 2007) are the other learning examples this thesis draws from. In summary, the thesis plans to synthesize these theoretical resources and develop a framework that helps to answer the identified research questions around designing and developing generic HIS that addresses problems of technology-context gap and scaling in the context of developing countries.

1.4 Research approach

Methodologically, the thesis has employed an action research approach (Baskerville, 1999; Baskerville & Myers, 2004; Braa et al., 2004; Lewin, 1946; Susman & Evered, 1978) with practical engagement in activities of HIS design and implementation in collaboration with the Health Information System Program (HISP). HISP, largely funded by the Norwegian Research Council and globally coordinated by a team at the University of Oslo, represents a network of researchers, designers, implementers and users of HIS working towards improving HIS across developing countries. A major activity in HISP, representing a key focus of this thesis, is the design and development of a HIS artifact called District Health Information Software version 2 (DHIS2). DHIS2 is a free and open source software for collection, validation, analysis and presentation of aggregate (or number-based) public health data. The

1 http://dhis2.org
2 http://www.hisp.uio.no
software is in use in more than 30 countries. As part of my study, I have conducted four key design activities inside DHIS2. These were:

- Design of a multidimensional reporting module supporting the morbidity and mortality reporting practice of Ethiopia and latter redesigning the same to make it work globally for multiple countries.
- Design of generic name-based recording, tracking and reporting module assisting immunization, pregnancy care, TB and other public health programs of developing countries.
- Investigation of a local dashboard module, designed for local needs by a team from India, in order to examine the feasibility to spread it globally across multiple countries.
- Design of generic mobile based reporting module.

Taking these four design activities as concrete empirical cases, the study draws from a five-year (2007 - 2011) in-depth longitudinal case material gathered through various qualitative data collection techniques. For data analysis, the study used a general inductive approach (Thomas, 2006) within the framework of an interpretive research tradition (Walsham, 1993) for constructing and interpreting subjective and inter-subjective meanings of the themes observed.

1.5 Contributions

The thesis makes both theoretical and practical contributions. Theoretically, it aspires:

- to conceptualize the process of generic technology design in the context of developing countries. With this, I intend to
  - extend the existing conceptualizations of generification.
  - conceptualize alternative innovation strategy to that of transfer and diffusion and social embeddedness for the context of developing countries.
  - conceptualize processes of scaling drawing from the perspective of generification design practices.

As a practical contribution, the thesis seeks to:
• strengthen DHIS2 so that it supports a variety of use cases from the public health practices of developing countries.
• suggest pragmatic guidelines and strategies for designing generic HIS artifacts in particular, generic organizational IS in general, in the context of developing countries

1.6 Thesis outline

The remaining part of the thesis is outlined in six chapters. The next chapter provides an overview to the research context. Chapter 3 then follows with a discussion of theoretical perspectives to help us understand generic HIS design challenges in the context of developing countries. Chapter 4 presents the research approach with detailed discussions of research methodology, data collection and analysis techniques. Analysis of findings, based on five conference and journal papers, is presented in chapter 5. Following this, chapter 6 brings a synthesis of the findings to make practical and theoretical contributions. Finally, chapter 7 presents concluding remarks and future research directions.
CHAPTER 2 RESEARCH CONTEXT

This chapter gives a situational analysis of the research context where the study was conducted. The purpose is to draw an informative picture of the research domain – HIS in developing countries. To this end, the chapter is divided into three sections. The first section provides an overview to the healthcare domain of developing countries with a focus on some of the challenges that HIS systems are engaged with. Then section two highlights some of the major HIS solutions currently in use in developing countries. Following a background to the research domain, the chapter then moves to section three providing an overview of the empirical context – HISP and DHIS2 – where this research was conducted.

2.1 Healthcare in Developing Countries

Healthcare in developing countries is a domain beset with a multitude of infrastructural, organizational, human resource and management related challenges (Sahay, 2001). What characterizes the domain include:

- inadequate health personnel distribution of 0.8 health workers per 10,000 inhabitants (WHO, 2007);
- mothers in maternity traveling for more than three hours to reach referral hospitals (Cham et al., 2005);
- a single health center serving a population of around 30,000 without a single telephone line connection (Sahay, 2001);
- only 0.011 billion hospital beds serving a population of 5.3 billion (Vital Wave Consulting, 2009); and other similar figures representing alarming shortages.

At the center of these inadequacy figures are healthcare organizations with an overdose of bureaucracy (Sahay, 2001). Though organized in a hierarchy of national, state, district, sub-center and other administrative units, work practices are deprived of flexible and responsive decision-making processes. Another challenge impeding the health service delivery is misalignment of resources exemplified by a focus on acquiring state-of-the-art urban hospitals while the majority of population in dire need of health services is in rural areas. For example, it is a common observation for health manpower to be concentrated in large urban hospitals for reasons, among others, that these hospitals have more attractive working conditions.
including salaries, drug supplies, medical equipment and exposure to new technologies. Such a focus on hospitals and curative medicine stands in stark contrast to the need for strengthening preventive medicine and the primary health care (PHC) system that struggles to reach the larger proportion of rural population of the country. In summary:

"[W]hat we have typically in developing countries is a PHC system that is extremely strapped for financial, human and medical resources trying to provide outreach care to large numbers of people spread out geographically in remote areas, while governments enamored with new technology and promises by vendors and international agencies pour in money into large complex systems in hospitals. How to shift this focus, is a major challenge for the future, especially in the context of introducing ICTs to support system geared towards preventive care" (Sahay, 2001, p. 1).

Overcoming these challenges and providing quality and equitable health services has been a priority for both national and international agencies who are engaged in various health sector reform interventions that represent national priorities. The two international level declarations – the Alma Ata (WHO, 1978) and the United Nations Millennium Development Goals (UN, 2000) – and numerous national level reform initiatives that followed them are notable examples.

The Alma Ata declaration, underlining PHC as an essential package, has urged governments, development workers and the global community to mobilize resources and bring health services to individuals and families in the community through practical, scientifically sound and socially acceptable methods and technology. Following this, the Millennium declaration has set eight Millennium Development Goals (MDGs) of which three of them are health related: MDG-4 for reducing child mortality, MDG-5 for improving maternal health and MDG-6 for combating HIV/AIDS, malaria and other diseases. Achieving these goals requires actions that overcome issues of poor infrastructure, weak HIS, and shortage of skilled personnel. One pursued strategy to overcome these issues and approach the MDGs, is a PHC system championed by community health workers (CHW)\(^3\) and rural healthcare organizations with a focus on the poor and rural community (Bhutta et al., 2010; Chen et al., 2004).

CHWs are members of a local community recruited to provide basic health services and medical care to their community. Health services provided by CHWs are primarily proactive

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\(^3\) Other names to CHWs include Village Health Workers (VHWs), Health Extension Workers (HEWs), Auxiliary Nurse Midwives (ANMs), health workers, barefoot doctors, health agents, health promoters, health advisers.
(Krieger & Higgins, 2002; Yach & Bettcher, 1998) and based on tracking of individuals, house-to-house visiting and preventive medicine (Brownson et al., 2003). Some examples of these health services are child immunization, pregnancy care, sanitation, family planning, TB and HIV/AIDS treatments (Cassens, 1987; Brownson et al., 2003; Schneider et al., 2008). In addition to health services delivery, CHWs are also engaged in other practices that includes collection of vital statistics, maintenance of health service records and generation of periodic aggregate reports. These are equally important to support the process of health services provision, through these activities the CHWs “provide health system managers [and decision makers] with information that may otherwise never reach them and can encourage those in the health system to understand and respond to the community needs” (Bhattacharyya et al., 2001). Contributing to these practices, appropriate HIS solutions are expected to have a huge potential to bring timely and accurate information and assist efficient and effective execution of health services, which contributes to the broader socio-economic development process of developing countries (AbouZahr & Boerma, 2005; Chetley, 2006). Drawing from these urgent needs, designing appropriate HIS solutions that works for the practices of PHCs and their CHWs is the empirical setting of this thesis.

2.2 HIS in Developing Countries

Currently, it is no debate whether information and communication technologies (ICT) brings value to the contexts of developing countries in general, and the healthcare sector in particular. A great number of researchers, practitioners, commentators and decision makers have asserted that ICTs play a vital role for improving the well-being of a society and contribute towards the socio-economic development of developing countries. Though application of ICTs has not always resulted in success, evidence suggests that it remains a positive dynamic force contributing to effective and efficient processing of healthcare practices (Walsham & Sahay, 2005; AbouZahr & Boerma, 2005; Chetley, 2006; WHO, 2000). During the last two decades, the healthcare domain of developing countries has witnessed a considerable progress in applying ICT applications to strengthen HIS (Tomasi et al., 2004). The applications range from electronic medical record systems, telemedicine infrastructures, and electronic cards for information storage and individual identification in hospitals to routine reporting systems, vital registration systems and mobile phone supported tracking, scheduling and recording systems in rural public health centers.
The combinations of these various applications with people, paper-based systems, organizational structures and work practices constitute the HIS of a country. The HIS constitute “a set of components and procedures organized with the objective of generating information which will improve health care management decisions at all levels of the health system” (Lippeveld et al., 2000). In a typical developing country setting, the levels reflect national, state, district, sub-center and other health administrative units. Across these levels, the purpose of the HIS is to facilitate collection, analysis, presentation and communication of timely and accurate data deemed useful for informed decision making processes. Some examples, supporting decision making processes for developing countries, are DHIS2, CRIS, Epi Info™, OpenMRS, Care2X and various other systems in the area of logistics, laboratory, pharmacy, finance, vital statistics and others. With these examples, my intention is not to provide an extensive list of HIS applications in use across developing countries, but to point to some of the major applications, and also highlight from where they originate. Table 2.1 provides a summary of some of the major HIS applications.

**DHIS2**: DHIS2 is an open source HIS targeted for the context of developing countries. It is a system for collection, validation, analysis, and presentation of aggregate statistical data – in the form of graphs, charts, bars and geographic maps – tailored (but not limited) to integrated health information management activities. The system is developed by a network of researchers and designers coordinated globally by the research group at the University of Oslo, Norway, with other development nodes in India, Vietnam and some other countries.

**CRIS**: CRIS, the Country Response Information System (CRIS), is an information system developed by UNAIDS Monitoring and Evaluation Division. It facilitates collection, reporting and analysis of project, financial and indicator data for the purpose of effectively meeting country monitoring and evaluation needs.

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4 District Health Information System, HISP International, [http://www.hisp.info](http://www.hisp.info)
6 EPI Info™, [http://www.cdc.gov/epiinfo/](http://www.cdc.gov/epiinfo/)
7 Open Medical Records System, [http://openmrs.org](http://openmrs.org)

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13
Table 2-1: Summary of the major health information systems in developing countries

<table>
<thead>
<tr>
<th>HIS</th>
<th>Category</th>
<th>Originated from</th>
<th>Country of Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DHIS2</td>
<td>Aggregate reporting system</td>
<td>HISP, Norway</td>
<td>The Gambia, Sierra Leone, Liberia, Ghana, Burkina Faso, Togo, Nigeria, Botswana, Malawi, Tanzania, Zanzibar, Kenya, Rwanda, Uganda, Tajikistan, India, Sri Lanka, Bangladesh, Vietnam</td>
</tr>
<tr>
<td>CRIS</td>
<td>Aggregate reporting system</td>
<td>UNAIDS Monitoring and Evaluation Division</td>
<td>“as of May 2007, CRIS is being used in 96 countries”(^9)</td>
</tr>
<tr>
<td>Epi Info™</td>
<td>Aggregate reporting system</td>
<td>CDC, US</td>
<td>Over 181 countries since the initial release(^10)</td>
</tr>
<tr>
<td>OpenMRS</td>
<td>Clinic/Hospital based system</td>
<td>Regenstrief Institute and Partners in Health, US</td>
<td>Kenya, Rwanda, Lesotho, Malawi, South Africa, Mali, Tanzania, Zimbabwe, India, Haiti, Nigeria, Honduras, Peru</td>
</tr>
<tr>
<td>Care2X</td>
<td>Hospital based system</td>
<td>Open Source Community</td>
<td>Kenya, Egypt, South Africa, Tanzania, Albania, Nepal and others</td>
</tr>
<tr>
<td>Logistics, Finance, Infrastructure etc</td>
<td>Primarily aggregate based systems</td>
<td>Different line departments</td>
<td>Health departments within the broader health system</td>
</tr>
</tbody>
</table>

**Epi Info™**: Epi Info™ is an epidemiological statistical tool provided by the Centers for Disease Control and Prevention, US. It enables epidemiologists, public health officials and other medical professionals to rapidly develop questionnaires and customized data entry forms and perform data collection and analysis using tables, graphs, and maps.

**OpenMRS**: OpenMRS is a community-developed, open-source, enterprise electronic medical record system platform under the leadership of Regenstrief Institute from Indianapolis and Partners in Health from Boston, US. It is a software platform and a reference application, which enables design of customized clinical based medical record system for the context of developing countries.


Care2X: Care2X is a collaborative open source project aimed at developing an integrated hospital information system. Taking “the patient” at the center of activities Care2X aims to integrate data, functions, and workflows in a hospital environment. It is composed of four major components – hospital information system, general practice management, central data server, and health exchange protocol – that can function individually.

As shown in the table, two categories emerge: aggregate reporting systems and hospital-based systems. Three of the systems – DHIS2, CRIS, and Epi Info™ – are primarily aggregate systems supporting monitoring and evaluation activities by providing features for collection, processing, and reporting of aggregate data. The other two systems, OpenMRS and Care2X, are hospital or clinic-based systems supporting practices of storage and processing of patient-based clinical data. Below, I present my critical reflections on these two categories of systems in relation to their appropriateness for the PHC practices performed by CHWs. To get a more holistic overview of the HIS applications in developing countries, I also bring an overview to mHealth systems, which are now considered critical for the collection and exchange of timely data – both aggregate and patient based.

2.2.1 Hospital based systems

In the hospital/clinic category, what we have are systems intending to replace the paper-based storage, retrieval, and processing of name-based individual records by introducing an electronic medical record system. These are also systems that intend to integrate the different activities encompassing hospital work practices; such as the management of laboratory data (including imaging), patient journals, drug supply, billing, and human resources. However, computerizing hospital practices has proved to be resource intensive, complex, and challenging even for the world’s richest nations (Ash & Bates, 2005; Ellingsen & Monteiro, 2000; Jones, 2000). This is not to argue against hospital-based medical record systems for developing countries, but to highlight the importance of having appropriately designed systems that minimize, if possible avoid, design-reality gaps (Heeks, et al., 1999; Heeks, 2006).

It is undoubtedly commendable and important to have hospital-based systems for example in urban areas where we have resources including finance, personnel, and required infrastructure. However, apart from the resource issues, one qualifying comment can be raised related to addressing design-reality gaps. Hospital-based systems are often designed on top of a curative
medicine business logic and a related data model that assumes “patients coming to hospitals and doctors making diagnosis and recording observations”. This is in stark contrast to the reality in rural areas, where the primary point of care is not a hospital with a doctor, but a resource strapped health center with lowly-trained health professional – the CHW. The CHW provides preventive medicine on a routine basis to individuals by either visiting them house-to-house or by urging them to come to health centers. In addition, an individual in need of preventive medicine, for example immunization vaccine or routine pregnancy checkup or family planning is not necessarily a patient – this makes the whole modeling and design around patient conceptualization problematic. In summary, hospital-based systems and their focus on patient-hospital-doctor interactions require serious design considerations and restructuring to match the realities of CHW managed rural health centers.

2.2.2 Aggregate reporting systems

Under the aggregate category, what we have are systems that process statistical data considered useful for efficient and effective management of health services. These are systems assisting in the collection, analysis and presentation of aggregate numbers in the form of tables, graphs, charts and maps. DHIS2, advocated by WHO\(^\text{11}\), is one example from the aggregate category.

The focus of aggregate systems in general, DHIS2 in particular, is to enable flexible reporting of routine aggregate reports up in the hierarchy of organizational structures and healthcare administrative units. However, a problem often associated with aggregate systems is that they suffer from issues of data quality (Mate et. al, 2009). My preliminary assessment in India, a country struggling to meet the MDGs, confirmed this. The health minister of India questioned the appropriateness of the existing number-based aggregate reporting system they had. The minister said:

"Why is it that despite high [Routine Immunization] coverage, we are failing to eradicate diseases like polio? We have to start double checking immunization numbers being [reported]

\(^{11}\) [http://www.who.int/africahealthinfoway/countries/DHIS/en/]
to us by states ... once vaccination data becomes name based rather than number based, we will be able to account for the exact number of children actually vaccinated.\(^ {12} \)

A CHW I interviewed in the state of Andhra Pradesh, Prakasam District, also raised a similar issue asking for a system that supports work practices beyond routine reporting. She asked:

"More than a reporting system, I also want a system which can tell me when a due date is for my pregnant woman; it is difficult to calculate delivery dates by hand"

The CHW raised the request during a demonstration of a mobile phone supported mHealth reporting system. During the demonstration, she made it clear how the mobile based solution becomes useful for sending reports from her remote health center, which otherwise would need her to travel to the nearest PHC office that has a computer. However, in addition to reporting, she demanded for the mHealth solution to support other practices such as notification for when to visit a pregnant woman or a child in need of vaccines and other actions during house-to-house visits.

### 2.2.3 mHealth systems

mHealth is a term for medical and public health practices supported by mobile devices – such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices (Germanakos et al., 2005; Istepanian & Lacal, 2003). mHealth applications range from the area of point-of-treatment, sensors and body networks for enabling real time monitoring of chronic diseases (Jovanov, 2006) to asynchronous exchange of short messages for follow-up of medication, data reporting, education and capacity building (Mishra & Singh, 2008; Vital Wave Consulting, 2009).

In mHealth for developing countries, quite visible in the literature is the work of the public-private partnership between United Nations and Vodafone. In their fourth publication – “mHealth for Development: The Opportunity of Mobile Technology for Healthcare in the Developing World” – they stressed the potential of mobile phones to address the major challenges of MDG 4, 5 and 6 (Vital Wave Consulting, 2009). According to Vital Wave Consulting, mobile phones are believed to have a huge potential to transform approaches to addressing the healthcare challenges especially in the areas of accurate and timely data

collection and transmission to support healthcare provision and treatment for example through the use of SMS notifications.

A driving factor for the attention towards mHealth across developing countries is the growing penetration of subscriptions in the general population. In the developing world, fixed-line Internet connections are rare and paper forms are still the primary mechanisms for public health data collection and exchange. On the other hand, mobile phone penetration in developing countries has grown at staggering rates over the past decade – from a little more than 10% penetration in 2000 to 60% in 2007 (ITU, 2008a; 2008b) and to 79% in 2011 (ITU, 2011). In 2013, there are almost as many mobile phone subscriptions as people in the world. There are 6.8 billion total subscriptions, out of which 89% are in the developing world (ITU, 2013). Such rapid increases of subscription and coverage has created a great deal of optimism to tap into the mobile phone information infrastructure and bring innovative mHealth applications and services (Vital Wave Consulting, 2009).

However, what is critically missing from these figures and most mHealth studies is the distribution of subscriptions, for example between urban and rural, and the impact of individuals’ subscription on the overall figure. For example, especially in the developing countries, it is common for an individual to have more than one subscription and engage in a self-managed business of “mobile renting” or “telekiosk” (Gillwald, 2005). It is also common for visitors and nationals who reside abroad to have subscriptions during their short-term visits to the country. Here, I should confess the number of subscriptions I had during my travel to developing countries while engaged with my research – I have more than five of these so called “life time subscriptions” which I do not use right now. Issues of usage of mobile phones, other than voice, and concrete national policy that involves both the telecom and the health sector, are for example some of the important points missing in the driving factor of mobile phones for healthcare initiatives. Especially the policy part, I feel it is critical for example to address the privacy and security concerns of HIV/AIDS patients during SMS exchange. Nonetheless, it is no doubt that mobile phones are forming a critical mass of infrastructure that we could tap to bring improved health service deliveries. Currently we see a proliferation of mHealth applications out in the healthcare domain of developing countries. Some applications are – FrontlineSMS from kiwanja.net, USA[^13]; ComCare from Dimagi, Inc, [^13]: http://www.frontlinesms.com/
USA\textsuperscript{14}, Cell-Life from Cell-Life, South Africa\textsuperscript{15}, D-Tree from D-tree International, USA\textsuperscript{16}; EpiSurveyor from DataDyne, USA\textsuperscript{17}, openXdata from openXdata, Norway\textsuperscript{18}, and Open Data Kit from University of Washington, USA\textsuperscript{19}.

As can be seen from these examples and from those listed in Table 1, most of the applications have originated from the developed countries and implemented in developing countries. Investigating such a phenomenon of transfer from the developed to the developing world, what has largely been highlighted is how systems that originate from outside often struggle to fit into the sociotechnical realities of developing countries or fail to scale beyond their pilot phases (Heeks et al., 1999; Heeks, 2006; Lind, 1991). In the literature, little is reported on how such systems are actually designed or how their designers attempt to deal with issues of generification that allows for a fit to dynamic and emergent needs of multiple countries. The aim in this thesis is to look into these issues – theoretically understand innovation of generic HIS and identify some practical design strategies. In addition to the theoretical and practical perspectives, the aim is also to design free and open source HIS artifact drawing from the strengths of the three – aggregate, clinic based and mHealth – categories of systems mentioned above. In particular, the aim is to design and develop mobile supported name-based recording and number-based aggregate reporting systems assisting the recording, tracking and reporting practices of CHWs. Below I elaborate on HISP and DHIS2 – which is the research setting of this thesis.

2.3 HISP and DHIS2

This research was conducted in the settings of HISP and DHIS2 by actively following and conducting design and development activities. HISP is a network of researchers, designers, implementers and users of HIS in the context of developing countries. It comprises of a network of organizations currently operating in many African and Asian countries, and currently initiating processes in some Latin American countries. DHIS2 is the particular software application that is used for enabling HIS deployments.

\textsuperscript{14} http://www.commcarehq.org/home/
\textsuperscript{15} http://www.cell-life.org
\textsuperscript{16} http://www.d-tree.org
\textsuperscript{17} http://www.datadyne.org
\textsuperscript{18} http://www.epihandy.com/index.php/Main_Page
\textsuperscript{19} http://opendatakit.org/
2.3.1 The birth of HISP and DHIS in South Africa

The HISP and DHIS network started first in South Africa in 1994 when a Norwegian researcher, bathed in the philosophy of the Norwegian union based participatory design tradition, got the opportunity to participate in South Africa’s post-apartheid Reconstruction and Development Programme (RDP) (Braa & Hedberg, 2001). In the RDP, grass root level efforts were made to improve, among others, healthcare by tackling some of the problems that resulted from deep inequalities that existed during the apartheid – for example increasing PHC coverage in previously underserved areas (Foster, 2005; ANC, 1994).

With the healthcare sector put to focus, the mix between the Norwegian traditions of empowerment and the RDP’s commitment to eradicating inequalities in the post-apartheid era, led to the birth of Health Information Systems Pilot Project (HISPP). A key aim of the HISPP was to identify information needs for district management teams and assist them in decision-making processes for efficient and effective resource allocations. The aim then translated into a motto of “information for local action” with a plan for outlining minimum and essential datasets for PHC and the developing of district level software for supporting the implementation and use of the datasets. The plan received external funding from the Norwegian Agency for Development Cooperation (NORAD) to conduct pilot projects in Western Cape provinces (Braa & Sahay, 2012). With help from another Norwegian activist, the HISPP team came up with the first version of the district software – District Health Information Software version 1 (DHIS1) – that allowed for capturing and analyzing monthly statistical public health data at district, regional, and provincial levels. The software, built on top of a proprietary MS Office platform, had features of flexibility and local control with the aim of empowering locals, which was at the core of the Norwegian tradition of participatory design. The system then went into implementation in two provinces in 1998.

Later towards the end of 1998, the HISPP team conducted an open day conference where it presented its achievements at both the grassroots and provincial levels in the Western Cape. Looking the achievements in the western provinces, representatives from Eastern Cape decided to use DHIS1 in their provinces, which the Norwegian University Council (NUFU) supported with new funding for the period 1999 – 2001. With addition funding from USAID, the DHIS1 went for a national level roll-out and became the de facto standard for the entire South Africa in 2000 (Braa & Hedberg, 2002). As the project continued with momentum and
operated at the national level scale, the team then dropped the pilot ‘P’ from the original HISPP and proclaimed it as a programme, the HISP, in 2000.

2.3.2 Scaling beyond South Africa

Since the upgrade to programme and the national level implementation in South Africa, focus in HISP turned to efforts of scaling in terms of both geography such as moving to new countries, and priority areas such as improving the software and building capacity through training and education. Growth of Masters programmes and involvement of PhD students in activities of design, development and implementation of DHIS1 became central activities around which the scaling efforts were attempted. This helped to introduce the HISP package – the notion of “information for local action”, local empowerment, minimum essential dataset and the software – to new countries that initially included Mozambique, India, Vietnam and Cuba.

In Cuba, two students from the Masters programme introduced the HISP package in October 2001 in collaboration with the National Statistical Office of Cuba. The students, trained in the Norwegian tradition of participatory design and local empowerment, started their intervention in two pilot provinces by attempting to develop minimum essential datasets using the DHIS1 software running on Microsoft Windows platform. However, it turned difficult to replicate the success of South Africa for various reasons including the challenges of using USA based Microsoft Windows product and the practice of information for local action being a rather alien concept in Cuba (Braa, Titlestad & Sæbo, 2004). From their experiences, the students learned minimum datasets and indicators for local action were foreign concepts to Cuba’s centralized health system, where all indicator reports are expected to be sent to the central national office in Havana on a daily basis. The students’ efforts of training those at the grass root level through participatory design, was not either liked by those at the national level who felt local workers below them are getting more skilled than them (Braa & Sahay, 2012).

Similarly in India, the introduction of the HISP package – especially the notion of “information for local action” – did not bring the expected outcome as it was met with institutional inertia characterized by a strong centralized mandate at both the national and state levels, and also extreme fragmentations and multiple reporting channels left from the legacy of the British bureaucracy (Braa & Sahay, 2012). Multiple attempts to smooth out data redundancies in different states did not materialize until HISP managed to get a breakthrough
in the state of Kerala in 2006 and established itself as an active participant in the national level HIS reform efforts including the redesigning of datasets, indicators and information flows in the year 2008. In Mozambique too, introducing the package and philosophy of HISP was a similar case of struggle. There, the challenge was to address requests from users to have a pre-packaged system ready to generate routine reports on the click of a button. This was against the practice of HISP and its participatory design tradition where it wanted to bring users along the path of generating, processing and consuming their own information – which in itself has a learning path as part of the capacity development and empowerment strategy. 
Another challenge from Mozambique was a request for web-based free and open source system; a total opposite to DHIS1 (a non-web-based standalone system that ran only on proprietary Microsoft platforms). The web and open source request was a big turning point that led to a new chapter in the history of HISP – a transition from DHIS1 to DHIS2.

2.3.3 Transition to generic DHIS2

The transition from DHIS1 to DHIS2 came in 2005. However, it was only in January 2006 that the first version came into deployment in Kerala (Staring & Titlestad, 2008). A team of students and researchers from the Department of Informatics, University of Oslo, started the process of transition. They started the move by first selecting and organizing a stack of “cutting edge” free and open source Java technologies with the intention of developing a generic system that runs over the web on any platform supporting multiple local languages. According to the description posted on the HISP website, DHIS2 is “a generic tool rather than a pre-configured database application with an open meta-data model and a flexible user interface that allows the user to design the contents of a specific information system without the need for programming. It is a modular web-based software package built with free and open source Java frameworks … developed in an open and globally distributed process with developers currently in India, Vietnam, Tanzania, Ireland, and Norway”20. From the description, three factors stand out in the new DHIS2 – free and open source Java and web frameworks; modular software architecture; and globally distributed design practice. The HISP designers consider these factors crucial for the generic aspect of DHIS2. Below I elucidate more on each of these factors.

20 http://www.dhis2.org
2.3.3.1 Free and Open Source Java and Web Frameworks

Java is a programming language known for its platform independency; it allows for building applications that run on various hardware and software platforms ranging from high-end server computers to low-end hand-held devices including mobile phones (Kramer, 1996). For Java, this is one of the key benefits often called “write once, run everywhere” – a slogan created by Sun Microsystems to illustrate the cross-platform benefits of Java. This makes Java popular among software developers as it saves the effort of writing a different version of the same software for different platforms or deployment operating systems. For HISP this comes very handy. From the experience in Cuba back in 2001, the failure to implement the DHIS1 on a platform other than Microsoft Windows was a turn-off point. Since then, it was strategic for HISP to restructure its system and bring a generic application, which is ready to run on any available platform.

The choice of web-based Java technology is another strategic decision informed by the interest to facilitate collection, analysis and exchange of data over a hierarchy of health administrative units that are located in geographically dispersed areas. The decision for the web was further shaped by the choice of online and offline mode of communications. This has given HISP and DHIS2 the edge to accommodate disparities of areas in developing countries – the absence and presence of internet connectivity in rural and urban districts. Also, aware of resource issues in the context of developing countries, the entire DHIS2 is based on the philosophy of free and open source software systems, which gives users and countries the opportunity to have it without a license fee.

2.3.3.2 Modular internal software architecture

Another marked difference in the new DHIS2 that contributed to the generic aspect is the modular structure realized with a three-layer internal software architecture composed of core, business and presentation layers. At the core, also called the “Store layer” in the DHIS2 documentation, rests an open meta-data model that deals with the storage and retrieval of data irrespective of the underlying database platform. The basis to the open meta-data model is the notion of DataValue, which assumes the DHIS2 is going to store a data value, a numeric one, for something that occurred in time-space – for example number of malaria incidence in a particular district during a particular reporting month. In the model, the what (e.g. malaria, TB, immunization, etc), the where (e.g. which district, health center, state, country, etc.) and
the when (e.g. during which month, week, year, day, etc.) aspects are left for users to decide in their respective contexts. The model deals only with meta-data specifications in a bid to bring generic aspects to the DHIS2.

Next to the core layer comes the business layer that deals with various pluggable service modules specialized for processing data that is being stored and retrieved. Some examples from the business layer are – aggregation service to facilitate collation of data across time and places; expression services to extract some meaning from the stored data, and a validation service to ensure data integrity. The top layer in the DHIS2 internal software architecture is the presentation layer, which provides an HTML based flexible graphical user interface that users, with little or no programming language experience, could easily translate it to the language of their choice.

2.3.3.3 Globally distributed design practice

DHIS2 is a system developed in a globally distributed fashion with participants from different countries (Titlestad et al., 2009). A global HISP team of students and researchers based at the University of Oslo are developing it; multiple local HISP teams based in different countries where the DHIS2 is running are also developing and customizing it. By distributing design and development throughout countries, the attempt in HISP is to bring the practice of shaping the DHIS2 closer to its users. As in the case of free and open source software development, participation in the design of DHIS2 is free and open for anyone who is interested. This has given everyone the liberty to shape the system in their own settings and interests. However, this approach is not without its challenges. It has for example led to numerous forking-out of code bases, which has become a complex problem to overcome.

When designing for multiple countries, it is important to pool together resources and best practices and establish a shared code base that could potentially work for all the countries involved. HISP approaches the whole design and development process from two levels. The first is a global level design process, which has a focus on the technical aspects of the software and other meta-level specifications leading to a single globally generic system. The second is the local level design processes where specific details are inscribed based on social, institutional, organizational and technological realities of the implementing units. HISP tries to keep the two levels close to each other through active communications, user- and developer
academies, masters and PhD level education programs and feedback mechanisms – both electronic and face to face.

Through the two level design processes, and associated communication and coordination mechanisms, the DHIS2 has currently established itself as a health system for more than 30 countries. Since 2006, the global HISP team has released multiple versions of generic DHIS2 each with added features, modules, and bug fixes. At the same time, the local teams have brought the generic system into their situated contexts. In summary, the initiation in South Africa, the scaling beyond South Africa and the transition to globally generic free and open source has made the DHIS2 a truly global system that worked for multiple countries in the health sector. For this thesis, such a context and story offers a fertile ground to further advance the key objective – which is of understanding and managing the design of a generic HIS for the context of multiple developing countries.
CHAPTER 3  LITERATURE REVIEW

This chapter presents a review of literature relevant to designing and implementing generic systems in the context of developing countries. The primary aim is to explore and synthesize existing theoretical and analytical developments and formulate a perspective that helps to address the research questions posed in the thesis. To this end, the chapter starts with a section that outlines existing discourses of IS innovations in developing countries accounting for technology-context mismatch that often happens when technology is circulated across countries. For a system to work globally in multiple countries, it is required to have a design strategy that strikes a balance between global and local contexts and reach a generic solution. In expounding this perspective, section two presents theoretical discussions of generic system design drawing primarily from the concept of generification. Taking this perspective further, in particular along the line of maintaining the working solution across time and space, section three discusses the concept of scaling and mechanisms of scalable system design with due attention to the evolvement of a socio-technical assemblage. Then section four presents discussion of design at a broader contextual space, organizational field level, in order to serve diverse contexts often seen at industry level. Finally, the chapter ends with a proposed summary of conceptual framework for analyzing practices of designing generic (H)IS that works for multiple contexts of developing countries.

3.1 IS innovation in Developing Countries: addressing the technology-context mismatch

Technology-context mismatch is a serious and historical challenge hampering effective IS utilization in the context of developing countries (Dada, 2006; Heeks, 2002; Lind, 1991; Rajapakse & Seddon, 2005; Yen et al., 2011). Arising from a mismatch between design and context along different dimensions, many interventions related to the introduction and uses of ICTs have been reported as either total or partial failures. The healthcare domain is no exception – having suffered from various forms of mismatches (Heeks, 2006; Kiyan 2007). In addition, funding is one institution often implicated with these failures especially when donors bring with them systems designed for different sociotechnical settings (Heeks, 2006; Heeks et al., 1999). Related to this are also problems of fragmentation and lack of coordination across different actors due to program specific funding (Chilundo & Aanestad, 2004; Jeppsson &
Okuonzi, 2000) and problems of scalability and sustainability once funding is over (Kimaro & Nhampossa, 2005). The problem seems lack of systems that adapt to heterogeneous as well as emergent sociotechnical realities. It becomes thus important, not only to critique lack of sensitivity of designers to local contexts at the hindsight of design, but to also better conceptualize appropriate design practices that support dynamic sociotechnical settings. Research calls for more investigation on the role of donors in shaping HIS related activities, including the neglected area of design, in developing countries (Walsham & Sahay, 2006; Walsham et al., 2007).

International donors are vital to the institutions of healthcare in developing countries, in particular through provisions of funding, technical expertise and artifacts. For example in 2006, the Ministry of health of Zambia received USD 150 million from USA alone for the HIV/AIDS program, which is more than the 136 million USD budgeted by the country for its entire healthcare operations (De Maeseneer et al., 2008). Between the year 1997 and 2002, funding to improve healthcare practices of developing countries increased from 6.4 billion to 8.1 billion USD (WHO, 2006), reaching 10.9 billion USD in 2007 (OECD-DAC, 2009); at the same time the “trend in aid to the health sector is set by few donors” (ibid.). It is only twenty-two nations that have pledged to shoulder a staggering cost of USD 195 billion required every year to stop deaths from disease and hunger (OECD, 2011). And yet, despite the pledge, it is only few countries who stepped forward with their commitments. Given this scenario, where a few are shouldering the huge cost of funding, and the reality that “Information technology forms an increasingly important component of donor-funded development projects” (Baark & Heeks, 1999, p.185), it is inevitable for donors to attempt to circulate artifacts across the multiple countries they operate. This circulation will necessarily require the artifacts to be transportable to new contexts out of the local contexts in which they were designed. To investigate such process of circulation, the IS research community has engaged with understanding processes of technology transfer and diffusion of innovations to developing countries (Avgerou, 2008).

3.1.1 Transfer and diffusion of technology: from developed to developing countries

The transfer and diffusion discourse, which is influenced by the theory of diffusion of innovation (Rogers, 1962; 2003) and technology acceptance model (TAM) (Davis, 1986), is
A common message from most of these studies is to exercise caution during processes of transfer and diffusion as contexts in developing countries are distinct from those of developed ones. Taking this perspective further, some studies have suggested for a shift from a-contextual technology and best-practice transfer to context specific appropriations and local adaptations (Avgerou & Land, 1992; Bada, 2002). However, with contextual issues getting stronger scrutiny, it is not clear how the transfer and diffusion discourse could become fruitful while its theoretical foundations, diffusion of innovation and TAM, are considered limited for unpacking contextual matters. For example, Lytyinen and Damsgaard (2001) criticized the
diffusion of innovation theory for its static and materialistic view of technology that ignored the complexity of IS solutions and associated innovation and diffusion processes. The theory also suffers from individual bias, as the success or failure of the diffusion is attributed to individuals rather than cultural, environmental, political and other surrounding sociotechnical influences (Nhampossa, 2005). Especially during failures, there is a tendency to put the blame on the destination, not on the source or the innovation itself. This is problematic as it provides little opportunity to acknowledge destination contexts and revise the innovation. There is also little discussion on user participation, participatory design and other forms of collaborations and user level innovations; users are mostly treated as passive consumers of innovation.

Similarly, TAM is widely criticized for its focus on individual users of computer systems with little attention to essential social processes of IS development and implementation (Bagozzi, 2007). According to Davis (1986), TAM assumes IS acceptance is determined by two major variables – perceived usefulness and perceived ease of use – and some external sets variables. In a more complex IS setting, researchers have found these variables limited and suggested for additional variables deemed important to measure their respective settings. This has led to multiple versions of TAM – TAM (Davis, 1986), TAM2 (Venkatesh & Davis, 2000), TAM3 (Venkatesh & Bala, 2008). For some researchers, the subsequent revision is a result of lack of rigor in the basic TAM model itself. For Benbasat and Barki (2007), the repeated attempt to redefine TAM, is “an illusion of progress in knowledge accumulation … and … a state of theoretical chaos” (p. 211).

There is no doubt that, TAM is an influential and widely applied theoretical model in describing acceptance of information systems. However, the issue that it focuses on limited set of variables (often considered deterministic), the notion of acceptance and the tendency of treating technology as a black-box are particularly limiting. For example, with a system being considered easy to use and useful to accomplish a work practice, users could fail to accept it for cultural, economic and political reasons, which are often hidden under the variable “perceived ease of use”. These are complex issues difficult to reduce to limited set of variables, mathematical formulas or statistical generalizations. Also, the emphasis on acceptance puts technology as a final and stable object ready to be used in production, which might not be the case especially when the technology is required to go through subsequent appropriations to reach the final acceptance. In addition, there needs to be an opportunity to unpack technology, and analyze which parts of it are accepted, rejected or appropriated –
users are not passive consumers who either accept or reject, they have an agency to make necessary adjustments. In the current modern world, what we refer to as technology or system is an integration of heterogeneous parts with different origins; it is therefore vital to be specific which part has worked, which has not – which I feel is critical in the acceptance or not of technology. Going away from transfer and diffusion, the alternative discourse widely discussed in the literature of IS in developing countries is social embeddedness (Avgerou, 2008).

3.1.2 Social embeddedness: in the context of a developing country

The social embeddedness discourse, drawing from the constructivist research stream, rejects those a-contextual artifacts and the notion of transfer by arguing for local cultivation and situated-design (Braa & Hedberg, 2002; Suchman, 2002). A key perspective in this discourse is the acknowledgement that technology is a result of inscriptions of both historical and existing beliefs and realities of contexts in which it has been developed (Akrich, 1992). The discourse brings attention to a new perspective that the need for technology should arise from local problematizations, and its design and implementation practices should largely be determined by situated socio-technical actants. It takes a view of local actors making sense of technology and accommodating it in their routines in locally meaningful way.

The study from Akrich (1992) is central to this discourse. Akrich presents a number of vivid ethnographic stories explaining how technology is “transferred” from developed to developing nations through several processes of reinventions, reshaping and transformations. Drawing from Akrich’s story, that tells transfer of forest waste compacting machine from Sweden to Nicaragua, Law (1997) argues “…there is no such thing as technology transfer. But instead they are passed. Passed from hand to hand. And as they pass they are changed. Become less and less recognizable” (p. 34). In the end, according to Law, it is a new technology that has been transferred to Nicaragua, not the one in use in Sweden. While in Sweden, the compacting machine was part of a web of social, environmental, industrial and other socio-technical elements. When transferred to Nicaragua, the machine was detached from the surroundings of Sweden and placed in different surrounding that didn’t even have forest waste but cotton waste. The very first alignment of the machine with cotton has created a different network than Sweden – the machine is also no more forest waste compacting machine but cotton waste compacting machine. Same is true when the Industry of Sweden is
replaced by the domestic oven of Nicaragua. A new association with different elements is formed. As part of the association, the machine itself has gone through subsequent transformations deemed necessary to forge the association with the surrounding actants. The end result was a stable network, different from the one in Sweden. Law (1993) argues such is a classic case of actor-network theory and the concept of translation as observed in the creation and recreation of networks, alignments and associations between social and technical elements.

A growing body of research has drawn from Akrich’s and Law’s perspectives to analyze similar stories, but stories of ICT transfer to developing countries (see for example Effa, 2012; Lungo & Igria, 2008; Mengesha, 2007; Macome, 2008; Madon et al., 2004). The studies have provided empirical evidences explaining the possibility of “transferring” technology from developed to developing countries through subsequent incremental translations leading to sustainable networks and institutionalizations in situated settings. In these studies, the concept of translation is seen as a vehicle to re-conceptualize technology transfer and diffusion as “technology translation” (Braa et al., 2004; Madon et al., 2004; Nhampossa, 2005) and “circulating translations” (Sæbo, 2013). An important aspect of the concept of translation is its emphasis on unpacking situated social and contextual influences that shape design and implementation of technology (Callon & Law, 1989; Madon et al., 2004), which was missing in the theoretical foundations of the transfer and diffusion discourses.

However, though useful to address contextual issues, there are two important issues that are problematic in the literature of translation and social embeddedness as far as the interest of this thesis is concerned. The first is the emphasis in translation is to make technology work in the destination context by forging the required association with situated socio-technical elements. There are little accounts of feeding back to the source. For example what is the implication of changing the forest waste compactor to cotton waste compactor for the actor in Sweden? Would it be possible to modify the machine in Sweden so that it could process both forest and cotton? Is it possible to make the machine generic and flexible enough so that it also supports processing food, cloth, plastic and some other wastes? Redeveloping a different machine every time a different and new socio-technical setting is encountered is a costly operation. The second point is, in the discussions of translations it appears transforming a technology from one form to another is non-problematic.
During translation, actor-network theory argues that “the spread in time and space of anything – claims, orders, artefacts, goods – is in the hands of people … modifying it, or deflecting it, or adding to it, or appropriating it” (Latour, 1986 p.267). It is true that technology is interpretively flexible to fit into some degrees of translations, but it may not be infinitely malleable to fit into all forms of translations (Devadoss & Pan 2007; Orlikowski, 2000; Pinch, 2008). Will it be possible to transform the forest waste compactor of Sweden to something else – not a waste compactor? Volkoff et al. (2007) also argues for the limitation of translation and actor network theory in dealing with technology and its materiality. They argued, although both technology and people are treated at the same level and collectively considered as actants, the conceptualization of translation and its emphasis on negotiation – which is a human activity – tends to privilege human actors by relegating technology as a non-problematic receptacle object. In addition, the deflection, modification or addition depends on the agency and capacity of situated people; which is in a state of dearth when it comes to ICT in developing countries.

In summary, existing strategies discussed in the literature of IS innovation in developing countries appear to be limited to address the concern of establishing a working solution for multiple contexts. The TAM and Diffusion of Innovation theories in transfer and diffusion strategy fail to account for the contextual issues that shape IS activities. With a focus on situated contextual issues, the social embeddedness strategy loses sight of the materiality of technology. In addition, the overarching argument of social embeddedness that takes “IS innovation as a process embedded in local conditions of a developing country” (Avgerou, 2008 p.134), seems problematic as it does not tend to consider the importance of transporting local solutions to multiple contexts. Transporting a locally embedded solution across contexts is not an easy task of lifting out a black-box of technology from one context to another; it is a complex task that has proved problematic (Berg & Goorman, 1999). There needs to be a design strategy, from the outset, that considers multiple contexts and how the systems support these simultaneously in an effective manner.

3.2 Design for multiple contexts

For the interest of designing a working solution for multiple countries, exclusive and independent focus on local contexts is non-pragmatic both practically and economically (Braa et al., 2007b). There needs to be a pragmatic strategy is of generic technology design practice
that helps to strike a balance between what to transfer globally and what to cultivate locally (Bjørn et al., 2009; Rolland & Monteiro, 2002).

3.2.1 Balancing between global and local

Discussion of designing an IS solution that works for multiple contexts is not new; has since long been reported in the literature related to large-scale global infrastructural systems. Acknowledging the complex challenges such systems pose to practices of design and development, research argues for a strategy that balances and integrates between global and local contexts (Bjørn et al, 2009; Keen et al, 1982; Rolland & Monteiro, 2002). In 1982, Keen et al suggested large technical systems pose complex problems of design and development. After following the experience of a bank implementing a common banking system in 40 countries, they concluded that successful outcomes depend on the balance and integration of various central and local organizational and technological factors across various dimensions. Rolland and Monteiro (2002) also reached to a similar conclusion after investigating a large-scale infrastructural information system used by one maritime classification company that had 300 branches located in 100 countries. They concluded, for systems to work across multiple settings, it is necessary to have design approaches that “strike a balance between sensitiveness to local contexts and a need to standardize across contexts” (p. 87). In the case of HIS, Bjørn et al (2009) urges “practitioners and systems designers to articulate and identify which aspects can be standardized without constraining important local flexibilities and which aspects require local reconfiguration to function in a particular work context” (p. 428).

One thing is common across these studies. Their empirical cases are either under one overarching organizational setting or under a unified political commitment. For example, one big US banking organization with branches in different countries in the case of Keen et al. (1982); one big Norwegian maritime classification company with branches in different countries in Rolland and Monteiro (2002); and eight different organizations all in one region of Canada that has a standardized national guideline and political space in Bjørn et al. (2009). My interest is to bring a generic HIS solution that works for multiple countries that exhibit significant diversity in political, organizational, social, cultural and institutional arrangements. There will of course be similarities across the countries, but each one of them and the HIS solution they require are independent. This requires maintaining similarity while at the same time managing required uniqueness to bring global transportability on the one hand and local
conformity on the other hand, which is equivalent to managing the “tension between standardization and flexibility” (Hanseth et al., 1996).

To manage this tension between standardization and flexibility, Braa et al (2007a) advance the notion of “flexible standards” claiming “if they are well defined and simple, they will be able to adapt to the frequent changes that are experienced in complex health environments” (p. 382). However, pointing standardization in health environment is a complex process, Hanseth et al (2006) warns against the danger of “overestimat[ing] universality of work practices, thus seeking order by simplification and abstraction” (p. 577). Designing a standardized as well as flexible technology that adapts to diverse contexts is indeed not an easy task of simplification and abstraction; neither is a task of seeking order and stabilization by suppressing local evolution and dynamics (Grisot & Vassilakopoulou, 2012). It is a complex process of managing both the technology and a diverse community of users and their contexts attached to the technology (Pollock et al., 2003; Pollock et al., 2007) – this is documented in the generification work of global EPR software package.

3.2.2 Generification work

Another global example that has demonstrated to work for multiple independent as well as integrated organizational settings is the Enterprise Resource Planning (ERP) system (Al-Mashari, 2003; Davenport, 1998; Hanseth et al., 2001; Pollock et al., 2003). ERP systems represent a suite of software applications that help to integrate business processes and their information flows across organizations embracing finance, accounting, human resource, supply, sales, customers and other departments (Davenport, 1998). Considered useful for their cross-contextual aspect, ERP systems have been deployed in many organizations over the last two decades. Though the large part of the literature has focused on investigating difficulties and remedies at the time of implementation (see for example Esteves & Pastor, 1999; Moon, 2007), studies that investigate ERP systems at the time of design are also emerging (see for example Grimm, 2009; Pollock et al, 2007; Wang, 2007). One key basis for this emerging ERP design literature is the concept of “generification work”, from Pollock et al (2007), which captures vendors’ strategies when designing a single generic artifact targeted for multiple customers. Generification is not a normative design strategy followed by generic software developers, it is rather an approach followed by a particular commercial organization.
when developing a particular product that has demonstrated to work for multiple customers. Nonetheless, it is a key learning example that this thesis seeks to explore.

The concept of generification refers to “supplier strategy of taking a technology that has worked in one place and attempting to make it work elsewhere, and, in principle, ‘everywhere’” (Pollock et al., 2003 p.318). However, making a technology working for a particular context leaves us with the technology being fixed in time and space (Berg, 1997). Transporting it to another context requires a complex work of disentanglement, where the fixed technology is restructured and disembedded from local realities (Berg & Goorman, 1999). This essentially calls for a mechanism – “a process by which software packages are successively emptied from references to local details to become standardized, generic solutions ready to travel globally” (Kallinikos, 2009:915). Though not directly related to technology, concepts of disembedding and embedding from Giddens (1990) are important here. Giddens defines disembedding as “the lifting out of social relations from local contexts of interaction and their restructuring across indefinite spans of time-space” (p. 21) and (re)embedding as “the appropriation or recasting of disembedded social relations so as to pin them down to local conditions of time and place” (p. 79-80). These concepts help to visualize the restructuring of generic software package across time and space so that it becomes globally transportable and locally flexible. The concept of refactoring (Fowler, 1999; Mens & Tourwé, 2004) from the literature of software engineering is the closest we have to that of disembedding. However, with its notions of distanciation and expert systems, the concept of disembedding provides more vocabulary than refactoring in understanding generification mechanisms within a social context. The discussion of expert systems as one form of disembedding mechanism, to provide a guarantee of expectations across distanciated time-space (Giddens, 1990), is a key sensitizing perspective that suggests for the establishment of experts such as consultants, implementers, trainers, standards and best practices to support processes of generification. This helps to (re)embed the emptied package back to local realities. Managing knowledge creation and transfer is one form of improving fit between ERP packages and organizational processes (Wang et al., 2007).

### 3.2.2.1 Generification mechanisms

To facilitate processes of generification, Pollock et al (2007) suggest three mechanisms for suppliers: management by community, management by content and management by social authority. For management by community, the suggestion for suppliers is to move design
“from the private domain of each user site, where only particular needs could be articulated, to a public setting, where community or generic requirements could be forged” (Pollock et al., 2007 p. 263). Clearly, focus at the broader community level brings a burden to suppliers, as they could be flooded with diverse sets of requests to be covered by the generic technology. To overcome this, the alternative generification strategy for suppliers is management by content, where common sets of requests are shaped and smoothed out using configurable templates while those not compatible across sites are “rejected or sifted from the process” (Pollock et al., 2007 p. 265). This in a way is homogenization, where members of the community are pushed to fit into the common requirements by undergoing organizational transformations. However, this is no easy task. It has led to many ERP misfit failures (Hong & Kim, 2002; Rajapakse & Seddon, 2005; Swan et al., 1999).

The third generification mechanism for suppliers is management by social authority where customers are ranked based on their strategic values to the supplier. Once a hierarchical list of customers is established, suppliers do not have to listen to the needs of each customer. Instead, they focus on the needs of only those ranked high in the list and shape the technology in line with the needs of these priority group customers. Those ranked less important “[are] pushed to the margins of the shaping process where they [are] not consulted or involved in design” (Pollock et al., 200, p. 269). Arguably, this is a strategic approach in supplier-customer relationships where business values and profit maximizations are at the forefront. However, it is not clear what political and institutional implications this will bring if applied in the settings of public sector in developing countries, comprising also of donors and aid institutions. Walsham (2008) also challenges the implications of segmentation during generification. He said “which [countries] get the most say in the generification process … how do power relations influence the final design and make the system more suitable for some than others … what are the consequences … positive or negative” (p.17). These are qualifying comments against the practices of marginalization in generification work. Especially when working with developing countries, it is important to avoid marginalization but establish alignment with locals, and enable local ownership by allowing local actors to participate in the multiple phases of system design and decision making processes (Braa et al., 2004; Puri, 2007; Titlestad et al., 2009).

Franke and von Hippel (2003) also warn against the strategy of segmentation when serving diverse users’ needs as it “leaves many seriously dissatisfied” (p. 1119). It is extremely
difficult for a single supplier to cater for diverse requests coming from all corners of use. One approach to overcome this is to open up the generification process and pay careful attention to user perspectives by seeking collaboration with users and other vendors (Johannessen & Ellingsen, 2009). This leads to bring users onboard to the design space. According to Franke and von Hippel (2003), the best approach is to provide users a common innovation toolkit that allows them to develop solutions that fit into situated needs. Franke and von Hippel, articulate this as “satisfying heterogeneous user needs via innovation toolkits”. The challenge then is to generify a minimum common core that users could build from and generate a working solution of their own. The literature of generative design, free and open source software (FOSS) development and open innovation shed some light on this.

3.2.3 Generative design and FOSS innovation

Traditional system design practices revolve around reductionist problem-solving activities of software engineering. With focus on problem-closure, instead of creating systems that support multiple human activities over time, traditional practices result in rigid final products that constrain human activity beyond the intended use (Gasson, 2003). Frazer (2002) calls such problem-closure approach misleading. This is true especially when one attempts to generate possible solutions for those wicked or ill-defined problems of IS design (Hevner et al, 2004). An emerging alternative to traditional system design, for producing technology that fits into multiple contexts, is generative design (Avital and Te’eni, 2009; McCormack et al, 2004). Generative design focuses not only on the final product, per se, but on the incorporation of rules, system dynamics and other resources and experiences into mechanisms that lead to the final solution (Chase, 2005; Chien, 1998; McCormack et al, 2004). With the means in place, the assumption in generative design is that it can guide users down an exploratory path towards the final solution (Chase, 2005).

Focus on the means is also a strategy central in meta-design (Fischer & Giaccardi, 2005). By facilitating the means, the goal is to establish a collaborative environment where local users are provided design resource that allows them to perform various re-framing and recasting operations and bring a working solution that fits into their situated sociotechnical realities (Avital & Te’eni, 2009). One example demonstrating this is FOSS development practice. In FOSS users are embraced as co-designers, provided all the freedom and resources to conduct design as they see it fit to their needs (Fischer et al., 2004; von Hippel, 2001). FOSS is also an
approach advocated for the context of developing countries (Staring & Titlestad, 2008; Mengesha, 2011). However, with most FOSS developers based in Europe and North America (Ghosh et al., 2002; Gonzalez-Barahona et al., 2008), we need to look for other mechanisms, beyond FOSS, and bring more engagement of users from developing countries.

FOSS includes both free software and open source software. There is a difference between these two – all free software qualifies as open source software, but not the other way round as there exist open source software systems with licenses that restrict certain freedoms (Stallman, 2009). In FOSS, users are freely licensed to use the software for any purpose; the source code is freely and openly distributed for others to use, modify and further improve. Such openness and participation helps to create a collaborative community for innovating software systems that help to solve problems of shared interest (Fischer et al., 2004). The whole phenomenon is a means to encourage and harvest innovations (Goldman & Gabriel, 2005). It is an open, distributed and collaborative form of innovation that leads to the creation of complex systems with limited involvement of commercial suppliers (von Hippel, 2001).

The openness and freedom for anyone to participate and do a choice of interest could sometimes be a disruptive force, especially for the intention of developing single generic software product that serves for all. The thing with a FOSS product is if someone finds it limited to fit into in a particular context, he/she is free to make the necessary changes and bring a working solution. Often such changes are communicated with the “gate keepers” of the original FOSS product (the trunk). It is well and good if the keepers approve the changes do the integration. If the changes are not approved, then a new version is said to have forked from the main trunk (Glass, 2005). Further developments could take place on both of these products – the trunk and the fork. Both products following their development cycles, it is very likely that they will bring less and less commonality, rivalry and death to each other. There is clear tension between being open on the one hand and trying to control on the other hand. If everyone is forking and not feeding back to the common trunk, it is very difficult to bring improved generic software of collective perspectives. This is a serious problem that warrants careful attention, policy and control to whether forking is something that should be allowed or not.

However, forking is also a necessary evil that ensures sustainability, productivity and quality in FOSS – the “right to fork open source code is at the core of open source licensing” (Nyman & Lindman, 2013 p. 7). In the philosophy of open source, it not forking that is a problem it is
rather the intention for forking. For example, copyleft licenses permit forking, but greatly reduce financial intentions for creating forks. An opportunity to smooth out the tension, therefore, is to craft suitable licenses. In FOSS there are various forms of governance structures and licenses with elements of policy and compliance as a means to achieve a common direction, control and coordination (Benkler, 2006; Wubishet, 2011). Having a suitable governance structure and license in place helps to establish coherency and facilitate joint contributions and collaborations among different actors.

Despite the tension and some elements of risk, the openness and collaborative aspects of FOSS and its potential for solving huge and complex software problems has convinced researchers and commentators to argue “avoiding FOSS is no longer an option”. Currently, it is common to see companies such as Google, Microsoft, Yahoo, Amazon, SAP and others who aim to sell en masse for heterogeneous user base acquiring, funding, and running FOSS products. This appears paradoxical – “why does a firm invest in open source which is accessible to competing firms?” Arguably, it is difficult to explain the association of commercial firms with FOSS through the lens of freedom which is central in the FOSS phenomenon – open innovation, I believe, offers a convincing explanation.

3.2.3.1 Open innovation

Innovation in the traditional view is part of industry production model taking place within a firm. It is a closed model that relies on local practices of research, development, production, marketing, servicing, financing and related processes. All activities in the value chain happen within a single firm. An alternative to this is open innovation (Chesbrough, 2003). Contrary to the traditional model, open innovation emphasizes on conducting product research, development, marketing and related practices in an open environment enabling firms to acquire and share innovation with others. This came out of recognition that no firm, however big it is, can rely on internal innovation resources in the contemporary context of globalization especially when we have increased mobility, diversity and interconnectedness of knowledge workers across geography and time zones. This has pushed major companies to go out of their organizational boundaries and seek alignment with the outside world.

Central to open innovation is this assumption that “firms can and should use external ideas, and internal and external paths to market, as the firms look to advance their technology” (ibid., p. xxiv). This brings some advantages, for example: cost reduction in idea generation
and development, increase in productivity, collaboration with customers and a potential for viral marketing (Docherty, 2006). However, there is also a disadvantage in open innovation, which relates to the extra cost of coordination and collaboration as firms have to look for and devise strategies that at the same time help them open up their strategic assets and also protect their competitive advantages (De Backer & Cervantes, 2008). Research suggests for managers and decision makers to have a careful interpretation of the term open and degree of openness, for example what to open, for whom, to what extent and under what circumstances – openness is a gradual and multi-dimensional concept (Balka et al., 2010).

As a collaborative product development model that allows firms for increased return on their investment, open innovation is also seen vital to the software industry. Software is a product developed through a particular production model, where FOSS is one such production model. In line with open innovation, FOSS development is “a production model that exploits the distributed intelligence of participants in Internet communities” (Kogut & Metiu, 2001). As a result, currently we have numerous examples of software systems developed through this production model. There are numerous companies, both commercial and non-commercial, linked with the FOSS phenomenon.

While there are some overlaps between FOSS and open innovation, there is a difference between the two as the latter incorporates business models enabling firms to sustain their position in the industry value chain over time (Chesbrough et al., 2006). This includes buying and selling of intellectual property rights, contractual agreements, acquiring of shares and other negotiation mechanisms. These are not often the case in FOSS, which is also called a socio-economic innovation model that relies not only on economic values, but also on social values as participants are not always after financial compensations. However, there are third parties and sister companies that run consultancy, customization and related services and business models that generate financial revenue.

In summary, given the various forms of governance, coordination and negotiation mechanisms the open and collaborative engagements seen above are well established innovation practices that help develop software systems – particularly generic software systems. For example, if we see some of the typical examples of FOSS product, we have Apache web server, Firefox, MySQL, Eclipse, OpenOffice and many others (West & Gallagher, 2006). These are typical examples of generic products available for free but known to work in heterogeneous user base, which I believe, is a vital point to the argument of FOSS
in the course of generic software production. With a production strategy devised out of one of the open innovation and FOSS production models, the quest for generification mechanism that helps to develop generic systems able to serve diverse contexts makes more sense when we bring the challenge of scaling into the equation. With scaling, the intention is to transport technology across contexts and sustain it within contexts by satisfying emergent needs across time (Braa et al., 2004; Sahay & Walsham, 2006). If we map the emergent needs of a context across time and across space, what we have is multiple heterogeneous user needs in time and space, which we need to answer by developing a generic technology. Looking at this scenario, it seems the more generic software we make, the better we are in addressing the challenge of scaling (Braa et al., 2007b), representing a direct relationship between scaling and generification (Johannessen & Ellingsen, 2009; Sæbo, 2013). However, there exists limited investigation of the impact of one on the other. Below, I present a review of existing literature on scaling, and reflect its relationships with generification.

3.3 Scaling: as a means of expansion and spreading

According to Sahay and Walsham (2006), scaling is “an important issue in IS, especially in the contemporary context of globalization, as attempts are ongoing to expand IS in the same context as well as take it into other contexts” (p. 185). Though considered important, discussions of scaling, along with on sustainability, is largely a neglected topic in the literature of IS in developing countries (Walsham & Sahay, 2006). Braa et al (2004) consider scalability a prerequisite to sustainability especially when one is concerned to ensure the long-term operation and usefulness of HIS solutions in developing countries. What makes the concept crucial is that there exists a large number of reports of IS initiatives that fail to scale and sustain beyond their pilot phases (Heeks et al., 1999; Braa et al., 2004). This calls for a better and deeper understanding of the concept of scaling including practical mechanisms to guide these processes over time.

In the literature, scale is conceptualized as the scope or size of an IS (Sahay & Walsham, 2006). Some units considered indicative of scale of an IS are:

- requirements and patterns of use covered (Monteiro, 1998);
- number of users served and functionalities provided (Sahay & Walsham, 2006);
- type and volume of data maintained (Shaw et al., 2007), and,
• degree of complexity (Braa et al., 2007) which relates to the number, type and connectedness of heterogeneous components in the IS (Hanseth & Lytinen, 2010).

While scale is concerned with the extent and degree of the various aspects of the IS product or process, scaling relates to “the process through which that product or process is taken from one setting and expanded in size and scope within that same setting and/or also incorporated within other settings” (Sahay & Walsham, 2006 p. 185). Two perspectives stand out from this conceptualization – scaling as expansion in the same setting and as spreading to multiple settings.

For Braa and Sahay (2012), scaling is an immediate step that follows design, development and implementation activities. They concluded this drawing from their empirical case of HIS design, development and implementation in multiple developing countries. They argued, scaling is a process through which working solutions are “spread out and taken into use, in a country or state, successively in all districts in a state, and in all hospitals in a state or a country, covering different user groups and technologies” (p. 83). Metaphorically, they see this entire process going along vertical and horizontal dimensions – vertically to point to the spreading across health administrative units and horizontal to represent to the coverage of different user needs.

HIS use in a country has this characteristic of “all-or-nothing” that renders usage of the system in one district useless unless it is possible to achieve coverage for the entire country’s facilities, districts, states and other health administrative units (Braa et al., 2004). In the face of this demand, the system needs to be spread throughout the country’s hierarchy of health administrative units and horizontally across health programmes (which represents a diversity of needs). The implementation of the HIS solution starting from the top national level to all the way down to the states, districts, facilities and other lower level administrative units relates to the vertical aspect of scaling (Braa & Shay, 2012). Horizontal scaling relates to the “diffusion to new places at the same level of the hierarchy” (p. 89).

Putting the vertical and horizontal dimensions together at the macro level, Shaw (2009) brings detailed aspects of scaling in terms of deepening and widening when particularly looking at HIS solutions for developing countries. The deepening aspect refers to process of taking the HIS solution to new levels along the hierarchy of health administrative units (Shaw, 2009). For widening, Shaw explains “the geographic aspect is widened when new geographic areas
are included in the system” (p. 145), which is similar to conceptualization of scaling as spreading in Sahay and Walsham (2006) and horizontal scaling in Braa and Sahay (2012). According to Shaw, both deepening and widening aspects are also visible when increasing the functionality of HIS – “the scope is “widened” when new functionality is brought to use in the system … the scope is “deepened” when the existing functionality or existing program data is used for more sophisticated purposes” (Shaw, 2009 p. 145).

Adding to the vertical and horizontal dimensions, Shaw et al (2007) bring “a third dimension to scaling … as the extent to which the system is rooted in people and work practices … which describes how well the system is working” (no page number). This third dimension emphasizes how the success or not of scaling is dependent on the degree of embeddedness of the HIS artifact in work practices, people, social systems, information use and ownership (ibid.). What this perspective sensitizes us that is, if for example, users do not have ownership to new information that has come out of scaling or if the newly scaled solution is not institutionalized and sustained, the scaling is of no use.

This also brings us back to the long established argument in the IS literature. For any technology to be useful in a particular context, or bring the aspired changes, it is vital that the technology and its materiality, as specific and as detailed as possible, be aligned, fitted, embedded in the socio-technical reality of the context (Markus & Robey, 1983; Monteiro & Hanseth, 1996). From this perspective, then, it is not as such about the technology spread across space, or expanded through time, that brings the required changes. It is rather the alignment of organizational structures, work practices and social processes with that of features, functionalities, modules and components of the technology – in general, the materiality of technology (Leonardi & Barely, 2008) – that brings the required changes (Zammuto et al, 2007). Looking at the embeddedness aspect, the interplay between the social and the material comes as a determining factor to the success or not of scaling. The onus then is on our mechanisms of scaling that allows us to manage the interplay between the social and the material in time and space. Below, I look into existing mechanisms of scaling

**3.3.1 Mechanisms of scaling**

Taking the broader view of scaling as spreading and expansion, research suggests some mechanisms, for example:
- flexible standardization with an emphasis on managing increased complexity (Braa et al., 2007);
- step by step transition with an emphasis on managing growth (Monteiro, 1998);
- mindful cultivation with an emphasis on managing increased type and volume of data (Shaw et al., 2007); and,
- establishing networks with an emphasis on managing the spreading of artifacts, people and funds (Braa et al., 2004).

These are valuable contributions to understand and guide processes of scaling. However, with the focus being on expansion and scale-up, discussion is limited on mechanisms for conducting scaling as spreading except for the networking mechanism of Braa et al. (2004) which also has limited discussion to the materiality of technology. In addition, when spreading to new settings, the settings might not be of similar scope/size that warrants expansion. There could also be a case where the artifact is required to scale-down in order to match with the sociotechnical realities of the new settings. Otherwise, a misfit between scope/size of the IS and contexts have resulted in failures arising out of design-reality gaps (Heeks, et al., 1999; Heeks, 2006).

Focusing on the fit between the social and the material during the course of scaling is an interesting perspective, which also brings the spreading and expansion mechanisms to the spotlight. For successful scaling, for example when expanding functionality of a particular technology in one context, one needs to establish a deeper embedding of the technology into work practices, ownerships, institutions and other sociotechnical realities of the context under consideration (Shaw, 2009). Following this, what we will have at the end of the scaling is a sociomaterial ensemble, fixed in time and space that only makes sense in the context where the scaling was conducted. An immediate concern then is how are we going to spread this ensemble to another context(s)? What we have is not a box of technology that is ready to be dispatched to a new context; it is an assemblage, which might not make sense to the context we are intending to transfer. This clearly calls for sociomaterial perspective of scaling, which is something missing in the literature. When looking at existing mechanisms of scaling, attention has been on the material with little attention to the social (for example, Monteiro, 1998) or in emphasizing the social while neglecting the material (for example Braa et al., 2004). A balanced and holistic understanding is further required as scaling necessarily involves both the social and the material. Braa and Sahay (2012) also urge for a view of
scaling not just in terms boxes of technology taken from one site to another, but as the adoption of certain design principles along the social and material dimensions – this for me is a call for a view of the sociomateriality of scaling.

Sociomateriality is an emerging research perspective paying due attention to the social and the material (Orlikowski, 2007; Orlikowski & Scott, 2008). It calls for a relational ontology that privileges neither the social nor the material but the entire sociomaterial assemblage (Knorr-Cetina, 1997; Latour, 2005; Pickering, 2010). In the sociomateriality worldview, there is an inherent inseparability between the social and the material, as there is no social without the material and no material without the social – the two only exist in relation to each other as an assemblage (Orlikowski & Scott, 2008). Key to this relational worldview is a focus on the constitutive entanglement of the social and the material where the two are enmeshed in a given situated context. Focus on the relationship provides an opportunity to better understand how the interplay between the two unfolds, which aspects, modules or functions of IS artifacts enable or constrain practices and structures of organizations (Monteiro & Hanseth, 1996).

Now recall scaling as expansion and spreading, where the attempt is respectively to sustain an existing solution in a particular context and transport an existing system to multiple contexts. In both cases there is “something” to be scaled, as we do not do scaling of the void. From the sociomateriality perspective, that “something” we want to scale is nothing but a sociomaterial assemblage that only makes sense in the setting it is being performed. Transporting the assemblage “as is” to another context is a futile exercise, it needs a complex work of disentangling (Berg & Goorman, 1999), which represents the separation of the material from the social. The sociomateriality perspective allows for temporal and analytical separation of the two (Orlikowski, 2007). Once disembedded, the material might not directly fit into the new setting we aimed for, as it will have traces of the old setting. We need to conduct material restructuring, reflecting the values, work practices, institutions and other sociotechnical realities of the new setting. Once reached to a fitting scope and format, we can complete the scaling by (re)embedding the restructured technology in the sociotechnical reality of the new setting – in the end forming a working sociomaterial assemblage in the new setting. Scaling across time is also a similar process of going through processes of disembedding, material restructuring and reembedding.

Looking at the entire process of scaling (both across space and time), at the macro level we have the movement of the sociomaterial assemblage. At the micro level, the movement was
possible following complex processes of disembedding, material restructuring and reembedding. Clearly, the success or not of the scaling depends on the outcomes of these processes. Referring back to the generification discussions in this chapter, these processes could greatly be facilitated if conducted on top of generic technology design practices. Because, with generification the emphasis is to maintain open, adaptive, flexible technology that serves for multiple heterogeneous contexts – which is the ultimate target of scaling.

### 3.3.1 Scaling and generification

In many cases, generification is a strategy followed during scaling. It helps to market a single software package that fits into the needs of multiple customers. In their discussion of generification work, Pollock et al (2007) explain how vendors set out from the start to develop a single product that fits into the needs of multiple customers. One interesting part in their discussion of generification work was the process of how a vendor gathers its customers from different parts of the world to a round table discussion for the purpose of eliciting and negotiating requirements that needs to be inscribed in the generic software. Key in the process was the activities of the vendor in trying to build common sets of requirements, sometimes by rejecting those considered organizationally particular. Witnessing this is a rare and unique opportunity – especially from the perspective of the vendor assembling its customers under one roof and going through the inception of a generic product that serves for all.

There is also a bottom up process of vendors starting from a single customer and slowly trying to reach more and more customers (Johannessen & Ellingsen, 2009; Sæbo, 2013). For Sæbo, it is scaling that drives generification. Drawing from an extensive empirical material of HIS spreading and expansion in developing countries, he sees generification as an “aggregate of particularities” (p. 86) or the “accumulation of particularities” (p. 122). He contends this by explaining an example of how the DHIS2 software is allowed to support different ways of data entry. Initially it was supporting a particular feature where entry is possible through an auto-generated vertical column of cells. A new requirement of making data entry screen similar to paper forms resulted with the additional feature of custom data entry that allows users to define a format of their choice. This way the DHIS2 was made to support the needs of multiple users by accumulating the features. However, conceptualization of generification as aggregation of particulars is in conflict with earlier discussions of generification that emphasize the practices of disembedding, refactoring and restructuring software systems so
that they are distanciated from particular references. Distanciation does not mean avoiding a particular feature; it is rather going through redesign, looking for a creative ways of supporting more than one feature with a single product. Otherwise linear accumulation of features results with bulky and sometimes confusing systems as users will face functionalities that they do not need.

Johannessen and Ellingsen (2009) also see generification as a strategy of scaling. Contributing to existing mechanisms of generification, they explored “how systems developed for a local practice, and tightly integrated with the existing infrastructure, can be adapted to a larger market” (p. 607). Key in their finding is moving from a single customer to a larger market requires a complex process that involves integration with the installed base and negotiations with other vendors and users. This is in line with the findings of Carmel and Sawyer (1998) that point to the importance of satisfying multiple stakeholders (such as analysts, market research organizations, reference clients and the media) when producing generic software packages, a process which also involves managing industry rivalry (Carmel & Sawyer, 1998; Grimm, 2009). An organizational field is a suitable unit of analysis to unpack the interactions of stakeholders at a broader contextual level, such as an industry (Chiasson & Davidson, 2005). Below, I take a brief a look at the concept of an organizational field.

3.4 Design at the organizational field level

Before summarizing my literature review, I would like to raise one qualifying point, which I think is critical but missing from the discussions of generification mechanisms. As can be seen from discussion of not only generification, but also designing for multiple contexts, balancing between global and local, generative design, FOSS and scaling is that the emphasis is not to design for a single customer or organization but for broader set of customers or organizations. For example in one of their generification mechanisms, Pollock et al (2007) suggests for suppliers to move focus “from the private domain of each user site, where only particular needs could be articulated, to a public setting, where community or generic requirements could be forged” (p. 263). However, a challenge here is on how to conduct requirements gathering and design at a broader community level while the epistemology and practices of our traditional system design approaches are at the organizational level? There needs to be a shift of focus from the organization level that represents a single customer to the broader organizational field level that represents the industry (Chiasson & Davidson, 2005).
Focus at the field level allows to develop a more structured and systemic understanding of how technologies are embedded in complex interdependent influences, and are consequently shaped by such broader influences (Orlikowski & Barely, 2001).

Organizational field is one of the key concepts from the literature of institutional theory. It refers to “those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products” (DiMaggio & Powell 1983:143). The conceptualization provides a useful framework to identify relevant actors and understand a phenomenon as negotiated and enacted across a community of organizations that share similar areas of interest. Research has shown the field concept as a powerful unit of analysis to understand the arrangement and interaction of constituting actors in various sectors – for example in healthcare (Jensen et al., 2009; Ruef et al., 1998; Scott, 2001), education (Vaira, 2004), agriculture (Egri, 1994), sport (O’Brien & Slack, 2003; Washington, 2004), and in general the industry (Chiasson & Davidson, 2005).

Healthcare is one domain that has been repeatedly analyzed using the concept of organization field (see for example Currie & Guah, 2007; Jensen et. al., 2009; Reay & Hinings, 2005; Ruef et. al., 1998; Scott, 2001). The field based analysis has demonstrated an interesting insight into the arrangements and interplay of various organizations – including producers, consumers, regulators, financers and others – that exist in a typical healthcare setting. However, the large part of the literature has neglected field-based analysis for HIS and IS design. There is an increased call for more utilization of the field concept as it provides a contextual space to better understand and shape IS activities at broader levels (Chiasson & Davidson, 2005; Mingerat & Rivard, 2009). The field focus provides a level of investigation that comprehends the importance of both connectedness and structural equivalence among organizations that exist in broader contextual space (DiMaggio & Powell 1983). This is not to suggest that all organizations in the field are equal and connected, but to highlight all in the field are equally important and action on one organization might affect others in the field. This helps to take the focus away from any single organization to the bigger set of organizations or to the entire space. In addition, organization field is seen something that evolves over time as organizations join or leave (Chiasson & Davidson, 2005; Hoffman, 1999). Again, this serves as a sensitizing device from taking any organization for granted and
to put an exclusive focus on it, and rather to focus on the entire contextual space formed by members of the field.

3.5 Summary and proposed conceptual framework

This chapter has reviewed conceptual resources drawn from body of knowledge concerned with the discussion of information systems design for serving a heterogeneous user base, particularly in the context of HIS in developing countries. From the review, a relatively well established, theoretically and empirically, conceptual resource is the notion of generification. However, though recognized in the practices of global software package suppliers, it remains less influential in the practices of technology innovators and researchers in the context of developing countries. The popular discourses under the context of developing countries are transfer and diffusion and social embeddedness, which, however, are found limited in some important areas such as design. This thesis follows the discourse of generification.

Following the notions of generification, this thesis seeks to formulate conceptual framework with due account to the realities of developing countries, which I argue is distinct from that of suppliers and vendors seen in commercial settings. Notions of scaling, FOSS and open innovation are other supporting conceptual resources this thesis has explored to further develop a conceptual framework. Drawing from the review, I extend the concept of generification to “open generification” in order to make it suitable to unpack theoretical and practical challenges of HIS design in the context of developing countries.

A distinguishing aspect of open generification is the qualifying term “open”, which relates to actors, their design practices and the contents of generification. The openness with regards to actors of generification is the emphasis that developing generic software package is beyond the realm a single supplier, especially with the current trend of innovation which is open, distributed and taking place in networks. It is important to open-up processes of generification and establish collaborative mechanisms with other influencing actors. For the content of generification, the emphasis is to keep things open and delegate the task of filling the required content – which could be at use, configuration or design level – for situated users as they are the ones best placed to do so. How to actually operationalize this in the context of developing countries is an empirical question the next chapters of this thesis will focus on.
CHAPTER 4 RESEARCH APPROACH

The previous chapter focused on literature review and conceptual framework that I draw on to understand the design of generic technology in the context of developing countries. This chapter presents in more detail the actual steps I took to develop the understanding. The chapter contains four main sections. Section 1 presents the ontological and epistemological paradigm of my research. Section 2 presents the research methodology. Section 3 presents data collection methods. Finally, Section 4 presents the techniques for data analysis.

4.1 Research paradigm: my personal orientation

Research in IS can be classified into three paradigms – positivist, interpretivists and critical (Orlikowski & Baroudi, 1991; Myers, 1997). The classification is based on assumptions of the nature and means of study of reality under investigation. For positivists, reality is independent of the researcher and can be described by measurable objective properties (Myers & Avison, 2002). For interpretivists, reality is not external, but internal, and is always accessed through social construction and is shaped by (and also shapes) social processes and contexts (Walsham, 1993; Myers, 1997). For critical realists too, reality “is historically constituted and that it is produced and reproduced by people” (Myers & Avison, 2002 p. 11). However, their focus is on opposition and conflicts with an objective of seeking an emancipatory role (Myers, 1997). Given these paradigms, the position a researcher takes drives the subsequent mode of inquiry. Walsham (1995) recommends for researchers “to reflect on their own philosophical stance, which should be stated explicitly when writing up their work” (p.76). Below I reflect on mine.

Originally, I am from an engineering school of thought, which is inevitably positivist, trained as a computer engineer and practiced design, development and maintenance of hardware and software systems including networks. I performed these activities while working both as a system administrator and as academic staff in the same university that trained me as an engineer. Following a positivist orientation, my practices draw on the assumption that quantitative measurements and requirements collected using procedures and instruments are necessary and adequate to capture use scenarios of a technical artifact and develop a system acceptable for all. However, this changed in 2007.
Sometime in the beginning of 2007, I met three members of HISP – one from global HISP and two from the local HISP Ethiopia team. HISP requested me to develop a module, inside the DHIS2, which was required for Ethiopia. I accepted the request, studied the local requirements, evaluated work practices, collaborated with the local HISP Ethiopia team and developed the module. After the module was completed, I accompanied the HISP team to a number of meetings, “how-to-use” demonstrations, and negotiations with the Ethiopian Ministry of Health. In some meetings, we got acceptance of the module by the Ministry, even by top officials; in others, we got a schedule for another round of evaluation; in some, we got a rejection that the module is not acceptable. From the HISP members too, there was a mixed message. The local HISP Ethiopia team accepted the module as working, and same also for some of the global HISP members. However, for some of the global developers, though the module was acceptable for Ethiopia, the way it was developed was unacceptable. There were quite many interpretations of the module – people were looking at it from different angles and reach to their own conclusions, and we were trying to understand their interpretations, align ours and negotiate for the final acceptable solution. The whole negotiation process was a baffling exercise to me. It exceeded my expectations of “collect requirements, model, code, deploy and it will work”, which I realized was simplistic and way behind the negotiations, politics and social construction we were trying to establish. For me the whole thing was a social process, which I could not understand with my technical worldview. This whole process convinced me to change from my engineering and positivist view to qualitative, social constructivism and interpretivist world view.

There is also another strong point for me to have an interpretivist stance. The object of study I am engaged with is understanding design of generic software product, which is the DHSI2, which is expected to serve diverse community of users located in multiple countries. These users have their own worldviews, depending of their situated socio-technical arrangements, that affect the acceptance or not of DHIS2. It is important for me to understand what is accepted and what is not accepted, including the reasons for acceptance or rejection. It is important to have such an understanding as it helps me to connect design decisions and their outcomes including what has worked what has not and further improve DHIS2.

My interpretive research approach, to understand processes around DHIS2, draws on the following view of Walsham:
“Interpretive methods of research start from the position that our knowledge of reality including the domain of human action, is a social construction by human actors and that this applies equally to researchers. Thus there is no objective reality which can be discovered by researchers and replicated by others” (Walsham, 1993 p. 5)

and that of Orlikowski and Baroudi:

“Interpretive studies assume that people create and associate their own subjective and intersubjective meanings as they interact with the world around them. Interpretive researchers thus attempt to understand phenomenon through accessing the meaning participants assign to them” (Orlikowski & Baroudi, 1991 p.5)

The strength of the interpretive approach is that it provides the opportunity to negotiate, understand and reflect on the phenomenon under study. In addition, the fact that the object of study – the DHIS2 – is a FOSS calls for supporting an interpretive worldview. Because in FOSS, what we have is a distributed community of users and developers who are from diverse contexts. The community members bring with them multiple value-laden perspectives and engage in activities of design to shape the software as per their worldviews. Understanding this fundamentally requires an interpretive research approach.

4.2 Research methodology: studying generification process

Research methodology is a strategy of inquiry that moves from the underlying philosophical assumption to research design and data collection (Crotty, 1998; Creswell, 2003; Myers & Avison, 2002). As made explicit in the previous section, this research follows interpretive philosophical assumptions. With this, my intention is not to understand DHIS2 development process as purely a technical system detached of its design and use contexts; but rather to understand it as a sociotechnical process infused with social, technical, cultural, organizational and institutional realities of both the design and use contexts. To operationalize this, I adopted the view that “… [sociotechnical] process is not captured in hypothetical deductions, covariances and degrees of freedom. Instead, understanding [sociotechnical] processes involves getting inside the world of those generating it.” (Rosen, 1991 p. 8) As a result, I went inside the social world of DHIS2 design and its use.
Once inside the world of DHIS2, I did not put myself as an “outside researcher”, I became an “involved researcher” (Walsham, 1995). This was also more of an ethical issue for me, because I did not want to simply stand and watch the struggle of designers (trying to build a working system for the good health of developing countries) and run away with my data. I played a helping role by actively participating in design and implementation processes. In the process, I played the role of both global and local level developer with full commitment and passion to solving problems at hand. The role shifting I had, from global to local and vice versa, was a result of my keenness to solve problems that surfaced in the course of my study. I do not recall a point where I felt I dictated the outcome of my design and development activities to my research interest. Actually there were times where I felt, I missed an opportunity to get “better data” for the issues I was researching. However, as an insider, I was given the freedom and opportunity to always go-back and communicate with my informants, send them emails and questioners to get their views. The advantage with this kind of close involvement is that it allows for an “in-depth access to people, issues and data. It enables participation in action, rather than merely accessing opinions as is the case in an interview-only study. Field participants see the researcher as trying to make a valid contribution to the field itself, rather than taking the data away and writing it up solely for the literature” (Walsham, 2006 p. 321).

Following my decision for interpretive and qualitative research orientation, the next step I took was choosing the research method that informs my investigation. In IS research there are four research methods to choose from – case study, action research, ethnography and grounded theory (Myers, 1997). Given my decision to engage in activities of design and development and solve stated problems of organizations, action research is the fitting choice than the other three. At the same time, given my emphasis for design of technology, design science (Hevner et al., 2004) is also a possible candidate. However, the emphasis that people and elements of organizations are not part of the constructs of design science framework (ibid.) was a turning point for me not to adopt design science research. As a result, in the course of my study I adopted action research methodology which I present below.

4.2.1 Action research

Action research is an established research methodology in use in the social sciences and medical studies since the mid-twentieth century (Lewin, 1946; Susman & Evered, 1978). In
the IS field, it has become increasingly popular since the end of 1990s (Baskerville, 1999). As the name implies, the methodology involves a combination of action and research for solving concrete practical problems while at the same time expanding the body of scientific knowledge (Baskerville & Myers, 2004). This calls for a focus on two levels. At one level, the focus is on activities for solving stated organizational problems. On the other level, the focus is on recording, studying and interpreting outcomes of activities in order to develop a new body of knowledge.

Conducting action research requires establishing a “client-system infrastructure” (Baskerville, 1999; Susman & Evered, 1978), that forms a research environment where researchers and host organizations state problems, specify and propose changes, try them out repeatedly, and revise actions based on evaluations until the stated problem is recorded as solved. The cyclic process of specifying, proposing and trying out changes and learning from them follows five identifiable phases of action research. These are diagnosing, action planning, action taking, evaluation and learning (Susman & Evered, 1978). In the course of following the phases, three effects are unavoidable: the acceptance of qualitative data analyses, adoption of ideographic viewpoint of research enquiry, and interpretive viewpoint of the research approach (Baskerville, 1999). These effects are unavoidable because the would-be problem solver (the researcher) accepts problems defined by hosting organizations also problem owners who in turn accept the researcher with a risk of blurred distinction between “researcher” and “being researched” (Manseil, 1991). Both parties shape the “client-system infrastructure” by generating value-laden qualitative data representing their worldviews. The “client-system infrastructure”, a negotiated outcome, is a unique representation of the two parties and their worldviews, which cannot be reduced or generalized but can only be understood through a unique, complex and holistic view of enquiry. Negotiating, understanding, and reflecting on phenomenon around the “client-system infrastructure” fundamentally require interpretivist perspective (Baskerville, 1999).

In this study, I negotiated and collaborated with the HISP network – globally in Oslo and local in multiple countries – to form my client-system infrastructure. As mentioned earlier, this study was carried out in collaboration with HISP and using the DHIS2 software. HISP comprises of a network of action research projects running in multiple countries since 1994 (Braa, 1997; Braa & Hedberg, 2002; Braa et al., 2004; Braa & Sahay, 2012). For the HISP network, the ultimate objective is bringing “better data better information and informed
decision making” in the healthcare domain of developing countries. Several researchers, designers, implementers and users are working towards this objective using the DHIS2 software. Reaching the objective requires overcoming the key challenge of designing and developing DHIS2 as a generic system that works for the multiple countries HISP is operating. It is with this key problem area that my research engages. On the one hand, there is the challenge of designing generic DHIS2; on the other hand, as mentioned in the introduction chapter of this thesis, there is limited theoretical understanding of designing generic technology and processes of scaling. To address these challenges – both practically and theoretically – my guiding research questions were:

**RQ1:** How can we understand generic HIS design in the context of developing countries?

**RQ2:** What are some strategies to help us design generic HIS that fits the public health practices of developing countries?

I investigated these questions by performing my own action research within the broader HISP project. Being performed within a bigger research project, it is easier to lose focus and engage in other agendas. However, I tried my best to stay focused and engage in activities of DHIS2 design and generification that helps me answer the mentioned research questions. Figure 4.1 presents the major activities I conducted in my research. As shown in the figure, I have conducted four main action research projects in collaboration with HISP: AR1, AR2, AR3 and AR4. It would have been easier to conduct a single action research project and summarize the observation. However, studying generic software package requires follow up over a longer period of time and studying the package’s biography from the perspective of multiple contexts (Williams & Pollock, 2009). These resulted in multiple action observations. At the same time, as shown in the figure, there were different outputs at the completion of each action research unit. This has helped me to bring multiple insights in answering the research questions. In addition, it was also an opportunity to reflect and further test the learning of earlier action research projects on latter ones. This, of course, is not to suggest the action research projects do not have their own learning and reflection phases, but to stress a stronger process of reflection and follow up on the learning outcomes.
As mentioned earlier, HISP has been running since 1994; but DHIS2 software came in 2006 (earlier it was DHIS1.4). I joined the HISP research network and started active participation in design in 2007. While working as a core developer for DHIS2, my intention was to understand how the DHIS2 is being scaled, how it is transported across countries, and how it is actually designed to facilitate processes of spreading and expansion. To help me facilitate the understanding, I came with existing conceptualizations of scaling as spreading and expansion on one hand and strategies of generification and design at global and local levels on the other hand. With these sensitizing theoretical devices, I studied DHIS2 expansions through functionalities (F2, F3, F4 and F5) and transportations to Ethiopia, Tajikistan, Sierra Leone and several other countries.

Because the DHIS2 was present before the start of my study, I did not have the chance to start the whole thing from scratch, what I could do was contribute to existing DHIS2 by extending it with new functionalities. It is for this reason that I engaged with functionalities F2, F3, F4 and F5. I did not pre-plan to develop these functionalities; they only came to picture following concrete requests from countries. While developing the functionalities, first I tested them with the requesting country then followed by testing them in other countries to evaluate their genericness. For those countries which I could not travel, I collaborated with local actors to conduct testing and receive feedbacks. Table 4.1 presents a summary of these functionalities and their respective action interventions.
Table 4-1: Summary of Action Research projects conducted

<table>
<thead>
<tr>
<th>Action Research</th>
<th>Event</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AR1</td>
<td>Adding new functionality to DHIS2 first locally and then globally</td>
<td>When DHIS2 was first introduced, it has support only for single figure aggregate reporting (F1). However, when transported to Ethiopia in 2007, it faced problem of technology-context mismatch. In Ethiopia, reporting requires multidimensional aggregate figures. To overcome the mismatch, I extended the DHIS2 (F2) as per the needs of Ethiopia. The result was a working system embedded in local settings of Ethiopia. To make the multidimensional solution useful at global level, I disembedded DHIS2 from the realities of Ethiopia and conducted redesign and restructuring to internal components of DHIS2. The result was a system that worked for Tajikistan, Sera Leone, India and other HISP countries.</td>
</tr>
<tr>
<td>AR2</td>
<td>Attempt to take local innovation from India to global level</td>
<td>Between 2008 and 2009, I conducted action research in order to spread a new DHIS2 functionality (F3*) innovated locally in India to multiple countries at global level. The functionality developed was a dashboard module that allows for graphical and tabular analysis of selected data and key indicators. However, since the module was highly coupled with local settings of India, it turned impossible to disembed from local settings and do restructuring for global level consumption. After several attempts, it turned pragmatic to design new generic module at global level and replace the local module from India (F3).</td>
</tr>
<tr>
<td>AR3</td>
<td>Adding new functionality to DHIS2</td>
<td>In 2009, I was conducting action research in order to develop new functionality (F4) inside DHIS2. The functionality requested was support for name-based recording, tracking and reporting practices in rural healthcare practices. The request came from India. However, the solution was designed in such a way that it is distanciated from specific conditions of Ethiopia. During design, I conducted study of work practices and interviews in India &amp; Ethiopia. In addition, there were also Skype conference calls and group email discussions with participants from several countries. With inputs from different countries, we designed the module in generic fashion.</td>
</tr>
<tr>
<td>AR4</td>
<td>Consolidating multiple</td>
<td>A local team from India designed DHIS2 mobile reporting for a specific report. Requests for different reports resulted with</td>
</tr>
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</table>
In summary, it is through these actions of DHIS2 spreading, expansion and generification that I collected my empirical data. Section 4.3 presents my data collection methods.

4.3 Data collection

Data was collected from two levels: globally from Oslo and locally from different countries. For local level data collection, I travelled to places which I thought were necessary. However, for some places, I relied on email and secondary sources of data such as discussions with those members of HISP who have actually conducted design, implementation and trainings. Reading project documents and other publications were also other relevant sources to my analysis.

In most cases, data was collected while serving as a core developer. This gave me the chance to closely observe several issues which I thought were necessary, for example – how do the people around DHIS2 see the software, what is a working and acceptable DHIS2 for them? Does the DHIS2 match user work practices? What is missing from DHIS2 to assist user work practices? How do designers at the global and local levels engage with DHIS2? With these questions at the back of my head, I went to field visits, seminars, meetings (with users, implementers and designers) and collected data through participations, interviews, observations, document analysis, email conversations and Skype conference calls. Figures 4-2, 4-3, 4-4 and Table 4-2 provide some details about my data collection methods.

Interpretation of data, followed by translations and inscriptions into DHIS2 – governed by community of users, implementers and designers all sharing a common mailing of discussions and negotiations – was the central part of my data collection and analysis routine. In addition, there were also follow up process of data collection, interpretations and design revisions. For example in one design follow-up, there were about 130 revisions of design data model. This shows the cyclic and overlapping nature of my data collection and analysis process.
Before doing design and development activities, I have always conducted interviews, meetings and onsite observations (see figures 4-2 and 4-3). This helped me to get deeper understanding of user requirements and organizational work practices. Field notes, interview transcriptions and other requirement documents have fed into my design activities. I have also returned back to users to evaluate their reactions to my final design outputs. This was done in cycles until an acceptable system was achieved.

![Figure 4-2: Onsite discussions and observations](image)

![Figure 4-3: Diary notes](image)

During design I have received inputs from other HISP designers – this helped me to have multiple perspectives, devise better design strategies and improve the functionalities under development. As part of feedback collection process, I have extensively used Google Docs – an online document sharing and collaboration infrastructure – to share my design blue prints. This has helped me to capture actual design inputs – changes in data models and blue prints – from peer designers based at global and local levels. From this, I see my design as a collective outcome than an individual’s piece. The fact that this all has happened under the umbrella of FOSS is also a strong point to indicate the final result was a negotiated outcome – there were
several moments where other members of HISP has actually intervened with the actual source code.

Figure 4-4: DHIS2 requirement analysis and design

As can be seen from Figure 4-5, email discussions were also part of the design process – this has actually helped me to get feedbacks from users who were not part of design blue print discussions. Through email, I was able to communicate and exchange ideas on a different level than the Google Docs design blue print communication. I have communicated with decision makers, managers, district officers, trainers and others who are not necessarily designers but key stake holders, whose inputs have greatly enriched to my design activities and related understandings.

Figure 4-5: Email discussions and tracing of design models

In addition to the above activities, I have also followed stable functionality releases and announcements by attending as well as conducting trainings, workshops and seminars (see figure 4.6). This was part of the strategy to build capacity as well as devise strategies for
subsequent improvements the functionalities under design. It was through all these activities that I collected my data – Table 4.2 presents a summary.

**Figure 4-6: DHIS2 trainings and workshops**

**Table 4-2: Summary of data collection methods**

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview</td>
<td>Face to face and email questionnaire interview of global and local level DHIS2 designers. 2 from Oslo, 2 from India and one from Tajikistan</td>
</tr>
<tr>
<td>Participant observation</td>
<td>Diary notes, in some cases presentation slides, were collected from the following list of activities</td>
</tr>
<tr>
<td></td>
<td>• Field visit to Ethiopia, Tajikistan, India (X4) and Vietnam</td>
</tr>
<tr>
<td></td>
<td>• participation in 7 seminars/workshops/trainings session (3 in Oslo, 2 in India, 1 in Vietnam and 1 in Tajikistan)</td>
</tr>
<tr>
<td></td>
<td>• participation in Skype conference calls with participants from Oslo, India, Vietnam, Tajikistan, Tanzania, Malawi, Sierra Leone and Zambia</td>
</tr>
<tr>
<td></td>
<td>• participation in group and private email conversations regarding design, implementation and use of DHIS2</td>
</tr>
<tr>
<td></td>
<td>• participation in design meetings</td>
</tr>
<tr>
<td></td>
<td>• participation in design activities</td>
</tr>
<tr>
<td>Documents</td>
<td>• Design blue prints and data models</td>
</tr>
<tr>
<td></td>
<td>• Requirement documents</td>
</tr>
<tr>
<td></td>
<td>• Training manuals</td>
</tr>
<tr>
<td></td>
<td>• Guidelines for developers, implementers and users</td>
</tr>
<tr>
<td></td>
<td>• Electronic archives (from emails, chats, DHIS2 country databases and other mediums such as Google Docs and Launchpad)</td>
</tr>
</tbody>
</table>
4.4 Data analysis

Data analysis was conducted using an inductive approach (Thomas, 2006), with the primary objective to extract understanding of meanings through a summarization of the findings and development of themes from raw data. This made me to read my transcripts several times and bring in iterative cycles of analysis and interpretations (Walsham, 1993; 2006).

Roughly, I followed three steps when conducting this cyclical data analysis and interpretation. In the first step, I was focused more on understanding and making sense of the raw data. For this, I used tabular data display (Miles & Huberman, 1994). From tabular data display, I then moved to the second phase where I conducted data reduction and abstraction to identify the common themes that emerged from the raw data. While organizing the themes, on the one hand, I was very careful not to lose footing from the raw data; on the other hand, I focused on getting closer to answering the research questions. In the process, there were a number of concepts and constructs that I engaged with. This can be seen in Table 4-3, where papers were analyzed for its theoretical construct and relationship to the main research questions. To move from the paper to thesis level analysis, I primarily leaned on concepts of global/local design, organization field, scaling and generification. However, before reaching to these concepts, I have picked and dropped few others – often with feedbacks from local seminars, reading and writing groups, supervisors and peer PhD student comments. In the third step, I focused on establishing relationships between the themes observed. The intention with this was to bring some degree of coherence and develop an overarching conceptual framework. The concept of open generification, discussed in detail in chapter 6, was the framework that I developed in the last stage of my analysis.

In addition to my own iterative reflections and interpretations, the outputs from my analysis were subject to scrutiny at different points in the course of my study. At one point, I volunteered to share my raw data while taking action research course. In the course, we were about six students exercising techniques of data display, reduction and abstraction. By sharing my data, I got the opportunity to see how fellow PhD students interpreted and extracted meaning from my data. This has helped me to reflect and iterate on my own interpretations and reflections and bring an improved one. Feedbacks from reading and writing groups, research seminars, conference papers, journal revisions and discussions with supervisors and other faculty have also helped me to refine my analysis and interpretations.
<table>
<thead>
<tr>
<th>Paper</th>
<th>Summary</th>
<th>Key Concepts</th>
</tr>
</thead>
</table>
| Interplay of institutional logics and implications for deinstitutionalization: Case study of HMIS implementation in Tajikistan | **Link with the thesis**: spreading existing technology; designing flexible technology  
**Observation**: When transporting existing technology to a new context, it is possible to face an opposing institutional logic, which is difficult to erode/overcome in an overnight.  
**Conclusion**: to overcome this we need to sow some seeds of change primarily by building a system with an inscribed flexible logic (containing the opposing institutional logics) | Institutional Logics  
Deinstitutionalization  
Flexible logic inscription |
| An institutional perspective in shaping mHealth systems: Case from India | **Link with the thesis**: expanding existing technology; designing generic technology  
**Observation**: when designing technology for a particular country/organizations, there are multiple institutions that shape the design beyond the country/organization under consideration  
**Conclusion**: In order to account for the influences of broader set of actors/institutions, including funding, we need to take a broader organizational field level perspective beyond the level of single organization. | Institutions  
Organizational Field  
Design at organizational field level |
| Understanding design-use interaction: the case of name based HIS system in India | **Link with the thesis**: expanding existing technology; designing generic technology  
**Observation**: when creating/adding new functionality/materiality to technology, the nature and constituent of the materiality is embedded and interdependent with contextual social processes, work practices and organizational structures  
**Conclusion**: the interdependency between the material and the social is a constitutively entangled one that is shaped by emergent and | Ensemble view of technology  
Technology materiality  
Constitutive entanglement  
Proactive design |
| Scaling as a process of managing sociomaterial assemblage: cases about HIS in developing countries | **Link with the thesis:** process of scaling | Scaling  
(Re)embedding  
Disembedding  
Material restructuring  
**Scaling as movement of sociomaterial assemblage** |
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td><strong>Observation:</strong> when looking at processes of IS scaling, the success (or not) of the scaling is dependent on the interplay between the social and the material, and on the affordance/constraint of the material</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Conclusion:</strong> in order to understand this, it is important to bring a sociomaterial perspective of scaling, in particular scaling as a process of managing sociomaterial assemblage through mechanisms of embedding, disembedding, material restructuring and reembedding.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Open generification: A design strategy for health information systems in developing countries | **Link with the thesis:** designing generic technology | Generification  
Embedding and disembedding  
**Open generification** |
<table>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Observation:</strong> when serving diverse contexts, it is difficult to design an independent system for each context. It is also difficult for a single supplier to design a generic technology that serves all</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Conclusion:</strong> in order to bring a generic technology that serves for all, an open and collaborative design practice is required. One guiding theoretical and practical framework to achieve this is open generification</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 5 RESEARCH FINDINGS

This chapter presents analysis and discussion of findings that resulted from the action research investigation of this study. The chapter is divided into two main sections. The first section presents empirical findings drawing up a selection of conference and journal papers produced in the course of the study. Five papers are selected for this purpose. The second section deals with an analysis and discussion of the findings. The section also presents contributions of the papers in relation to the main aim of the thesis which is about theoretical and practical understanding of the process of generic systems design and information systems scaling.

5.1 Summary of research papers

In this section, a summary of five individual papers is presented. Each paper is summarized in terms of its objectives, methods and findings. The papers are presented in their chronological order, indicating also my research progress and proximity to the central aim of the thesis.

5.1.1 Paper I: Interplay of institutional logics and implications for deinstitutionalization: Case study of HMIS implementation in Tajikistan


This paper presents HIS design and implementation efforts in the context of Tajikistan. The efforts were in the form of an action research project where all the authors had an active involvement in proposing, designing and piloting a computerized health data management system for the national ministry. The project was carried out over an intensive period of about three months from November 2007 to early February 2008. Broadly, the project components involved an initial situation analysis and identification of local technical partners, followed by a month of systems development and testing for the first prototype, and then two weeks of training and piloting in a district called Kulyab.

As an action research endeavor, there were practical and theoretical objectives with the paper. Practically the objective was to have a complete overhaul of existing data collection tools and
practices with a focus on achieving efficient and local level decision making processes. This was in line with the goal of Asian Development Bank who was funding the health system reform of post-Soviet Tajikistan. The theoretical objective was investigating implications of existing institutional logics to the reform process. Practically, the project was with the DHIS2 software that was known to work in different countries before Tajikistan. Theoretically, the paper revolves around the theme of conflicting institutional logics observed in the institutions of HISP and the Tajikistan Ministry of Health. HISP and DHIS2 are based on the logic of distributed and local-level decision-making processes, minimal data set and information for action where only data that leads to action is collected. However, in the post-Soviet Tajikistan environment, the dominant practices were centralized planning, statistical analysis and vast amounts of data collection that descended from the old Soviet institutions.

To move forward with the reform processes, initially it was considered necessary to erode existing health information institutions of Tajikistan and replace them with that of HISP – which in the paper is discussed as deinstitutionalization. However, this turned impossible as the Health Ministry of Tajikistan made a clear and authoritative order not to change anything but to develop a system that supports existing institutions; the Asian Development Bank could not exert a pressure on the Ministry for the deinstitutionalization either. It was a similar scenario with HISP – HISP also did not want to erode its institution that had been nurtured for more than a decade. Developing a system only for Tajikistan was also considered ineffective. To move from this impasse, it was necessary to devise a second approach where the conflicting logics were supported by a single generic system. This required restructuring the DHIS2 so that it supported the conflicting institutional logics of Tajikistan and HISP. In the paper, this is described as a process of inscribing a flexible logic. This turned out to be a success and led to the acceptance of the new DHIS2 by the Ministry in February 2008. Currently, in 2013, the DHIS2 is still operating in Tajikistan with the Ministry conducting national level implementations.

5.1.2 Paper II: An Institutional perspective in shaping mHealth systems: Case from India

Gizaw, A.A. Proceedings of the IFIP WG 9.4 Conference on Social Implications of Computers in Developing Countries, Kathmandu, 2011.
This paper presents my action research investigation on the role of institutions when designing a mHealth module inside the DHIS2. The module is for supporting practices of name-based health data recording, tracking and reporting using mobile phones.

The paper starts by introducing mHealth as a relatively new phenomenon which is getting increasing attention in the healthcare sector of developing countries. It presents the role and commitment of national and international level institutions for making and adopting mHealth a cutting edge technology supporting healthcare efforts such as the MDGs. Acknowledging the massive opportunity, the increasing number of mobile phone subscriptions brings to mHealth practices, the paper argues for more careful and holistic understanding of the phenomenon. The paper argues, what we see in mHealth is not just about increasing numbers of subscriptions, but also in increasing number of actors representing a range of institutions. The actors range from international donors, political bodies, mobile phone vendors, telecom operators and technology designers to local policy makers, health administrators, CHWs and the rural community. In the paper, the influence of these institutions were empirically investigated in the healthcare context of India and the DHIS2 software. Drawing from the empirical case, the paper developed a framework conceptualizing mHealth as an organizational field represented by values and rules of multiple institutions and their interplays.

Two points are worth remembering from this paper. The first is the discussion of mHealth beyond the hype of the increasing number of mobile phone subscriptions. The paper provided a sensitizing framework highlighting the impact of not only subscriptions but also the social, cultural, political, organizational and other institutional forces shaping mHealth design, development and implementation processes. The second point is the discussion of mHealth design at the organizational field level. As documented in the paper, despite the initiation of design based on the context and needs of India there were strong external forces that shaped the final solution. Among HISP members, there was a clear consensus that the design should not be tied to the local needs of India. As a result, many informants and perspectives outside from India were involved in the design process. This helped to make the solution useful for not only India but also for Ghana, Malawi, Tajikistan and other HISP countries. The field perspective was a useful level of analysis that helped to better understand the forces outside India and bring a generic solution that worked for many countries.
5.1.3 Paper III: Understanding design-use interaction: the case of name based HIS system in India


In this paper, the discussion is about the same technology introduced in paper II, but this time investigating its evolution over time. The investigation is based on action research where all authors had active involvement in different capacities ranging from system design and development to implementation and training.

Ever since the first prototype of the name-based module was put to use, it was going under continuous evolution because of various sociotechnical inputs. In the paper, this was traced using a technique termed as “sociologically informed data modeling techniques.” This amounts to archiving of data models and the tracing of changes in them as the analytical focus to understand populating of the changes and their relations with work practices and requirements. Conceptually, the paper draws from the ensemble view of technology, where technology is seen as only one piece in a web of sociotechnical elements. The ensemble view also accounts for a dynamic interaction between the social and technical elements.

A central motive in the paper was the attempt to be specific about technology and investigate the affordances and constraints technology materiality offers to human agency. In the literature, attention is on organizational changes with technology either taken-for-granted or unspecified. Leonardi and Barely (2008) pointed out that this is largely due to the fear sliding into technological determinism and called for researchers to adopt materialistic and voluntaristic stances and investigate affordances and constraints of technology materiality to organizational practices. The paper was an empirical response to this call. It provided a detailed picture of design-use interaction over time with a focus on how materiality emerges and interconnects with work practices, organizational structures and social process. The paper demonstrated how the recording, tracking and reporting modules of the DHIS2 emerged, and evolved in the healthcare setting of India. In addition, the paper demonstrated how DHIS2 materiality puts a notable influence in changing existing practices. For example, the tracking and activity planning functionalities of DHIS2 can potentially affect the house-to-house visiting patterns of health workers. The whole interplay and interdependency was a constitutively entangled process, shaped by emergent and situated agencies of both the human
and the material. The paper argues that understanding this mutual process and being flexible in the design process to proactively respond to changes is crucial to getting the design right.

5.1.4 Paper IV: Scaling as a process of managing sociomaterial assemblage: cases about HIS in developing countries


This paper engages with the concept of scaling. It brings a sociomaterial perspective of scaling in the context of HIS design and implementation for developing countries. HISP and DHIS2 are the empirical cases.

Scaling, in existing research, has been treated primarily as a technical process of expanding the scope and size of an information system across time in a particular setting and its spreading across space in multiple settings. This focus on the outputs of the scaling process has come at a relative neglect of the actual process of scaling that bridges different time-space contexts. In the paper, we have tried to redress this imbalance by taking a holistic view of scaling as a process of managing sociomaterial assemblage, with focus not only the size or scope of technology but also the social and contextual factors around the technology. The paper was also an attempt to bridge the two perspectives of scaling – scaling as spreading and scaling as expansion – and build a holistic conceptualization accounting for the two.

The key analytical drive in the paper is the perspective of taking scaling not as an after design issue but as an issue highly dependent of design processes. In traditional systems design practices, the primary interest is to develop a system that works for a particular context or organization. As a result, design practices are tightly coupled with target organizations, resulting with systems deeply embedded in sociotechnical realities of target organizations. What we have at this point is not a blackbox of technology ready to be dispatched to other organizations but an embedded system – a sociomaterial assemblage – fixed in time and space. Spreading the assemblage to other organizations is extremely difficult, if not impossible. It is a similar challenge for scaling as expansion in a particular organization; because there again we are dealing with new needs of the organization observed in a different time frame. It requires us to move the assemblage from the first timeframe to a second one. To overcome these challenges, design practices need to be sensitive enough and keep an eye on the needs of transportations and expansions in time and space. The paper argues for a re-
conceptualization of scaling as a movement of sociomaterial assemblage in time and space and suggests four key mechanisms: embedding which refers to the efforts to make a system work in a particular time-space context; disembedding to take the working system from a particular to a new time-space context through material restructuring; and reembedding to make and embed the system work in the new time-space context. The paper also suggests the use of generic technology design practices as a means to facilitate the scaling mechanisms.

5.1.5 Paper V: Open Generification: A Design Strategy for Health Information Systems in Developing Countries


This paper investigates the process of designing generic software package that can work for multiple settings. Empirically, the investigation is based on case material of HIS design for the healthcare settings developing countries. DHIS2 and the practices of HISP designers to make the DHIS2 work for more than 30 countries are the empirical bases for the paper.

The paper starts by first commenting on the existing discourse of IS innovation in developing countries. In particular, it points to the limitations of transfer and diffusion and social embeddedness innovation strategies for developing generic technology for multiple countries. For technology to work in multiple countries, the main stream IS research advises for a pragmatic strategy of striking a balance between what to transfer globally and what to cultivate locally. Moving beyond the pragmatic advice, the paper seeks to articulate a design strategy drawing from the concept of generification.

Generification is a strategy used by ERP suppliers for producing software package that serves diverse user needs. A central theme in generification is suppliers’ strategies for managing community of users of the generic software package which it is expected to serve. Pollock et al (2007) suggest three such mechanisms: management by community, by content and by social authority. For management by community the emphasis is for suppliers to shift attention from a single target organization to a bigger community of users. The focus on a bigger community of users clearly brings the challenge of diversity. To overcome this, management by content suggests for suppliers to identify and design only for those requirements considered common across the community. For those considered organizationally particular, the strategy is to filter, curb or reject during the generification
process. In management by social authority, the strategy is for suppliers to hierarchically segment their customers and design only for those considered strategically important. Those ranked less important are, simply marginalized in the generification process. The paper argues that these mechanisms of generification are limiting to bring a truly generic system that can serve diverse local sociotechnical contexts.

Emphasizing the inherent contradictions between generic solutions and the diversity of local contexts, the paper describes a generification process that is different in the sense of being open and collaborative. The emphasis of the paper is not on managing a community of users attached to the software package, but on managing diverse needs of the community the software is expected to serve. The paper acknowledges the existence of commonality and specificity across the community and suggests for collaboration of global and local level designers as a management strategy. The emphasis for global designers is to maintain a generic common core across the community and open up the design space for local level designers to innovate for their specific needs. For local designers, the emphasis is to draw from the common core and bring a working solution of their own in their specific settings. To coordinate global and local level innovations, the paper suggests the process of embedding (for implementing the generic in local contexts) and disembedding (for taking the local innovation back to the global). It is a complex task to keep this coordination running, and considerable challenges lie in material restructuring, architectural innovation, making global out of local, avoiding local fork-out and negotiating priorities. At the same time, this approach yields substantial benefits as local level innovations in situated settings are opportunities to advance the generic software. In the paper, this process is conceptualized as open generification.

5.2 Synthesis of research findings

The findings of the papers presented above highlight important perspectives that help to answer the research questions posed in the thesis and in return provide a detailed understanding of the issues related to generic information systems design. In this section, I will further synthesize the findings and explicate the perspectives they bring. By doing so, my intention is to lay the groundwork for developing a coherent conceptual framework that I present in chapter 6.
I will start the synthesis by first positioning the papers into three levels – see figure 5-1. As can be seen from the figure, at the first level are papers I, II and III. These papers discuss the phenomenon of DHIS2 spreading and expansion. The discussion then moves to the next conceptual level in Paper IV which discusses DHIS2 spreading and expansion drawing from the concept of scaling. To achieve scalable systems, Paper IV suggests for the adoption of generic technology design practices. Building on this, Paper V brings a detailed discussion of generic technology design drawing from the concept of generification. The last paper introduces a new concept, *open generification*, as a framework to understand and guide design of generic technology that can work for diverse contexts.

![Figure 5-1: Research progress](image)

As observed in the first two papers, institutions exert a considerable influence during technology transfer and expansion. Technology is a carrier of institutions; it carries the values, norms, beliefs, contextual realities, in general institutions, of its designers and place of design. When transporting existing technology to a new context, a clash of institutions is imminent especially if the new context has different, potentially conflicting, institutions. For the transporting to be successful, there needs to be either deinstitutionalization (where one of the conflicting institutions is eroded and replaced by the other) or technology restructuring (where technology is redesigned to support the conflicting institutions). Developing separate technology for every institution can also be another option; however, this is not in the spirit of
transporting existing technology. Hence the choice is between deinstitutionalization and material restructuring.

From the two choices, eroding institutions is a complex undertaking difficult to complete in short period. A relatively easier undertaking is material restructuring where technology is redesigned to carry diverse sets of institutions, including conflicting ones. Paper I presents a detailed account of this process. It presents a clash of institutional logics between technology supplier (HISP) and the technology consumer (Tajikistan). Since it was impossible to erode institutional logics of HISP and Tajikistan, the pragmatic solution found successful was to restructure the DHIS2 and bring a generic system flexible enough to support the logics of both HISP and Tajikistan. An important lesson here, as far as the aim of the thesis is concerned, is generic technology needs to support diverse sets of institutions, including conflicting ones.

Continuing engagement with institutions, but moving beyond conflicting ones, Paper II investigates the role of institutions when developing a new module. Personally as researcher, there was one important lesson that I brought from Paper I to Paper II. That was a conviction not to develop another system for HISP but to make the DHIS2 more and more generic by either adding new modules or restructuring existing ones in order to support emerging needs. The personal belief was crucial especially in light of action research where the researcher, has a big role in shaping the entire course of the research. The experience of restructuring DHIS2 and supporting the needs of Tajikistan, which was in total opposite to that of HISP, was an encouraging point that made me pursue generic technology design more strongly than ever. The experience was also a clear indication that exclusive focus on a particular organization or institutional logic is problematic if the intention is to bring technology that works for diverse contexts and multiple organizations. For technology to be truly generic and transportable across organizations, design needs to have a broader focus beyond the level of a single organization. Paper II has thoroughly investigated this drawing from the experience of designing the new mHealth module – mobile supported recoding, tracking and reporting module – inside DHIS2. The paper suggests a focus at the organizational field level as it brings opportunities to account for the needs of multiple organizations that may or may not share similar institutional values.

At the foreground of Paper III, is the investigation of design-use interaction. The paper documents how technology materiality is embedded in a web of social and technical elements of a particular context. At the background, however, there is a silent investigation of technology
sustainability. The paper investigates the evolution of the same module introduced in Paper II. Tracing the changes over time was especially important to the topic of scaling, which is one of the central themes in the thesis. Scaling is a prerequisite to ensure sustainability of information systems. It accounts for practices of spreading a system to new settings or expanding it overtime within an existing setting. As concluded in Paper III, a system in use in a particular setting at a particular time is part of a web of socio-technical elements of the setting under consideration. Changing the system over time, because of changes in user needs, is tantamount to moving from one web of socio-technical elements to another. To facilitate this, Paper III suggests for proactive design practice that facilitates changes. Being proactive to changes allows remaining vigilant and embracing emerging needs.

Spreading a system to a new setting is a similar exercise of lifting the system from the web of sociotechnical elements of the old setting and embedding into the new setting. Essentially, this requires being flexible in design and to respond to situated realities in time and space. The suggestion from Paper III is proactiveness, but a question to ask then is how exactly to do this? How do we lift out technology from one web of socio-technical elements and put it into another? These are the questions investigated in Paper IV. In Paper IV the topic of scaling is no more at the background, it is at the foreground taking the center stage. The paper brings a direct and deeper theoretical reflection on the concept of scaling. Consolidating the spreading and expansion perspectives, Paper IV re-conceptualizes scaling as a movement of sociomaterial assemblage. One advantage with the re-conceptualization is, that it brings attention from increasing number, size, scope or coverage, to actual processes of scaling with due attention to social and technical elements. The required metrics of scaling – number, scope, size, coverage etc – are in anyway visible once we managed to conduct a successful scaling. What is crucial, though, is to keep an eye on the process of managing the assemblage in time and space. As strategy of managing the assemblage, Paper IV suggests the mechanisms of disembedding, material restructuring and (re)embedding. The paper also suggests the practices of generification to facilitate scaling.

Continuing with generification, Paper V brings detailed discussion of developing generic software package that can work in diverse settings. Following an extensive review of literature and critical reflections on generification, Paper V introduces the concept of open generification as a framework to guide and understand processes of generic technology design in the context of developing countries. The hallmark of open generification is an open and
collaborative design practice with a focus on mechanisms of embedding and disembedding. Table 5.1 presents a summary of the research papers in light of their contributions to the research questions.

Table 5-1: Research papers and their responses to the research questions

<table>
<thead>
<tr>
<th>Research Papers</th>
<th>How can we understand generic HIS design in the context of developing countries?</th>
<th>What are some strategies to help us design generic HIS that fits into the public health needs of multiple countries?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interplay of institutional logics and implications for deinstitutionalization: Case study of HMIS implementation in Tajikistan</td>
<td>We can understand that generic technology design requires accounting for conflicting institutional logics</td>
<td>Inscribing flexible logic</td>
</tr>
<tr>
<td>An institutional perspective in shaping mHealth systems: Case from India</td>
<td>We can understand that generic technology design requires focus beyond the level of a single organization.</td>
<td>Focus at organizational field level</td>
</tr>
<tr>
<td>Understanding design-use interaction: the case of name based HIS system in India</td>
<td>Understanding design as a process shaped by emergent and situated agency of both the human and the material.</td>
<td>Proactive response to design-use interaction</td>
</tr>
<tr>
<td>Scaling as a process of managing sociomaterial assemblage: cases about HIS in developing countries</td>
<td>We can understand scaling of information systems as movement of sociomaterial assemblage.</td>
<td>Mechanisms of embedding, disembedding, material restructuring and reembedding.</td>
</tr>
<tr>
<td>Open Generification: a design strategy for health information systems design in developing countries</td>
<td>We can understand design of generic technology through the lens of open generification.</td>
<td>Open and collaborative design practice with mechanisms of embedding and disembedding</td>
</tr>
</tbody>
</table>

As can be seen from the table, each of the papers have raised important theoretical and practical perspectives towards the understanding and conducting of generic system design – in particular generic HIS design for the public health context of developing countries. Some
theoretical perspectives from the papers that emerge are: generic technology design is a complex undertaking that aims to develop software packages serving diverse requirements, at times conflicting ones, coming from a set of organizations; it is a dynamic and proactive process for supporting emergent socio-technical realities in time and space and; a practice that demands for open and collaborative approaches. The last paper suggests open generification as a coherent conceptual framework to explicate these perspectives. It is a theoretical contribution with key implications to existing body of literature – the coming chapter presents detailed discussion on this. In the chapter, I unpack the concept of open generification, discuss its constituents and articulate its implication to both theory and practice. The chapter also brings two strategic and three operational guidelines as practical contributions for operationalizing the notion of open generification in actual design. A working HIS software – modules inside DHIS2 – supporting the public health practices of developing countries is also part of the practical contribution discussed in the chapter.
CHAPTER 6  RESEARCH CONTRIBUTIONS

This chapter presents theoretical and practical contributions of my research. The main aim of the research has been to provide improved theoretical and practical perspectives for designing generic HIS solutions that fit into the contexts of multiple developing countries. I followed this by conducting an action research investigation within the HISP setting and DHIS2 software that is being used in the public health sectors of African, Asian and Latin American countries. Drawing from the empirical findings discussed in the previous chapter, I further develop coherent theoretical and practical contributions in this chapter. I start with theoretical contributions.

6.1 Theoretical contributions

This section presents key theoretical contributions drawing from the analysis of findings in chapter five. For designing generic technology that fits into multiple contexts, prior research has suggested for a pragmatic approach of striking a balance between global and local settings (Bjørn et al., 2009; Rolland & Monteiro, 2002). Moving beyond the advice of pragmatism, this thesis has sought to operationalize how this can be achieved, including developing design principles, by considering the very nature of contexts where generic technology is developed and implemented. My insights help to extend the concept of generification (Pollock et al., 2007), and are structured as a conceptual framework including providing implications to the literature of generification, scaling and innovations in developing countries.

6.1.1 Open Generification – a conceptual framework

Drawing from theoretical and empirical foundations of the previous chapters, the proposed framework presents key elements and their interplay that constitutes generic software development process, which I refer to as open generification. By highlighting the constituting elements and their interactions, the framework unpacks the black box of open generification and provides conceptual resources for a common understanding of the major issues. The framework also contributes to explain existing discussions of the generification conceptualized as “strategies through which suppliers produce software that embodies characteristics common across many users” (Pollock et al., 2007 p.254).
I conceptualize open generification as an open and collaborative design practice for producing software that serves diverse user needs. Here, I do not imply absolute diversity that crosses sectors, but diversity bounded within a particular sector — in my case the public health sector of developing countries. Though focused in a particular sector, variations in work practices, organizational structures, political systems, institutional arrangements and other social and technical realities within and across countries pose ample diversity that demand effective design strategies. Open generification is my proposition — see figure 6.1.

![Diagram of Open Generification: a framework](image)

Figure 6-1: Open Generification: a framework

I see open generification as an alternative strategy applicable to suppliers (both commercial and non-commercial ones) who want develop generic systems from the start or move locally developed system to a larger user base. What distinguishes open generification from existing strategies is the emphasis to account for innovations that happen both inside and outside the realm of a particular supplier. I submit this based on two arguments. The first is that innovation is increasingly becoming a distributed activity that takes place in networks and ecosystems (Boland et al., 2007; Selander et al., 2010; Yoo et al., 2008). The trend is a move away from closed to open innovation (Chesbrough, 2003; Chesbrough et al., 2008) and also to open user innovation (Hippel, 2013) that includes end-users. There is a considerable degree of
innovation happening outside the scope of a single supplier, it is therefore important for suppliers to tap into this phenomenon and our understanding of generification needs to account for that.

The second argument is, when serving diverse user base that exhibits distinct social, cultural and political institutions, it is increasingly difficult for a single supplier to be the master and creator of all and run things top-down. With the current advancement of ICT and computing resources, organizations and users are collecting and processing huge volumes of data to various degrees of sophistications. Local actors are better situated to formulate and decide on these issues if they are provided with the necessary resources (Franke & von Hippel, 2003). Therefore, complementing the top-down approach, there needs to be a bottom-up approach where local level innovations are fed back to the supplier at global level for formalizations and inclusions to the generic software.

The openness of open generification is a reference to these distinguishing aspects. In particular, the openness relates to actors and contents of generification. With actors of generification, the emphasis is to open up the process of generification for external stakeholders. This implies establishing coordination platforms and mechanisms for effective collaboration towards a common goal – FOSS with some form of governance structure, organization or individual level contractual agreements and other ways of securing intellectual property rights are some mechanisms to facilitate for this. Openness in content of generification relates to the importance of delegating some level of control for situated actors in the course of defining what goes in the generic product. For example while it is possible for a supplier to develop a reporting system with some meta-level structures, what is being reported, how often, by whom and other contents are best defined by situated actors. This is more than the use of templates and configuration tweaks. With templates we are setting a precedent and scope and at the same time forcing organizations to fit into some form of prescriptions, which however, may result in misfit failures. In open generification, the emphasis is to leave design open and encourage users exercise the agency they value. Practices of Meta-, generative-, participatory- and FOSS-design are some mechanisms to facilitate for this. A positive consequence of this is, beyond developing a software system we are also developing collective capacity that solves complex and resource intensive tasks. For example in HISP, had it not been for the participation of local actors it would have been impossible for a small team from Oslo to bring a system that worked in more than 30
countries. Similarly, given the limited expertise and capacity, it is challenging for most of the countries to develop a system like DHIS2. What worked is the collective capacity where everyone has a stake.

However, the notion of openness that anyone can participate and get a system of his/her liking is an ideal situation. In actual practice there are distortions to this. For example in FOSS, though participation is potentially open for all and free of cost, what we see participating gets focused to those with expertise, time, passion and commitment to FOSS. It is a similar case in open generification - there are constraints and distortions from the ideal openness, especially in the context of developing countries where we have a number of distortion factors such as relating to skills, infrastructure, funding, politics and others. The dashboard and multidimensional cases of DHIS2 are fitting examples to explain this. The multidimensional and dashboard requirements came from Ethiopia and India respectively. However, because of other priorities and limitations in resources it was difficult for the global team to design for these requirements. But since the DHIS2 is FOSS, local actors took the initiative of developing for their requirements. In the multidimensional case, there was a limitation of infrastructure (e.g the Internet) that hindered coordination and synchronization of local innovation with the global team and software code; this resulted with a solution not useful outside Ethiopia. Later, once a member of the local team joined the global team and started discussions and communications, the multidimensional solution got a redesign to a new generic level.

In the dashboard case, the issue was about skill and quality of software code. There again the local team came with a specific solution that worked only for India. In the process there was communication and coordination between local and global teams, however it was challenging for the local team to practice modular and architectural design practice that was considered useful in the generification of DHIS2. The global team even attempted to refactor the local dashboard solution and build a generic solution out it. However, going through the thousands of lines of codes and conducting refactoring and restructuring turned out to be a frustrating encounter which convinced the global team to abandon the local solution and bring a new dashboard solution. Funding and politics are also distorting factors that put some restrictions on the openness, in particular which features to include or not. The impact of the distortions is not necessarily a path towards particularization. It is a limitation to the degree of openness, being pragmatic and focused into specific areas, manage resources and prioritize issues – an
all inclusive generification is a process that emerges through time. With regards to focus area, the framework of open generification suggests for an organizational field as a guiding conceptual framework as it helps to stay focused on a particular sector or industry. For participation, the framework suggests at least two levels – global and local – and mechanisms of embedding and disembedding to coordinate between the two.

As shown in Figure 6-1, the elements at the global level are global innovation and the generic artifact. For example, a supplier, its designers, associated design practices and a single generic artifact constitute the sociotechnical elements at the global level. At the local level, are local innovations and specific artifacts. It is normal to have multiple instances of local innovations and specific artifacts at the local level depending on the existing sociotechnical realities and situated design practices. Between the global and local, there is the need to enable a continuous interaction, depicted in the framework as two distinct processes of cyclic interaction. These are processes of embedding, when going from the generic to multiple specifics; and disembedding, when coming back to the generic from multiple specifics. The interaction takes place in a broader contextual space of a particular sector characterized by work practices, organizational structures, infrastructures, standards, policies, and funding, as well as political, cultural and societal values. The organization field depicted at the center of the framework is a representation of these contextual elements. Next, I elaborate on the field and other elements of the framework.

6.1.1.1 Organization field: a design space for open generification

The problem space we target during design has a major influence on the nature of the solution we aim to develop. Technology is a result of inscriptions of both existing and historical beliefs and realities of the problem space we target. In traditional system design practice, an organization is often the target problem space and hence the context that defines the materiality of technology that comes out of design. For the interest of designing generic technology that fits into the needs of multiple organizations, a focus at individual organization level is limiting, as it is practically and economically challenging to do the same for each organization we would like to design for. Even if there is a small window of opportunity to focus on each, it requires us to predefine the list of organizations and their types at the time of design. Those organizations that come at the end of design will not be part of the focus and hence a bigger risk that the generic technology might not work for them. This undermines the
“level of genericness” of the generic technology. I suggest for a focus at the organizational field level to overcome this.

Focus at the field level helps to reposition efforts from a single organization to a larger set. It sensitizes us that members in the field are equally important and action for one organization might affect others in the field. In addition, the field is dynamic and evolving over time as organizations join and leave; this serves as a sensitizing framework from taking any organization for granted and to put an exclusive focus on it. For example in the multidimensional reporting module of DHIS2, Ethiopia was the first country who asked for it in 2007. Had HISP approached the design of the module in the specific way Ethiopia requested, the module would have been no use, since Ethiopia had now stopped using DHIS2 and had departed from the HISP network. However, since other countries were considered at the time and the design was approached accordingly, many countries are currently using the module – even those that joined HISP after the departure of Ethiopia.

An organizational field perspective also allows for an opportunity to observe conflicting institutional logics (Currie & Guah, 2007). I consider systems designed under an organizational field to be more generic and flexible than otherwise. For example, in existing discussions of generification, the practice is to adopt a community focus where divergent user needs are curbed, sifted, or rejected as long as design is conducted for those considered as surrogates (Pollock et al., 2007). However, with a field focus what we see inside is not just community members whom we can push aside without a consequence; but members are taken as serious stakeholders with strong institutional forces far too consequential to ignore. This was exactly what happened to HISP in Cuba and Tajikistan. In Cuba, there was no way for HISP to convince the authorities to use a software package dependent on the US based Microsoft Windows platform, though the software was popular in other HISP countries. The result was for HISP to leave Cuba with a realization that its software needs serious restructuring so that it becomes platform independent and can run on multiple platforms. In Tajikistan, HISP was faced with a different institutional logic of maximum dataset and voluminous data collection, which was in conflict to its decade old institution of minimum dataset and focus on essential data collection practices. When attempting to convince the Ministry of Health of Tajikistan for change, HISP was told unequivocally by the Ministry to design without making cosmetic fixes let alone reductions to what is being collected. HISP
managed to survive in Tajikistan by designing a system flexible enough to accommodate the conflicting logics.

An organizational field represents a recognized area of institutional life shaped by the values and interactions of an aggregate of organizations including producers, consumers, regulators, funders, policy makers and other influencing actors (DiMaggio & Powell, 1983). Research has shown the field concept as a powerful unit of analysis to understand the arrangement and interaction of constituting actors in various sectors. Beyond producers and consumers, or designers and users of technology, the focus at the field level provides an opportunity to observe and account other influencing actors that are impossible to ignore in the generification process. For example in the healthcare sector of developing countries, as a result of the UN’s MDG declaration and its 2015 deadline, international funders have clearly influenced the sector even though they are not as such direct consumers or producers of the HIS technology.

Another advantage with the field concept for generification is a clear distinction and unit of analysis between the global and the local. In existing discussions, there exists only a hazy characterization of the global – it is not clear what encompasses the global and its boundary or scope is. In their ERP generification discussion, Pollock et al. (2007) suggest designers to shift focus from an isolated individual organization to a larger extended community. However, the question is how do we frame this community and focus onto it? This is not clear, especially when seen from the perspective of traditional system designers who have been exercising design at the organizational level. By framing locals as organizations and the global or “extended community” as organizational field, the framework offers a clarification. It directs to a natural and systemic transition of focus from the organization to the industry, and the field concept is a suitable unit of analysis to understand the contextual space the industry forms (Chiasson & Davidson, 2005). According to Pollock and Williams (2007), SAP has conquered the world by being a leader in the ERP industry. Understanding the industry is vital to have a full grasp of ERP generification process and organizational field is an appropriate unit of analysis to facilitate this.

6.1.1.2 Global and local level innovations: collaboration in open generification

One pillar of open generification is the perspective that design of global software package that caters for diverse contexts is best achieved by collaboration of designers configured at
different levels. My analysis reveals collaboration of designers at global and local levels. This is in line with the organizational field and organizational levels of analysis identified in the previous section. At the global level, the prime task of the designers is maintaining a common core across the organizational field. At the local level, the task is for designers to establish a match between the common core and local organizational needs.

In the literature of generification, it is emphasized how production of a generic software package takes place in the space of global suppliers. However, a key argument that open generification brings is the impracticality for suppliers to produce a software package ready to fit every aspect of consumer needs – the fit comes only after considerable work at the place of local consumers. This necessitates for global level suppliers to make a concession of design space allowing for local level consumer innovations. Traditional system design practices are not good candidates to facilitate this, as they target for design closure. What is required at the global level is some sort of generative design practices that leaves the design space open and provides necessary resources and mechanisms enabling locals to generate a working solution of their own. Meta-design and FOSS development practices are potential strategies, because they are open and provide a half-way completed solution.

A critique against generification is this notion of design from nowhere, where a software product is cut loose from its place of production and transported en masse to places of use (Suchman, 2002). An open generification conceptualizes a two-stage process, design for commonwhere followed by design for specificwhere. If we look into the reporting case of DHIS2, across the countries there is this practice of timely health data reporting by health administrative units. There is no problem for global designers from Oslo to conduct meta-level architectural design in line with this common view of practice. However, a problem is if the Oslo designers adopt specific assumptions of report contents, reporting hierarchy, reporting time and close design. It might be possible to complete design for one or two specifics and provide a solution ready to click and run, but is extremely challenging for the Oslo designers to design for the whole range of specifics across the countries. Far worse, it is difficult for the Oslo designers to predetermine countries that will use the DHIS2 in the future. What the Oslo team did was design only for the common ones, and leave the rest open for the countries to decide. There is no one better than the local users themselves to design for what to report, for whom, by whom, when and other specific details. This way the Oslo team was also relieved from shouldering the full task of developing a solution that works for
multiple countries as the locals have greatly helped in establishing working solutions. At the same time, the locals were never left alone to develop the solution they needed; they were helped by a half-way completed solution.

Local level innovation is necessary not only to support specific organizational needs but also to ensure local processes of participation, ownership and capacity building. With the recognition of local role in the whole process, comes the necessary package of bringing the locals up to the task – for example trainings, infrastructure development, funding and other valuable inputs. For example, HISP is active in running Masters and PhD programs in the area of health information systems implementation and design for the context of developing countries, which enables local capacity building. Despite all the good, local innovations are not without a problem to generification, as they bring a serious threat of particularization. This is true especially when the locals have all the freedom to fork-out from the common core. For example, if the common core provided to locals does not have all the necessary ingredients to support specific needs, then there is great chance for the common core to get modified by locals in line with their needs. Nevertheless, the very first reason the common core went modified is an opportunity to bring an improved generic common core. To facilitate the improvement, there needs to be a process of disembedding local additions from the common core, followed by restructuring and architectural innovation to the common core so that it supports the local additions in a generic fashion. To support effective generification, I suggest for mechanisms of disembedding and embedding.

6.1.1.3 Embedding and Disembedding: a mechanism for open generification

The prime interest in generification is maintaining a global software package that serves a bigger community and its diverse user needs. If we take a particular sector or industry, there is ample diversity of needs because of variations in work practices, organizational structures, social, political and cultural norms among members of the community. Such diversity essentially calls for some level of uniqueness in the systems required by particular members of the community. However, the intention in generification is not to develop compartmentalized systems accounting for the uniqueness, but instead to develop a generic software package that gives way to multiple unique systems. Let us take a seemingly simple issue of language for illustration.
Despite having the required functionalities, a global software using English as a medium of communication has brought less success while its users were expecting Japanese language (Joshi et al., 2007). Obviously, it is difficult to convince the users to go for English. The software needs to support Japanese, or if we take a broader look and aim for a truly generic software, there needs to be support for as many languages as possible. Developing as many software as language is not generification, rather compartmentalization. Providing a software package with hundreds of languages loaded onto it, while a user wants only one, is not effective either; it is costly and confusing. There needs to be a systematic way of developing a single software package that allows for redressing of multiple languages. The framework offers mechanisms of disembedding and embedding to facilitate supporting the required heterogeneity. In the phase of disembedding, the software is dissociated from any local language format. The software comes to support a particular language of choice during the embedding phase. When the same software is required to support another language, it needs to go through the same processes of disembedding (which is taking off the language dress) embedding (putting on another language dress). These processes, I argue, are crucial to maintain support for heterogeneity of not only language but also other needs. A coordinated process of disembedding and embedding is an effective mechanism for generification and transportation of software package.

Disembedding and embedding are two distinct processes configured, respectively, at global and local levels. In disembedding, the emphasis is to generate a global software package ready for transportation across multiple local contexts. This involves a complex work of architectural innovation, material restructuring and negotiations. Configured at the global level, a broader view of work practices, organizational structures, societal values and other institutional arrangements recognizable at organizational field level is the sensitizing contextual device that shapes the disembedding process. The output of this process of disembedding is a generic and open software package that is not tied to specific local sociotechnical arrangements. The less tied to specific local formats, the more transportable the global software is. However, this comes at the cost of the embedding process. A global software package, detached from local sociotechnical realities, comes to work only after the process of embedding at local levels.

I identify two types of embedding processes. The first is for appropriating or pinning down the “empty” global software in the local setting. This involves filling out or configuring
missing parts left intentionally open during the disembedding process. The second is much more than this, where the generic software is made to work for specific needs that are not anticipated during disembedding. This involves local level innovations, which could be creating, removing or modifying parts from the global software. This is possible because the open and collaborative aspect of the generification process offers a design space for users (locals) to make the necessary innovation and satisfy their heterogeneous needs (Franke and von Hippel, 2003).

Local innovation during embedding is an opportunity to develop improved generic software. It allows for a bottom-up generification process that goes back from the local to the global or from users to suppliers. However, a challenge here is, it might not be possible to take the local innovation “as is” to the global level as it will be tightly coupled with local realities. Hence, designers need to undertake the complex work of disembedding the solution from local realities through material restructuring, architectural innovation, and negotiations. As observed in the dashboard case of DHIS2, sometimes it might be difficult to disembed a solution from its local setting and make it part of the global core. Nevertheless, designers can at least take note of the need and idea that led to the local innovation and make fresh innovations at the global level with less attachment to local contexts. At the same time it is important to establish an expert system that attaches the distanced system back to local realities. In DHIS2, every country has a local HISP team responsible for reembedding.

### 6.1.2 Implications of open generification

With the introduction of the concept of open generification, I see three major implications to the body of knowledge (see figure 6.2). The first implication is to the discourse of information systems innovations in developing countries (Avgerou, 2008). The second is to the literature of information systems scaling (Braa et al., 2004; Sahay & Walsham, 2006) and the third to the discussion of generification mechanisms (Pollock et al., 2007).
6.1.2.1 Implications to the discourse of IS innovation in developing countries

In the literature of information systems innovation in developing countries, two prominent discourses existing are transfer and diffusion and social embeddedness (Avgerou, 2008). While the transfer and diffusion theme argues for the acceptance and appropriations of a-contextual technology designed outside the contexts of developing countries, social embeddedness emphasizes homegrown technology that has come through situated design practices. Finding a middle ground between these two, the open generification concept uncovers an alternative innovation discourse, reflecting practices taking place both inside and outside the contexts of developing countries.

For many developing countries, it is practically and economically challenging to home-grow their technological solutions. There is a substantial dependence on continued flow of development aid from the outside. At the same time, it is futile to recommend to development aid partners to structure their product innovations focused on individual countries, especially when they are engaged with more than one country. In light of these issues, there needs to be a strategy that allows for a smooth transfer of technology from one country to another with due attention to contextual matters, both at sources and destinations of transfers. The concept of open generification offers a framework to facilitate this. What is new in open generification, from that of transfer and diffusion and social embeddedness, is it suggests for design practices leading to open and generic technology ready for embedding in local contexts and disembedding from local to global contexts. I see this as a new paradigm calling for further exploration. For more than a decade, attention has been on strategies of transfer and
diffusion and social embeddedness. This has brought little success; we continue to witness failures arising from mismatch between design and reality, which “manifests an acute anxiety about failure” (Avgerou, 2008, p. 37). To move from this, we need a critical look into existing innovation strategies and bring alternatives, the concept of open generification is a step in this direction.

6.1.2.2 Implications to the literature of IS scaling

Information systems scaling is an important issue in the contemporary context of globalization. In the literature, it is conceptualized along two dimensions: scaling as spreading and scaling as expansion (Braa et al., 2004; Sahay & Walsham, 2006). Scaling as expansion concerns increasing the functionality, capacity or in general scope of an information system in a particular setting. Scaling as spreading refers to the transfer of a working information system to multiple distinct settings, which is a pre-requisite to ensure the sustainability of the system. However, there exists inadequate discussion on a coherent framework, which accounts for both perspectives.

A coherent framework helps to sensitize us to the consequences of one on the other. For example, in the existing discussion attention is on increasing the size or scope of a system in a particular setting. At the same time, the spreading literature argues for transportation of this system to multiple settings to ensure its sustainability. A question to ask then is do the settings demonstrate similar size and scope that warrants the expansion? Answering this is crucial especially in the face of design-reality gap induced failures. There needs to be mechanisms – beyond increasing size or managing complexity – that allow us to establish a fit between the system under scaling and sociotechnical realities at destinations of transfer. In addition, our understanding of scaling needs to offer conceptual resources that allow us to understand and guide how to disembed a working system from a particular setting and embed it in another setting. In the literature, there exists little discussion of these issues. To alleviate this, Braa and Sahay (2012) urge for the adoption of certain design principles along social and material dimensions, rather than analyze the movement of boxes to understand scaling.

If we take a broader look of scaling, the concern is to keep an information system operational across time and space – across time to ensure the required scope in a particular setting; and across space to facilitate the spreading to multiple settings and hence ensure sustainability. Open generification offers conceptual resources to understand and guide this. The framework
first suggests strategies to design open and generic system that works for multiple settings. It then proceeds to identify embedding mechanisms that allow us to make the open systems work in a particular setting at a particular time. The embedding leaves us not with a black box of technology ready for transportation to a new setting or change in the same setting. What we have after embedding is a sociomaterial assemblage fixed in time and space. If any change is required to the embedded system, one needs to conduct a work of disembedding, material restructuring and reembedding. Spreading across space requires a similar process of disembedding, material restructuring and embedding in the new setting. Looking at the entire process, at the macro level we have managed to move from one sociomaterial assemblage to another. At the micro level, the movement was made possible through a complex process of disembedding, material restructuring and reembedding. Drawing from this, I argue for the re-conceptualization of scaling as movement of sociomaterial assemblage across time and space and suggest processes of embedding and disembedding as scaling mechanisms.

6.1.2.3 Implications to the literature of generification

Another implication I see from the concept of open generification is to understand mechanisms of generification. In the literature, Pollock and colleagues offer three mechanisms to facilitate generification process: management by community, management by content and management by social authority (Pollock et al., 2007; Pollock & Williams, 2009). These are mechanisms to manage community of users attached to generic software; however, little is discussed on how to support diverse needs of the community by the generic software.

In management by content, the strategy is to translate collective requirements into functionality used by all members of the community. In this strategy, when those requirements considered organizationally particular appear, they are sifted, curbed or rejected. In management by social authority, the strategy is to segment the community into hierarchy and design to the needs of only those ranked highly important and considered surrogates that others will follow. Those ranked less important are ignored, marginalized or not consulted in the design process. For IS research advocating user participation, context sensitivity and situated design, this approach is problematic. At the same time, market segmentation is considered ineffective especially when one attempts to serve heterogeneous user needs (Franke & von Hippel, 2003). Therefore, there needs to be an alternative generification mechanism to help us develop generic software package that serves not only a community of
users but also cater to the diverse needs of the community. Open generification offers one such mechanism: a coordinated process between practices of embedding and disembedding.

The premise in open generification is the acceptance that generic software package that serves diverse user needs is best achieved by a collaboration of global and local level innovations. At the global level is architectural innovation, material restructuring and other meta-level practices focused on the distanciation of the global software from local formats, which represents the disembedding process in the framework. The output from disembedding is generic and open software package ready for transportation and appropriation in multiple local contexts through a process of embedding. The embedding process also accounts for innovations practices of making the generic software support specific local needs not anticipated by the global team. This always leads to a specific software, which may or may not be of interest for other local contexts and the global team. When it is of interest, the process of disembedding from the local and back to the global is the opportunity to takeout the specific software from its local contexts, restructure, and put it back in the generic software – in the end to improve the generic software. Summarizing the whole cycle of process, I see a coordinated process of disembedding, embedding and disembedding serving as a generification mechanism.

The mechanism of disembedding and embedding also allows for a view of generification as an evolving process – that we do not produce generic software in one go, it is always a cultivation process. First, it is quite rare that we start developing generic software from the very beginning with all the visions and needs we would like to cover in place. In the modern infrastructural world, we always start from an existing installed base (Ciborra & Hanseth, 1998), often specific systems tied to a particular context. The question then is how are we going to move from this to a larger user base? Similarly, even within the practice of generification, genericness is always a relative achievement bounded by the current thinking, user base, infrastructure, industry standard, best practice and other resources. Today’s global is tomorrow’s local. Here again, the question is how are we going to move from local to the global? The disembedding and embedding mechanisms in open generification are conceptual resources to understand the evolving and cultivating aspects of generification.
6.2 Practical contributions

With the study conducted in an action research framework, I see significant practical contributions coming out of this thesis. As part of my research, I have been actively involved in activities of HIS design and development for the context of multiple developing countries over many years. The contributions presented in this section are a result of my reflections from these activities. I articulate them in terms of HIS artifact supporting public health practices of developing countries and strategies for designing generic systems.

6.2.1 HIS artifacts to support public health practices in developing countries

As pointed in chapter two of this thesis, the healthcare context of developing countries is a domain that shows an increasing number of artifacts. At the same time, it is a domain witnessing continued failures of systems because of the mismatch between design and reality. The public health area is composed of rural healthcare organizations and community health workers who are engaged in practices of health information recording, tracking and reporting in addition to preventive public health service provisions to rural communities. However, what we often see out there are systems of aggregate reporting and hospital recording, which are in stark contrast to the infrastructure and needs of the area.

For many countries, rural healthcare organizations and the practices around them form a foundation for national health systems. Any mismatch between design and reality in this foundational area is detrimental to national health management, consequentially to social and economic developments. Therefore, paying due attention and developing appropriate solutions to this area is of paramount importance. It is with this spirit that the HIS artifact (modules of DHIS2) have emerged from this thesis. As a result, the DHIS2 has come to support practices of recording, tracking and reporting in public health contexts of developing countries.

6.2.1.1 DHIS2: from number only reporting to generic multidimensional and name-based reporting

Prior to my engagement with this thesis, the DHIS2 was a system that facilitated aggregate statistical health data management – for example, number of people provided malaria
treatment by a particular health facility in particular month or immunization services provided to children or pregnant women. Support for such kinds of practices was inscribed in a generic fashion using the free and open source DHIS2. The DHIS2, released by global HISP team from Oslo, had functionalities that support definition, collection, reporting and presentation of aggregate data for various health programs that users could envision.

However, in 2007 the generic DHIS2 could not fit to the reporting practices of Ethiopia. In Ethiopia reporting practices were based on multiple aggregate data – for example what is the total number of people treated for malaria; of the total how many are male, female; of the male treated for malaria, how many are under the age of 5, above 5 and so on. To make the DHIS2 work in Ethiopia, I collaborated with the local HISP Ethiopia team and conducted local level innovations. In the process, we embedded the specific age and gender dimensions of Ethiopia and associated requirements in the core, business and presentation layers of DHIS2. This helped to bring the first working solution that supported multidimensional reporting.

After the first release, we made discussions with members of the global team who suggested the multidimensional solution was not generic enough to support similar practices outside Ethiopia. Following discussions and design deliberations, we collaborated to lift out the core, business and presentation layers of DHIS2 from the context of Ethiopia by removing the specific age and gender additions. While disembedding, we also redesigned and restructured the internal components of DHIS2 and developed improved generic software that supported not only single aggregate reporting, but also multiple aggregate reporting for the needs of both Ethiopia and other countries. The first national level implementation of the multidimensional reporting was in Tajikistan; since then the solution is in use in almost every country HISP is operating.

With success in elevating the DHIS2 from single aggregate reporting to multidimensional aggregate reporting in a generic fashion, I then moved to name-based reporting. I envisioned the name-based design as a natural scaling for the DHIS2. Initially it was about answering how many people are treated for a particular ailment, with the multidimensional it went to answer how many female, how many male, what is the age distribution, how many are inpatient, outpatient and so on. With the name-based, the intention was to answer who is actually treated, when, where, by whom and so on.
The practical motivation to design name-based recording, tracking and reporting DHIS2 module was a concrete request that came from a state of India. The state Health Minister asked for a system that supports immunization data recording. However, we did not develop a system only for India, neither only for immunization recording. We developed a generic system that supported pregnancy checkup programs, HIV/AIDS programs and other health programs targeted in worldwide MDG efforts. To inform design with actual work practices, I visited health facilities and observed day-to-day practices of health workers for different states of India and Ethiopia. In addition, I also conducted Skype conference calls and email discussions with informants from multiple countries. This helped to get as many diverse work practices as possible. After a thorough understanding to actual work practices, we provided a Meta system distanciated from a specific work practice(s). The system had only resources and menus for the users to design further.

For example, in pregnancy checkup programs the informants specified diverse work practices – some tracking pregnant women in 3 subsequent follow-ups, others in 5, and those in poor areas asked for 7. There was also a suggestion for variations of follow-ups from women to women, as those in high risk categories required more follow-ups. To handle these variations, we provided menus where users themselves could define a pregnancy checkup program of their own with the required number of stages for the subsequent follow-ups. To use the system, it was necessary for the users to first specify and embed the type and stage health programs. Users were also given full control on the specification and embedding of what to record, report and track.

If we take a broader look to this natural scaling of DHIS2 – from single total to multiple totals and finally to individual name-based reporting – we see open generification design process at the center stage. At the start, there was one generic DHIS2. When it faced a mismatch in Ethiopia, locals performed situated design that left with embedded DHIS2, which turned non-transportable to other countries. To make it transportable, global and local level designers collaborated and conducted disembedding, material restructuring and redesign. This resulted in a generic and transportable system that traveled to multiple countries through local embedding processes. For the individual name-based scaling, design was deliberately targeted not at the individual organization level (only request of India) but at an organizational field level (with informants from multiple countries). The result was a generic system that supported multiple health programs for multiple countries.
6.2.1.2 DHIS2: from multiple mobile reporting applications to single generic mobile reporting application

This thesis has also contributed to bring a generic DHIS2 for mobile-phone based health data reporting. Initially DHIS2 had support only for computer-based reporting. In 2009, a request from a state of India resulted with a local system that was tightly coupled to the specific request raised at the time. After sometime, three more requests from India – this time from another state – resulted with three more DHIS2 mobile-phone reporting applications. More requests from other countries where HISP was operating also resulted with additional mobile applications. In just one year, HISP ended up in managing seven different applications all providing the same functionality of data reporting but for different reports. This turned a concern for global HISP members and a search for generic solution became an immediate priority. I intervened at this point.

During my intervention, I followed open generification as my guiding principle. The first step I did was to study those mobile applications which I had access to their source codes. From my study, I found out that each of them have embedded the specific reports they were supporting. At the source code level, there were specific inscriptions of number of data elements, types, and the frequency at which they will be reported. The applications were designed in a typical traditional system design practice model, where problems are specified and closed/completed. There was no way for users to exercise their agency, even the trivial of adding or removing a data element from a once specified report. If such need arises, the solution followed was to design a new application.

Following the disembedding mechanism of open generification, I removed report specific inscriptions from the source code and conducted architectural level design by restructuring the DHIS2 mobile reporting module as a client/server application – I architected DHIS2 running on a computer as a server and developed a new application that runs on a mobile-phone as a client. The advantage obtained with this was, DHIS2, as a generic system, had already established functionalities and resources that enabled users to define a report of their choice. To make those reports, I developed a functionality that allowed users to do so. Then from the mobile side, I developed an application that downloads reports – defined by users and marked for mobile reporting – from the DHIS2. Once reports have reached the mobile phones, users have the choice to do the reporting. If they want to modify their reports, they were allowed to
do it from the DHIS2 side and update by downloading the new ones. Similarly, adding and removing reports was under full control by the users.

6.2.2 Strategy for designing generic systems

Another practical contribution from this thesis is the development of a pragmatic strategy for designing generic HIS. An implication from this, representing the bigger picture, is design principles for achieving aspects of genericness not only in the HIS but also in other information systems areas. My intention is not to provide a sequence of instructions and prescriptions that practitioners need to follow, as I don’t believe generification can be achieved in a sequential and linear manner. There may be some elements of these; but the crucial challenge is the managing of interactions and configurations of social and technical elements at different levels. In this section, I identify some of these interactions, point to some forms of desired configurations and suggest some mechanisms to achieve them.

A normative guiding principle in generification is the need to support a heterogeneous user base, which provides the foundation to formulate some practical design strategies. For a system to be considered generic it needs to work in diverse contexts, be transportable from one context to another, and support changing and emerging user needs. Two points are worth stressing looking at these demands: the first is design for generic systems is an ongoing battle against a moving target; and the second is traditional system design practices that focus on problem-closure and individual organizations are limiting. With this understanding, I outline five design principles – two at a strategic and three at the operational levels with illuminating examples from the design process of DHIS2.

6.2.2.1 Strategic level

i. Focus on a particular sector

The emphasis in generic system design is serving diverse user needs – diversity across time for serving the needs of a particular user or organization through time and across space to support the needs of a geographically dispersed user base. There should not be a predefined user list or set of requirements in generic system design. However, at the same time, we are not approaching a “wild problem” with an unbounded focus area. There needs to be a relatively bounded problem area, a particular sector or domain, which we need to focus on.
For example, systems designed for healthcare and education are different. Even within the healthcare sector, there are systems targeted for telemedicine, hospitals with curative medicine practice, facilities with preventive medicine practice and others. In the packaged software industry, ERP and CRM (Customer Relationship Management) are different systems – while the first focuses on managing and coordinating large amount of data to run an organization, the later focuses on managing organization data related to contacts and customers. An ERP system may contain CRM, but still, both are typical generic software packages designed independently to serve diverse user needs.

The point here is, even if there is no predefinition of users or set of requirements to serve, there needs to be a focus area, a particular sector or market that the generic system will be targeted for. It is possible to gradually increase the scope as the system matures and grey areas are uncovered through time; integration and interoperability are strategies to facilitate this. However, as a start, we need to aim for a particular sector as it brings a number of advantages: it allows to start simple (still within the scope of generic system design); identify common set of norms, values, and work practices in the sector; identify the major players, stakeholders, regulatory frameworks, infrastructures, competing firms and others. For example, in the HISP and DHIS2 case, apart from other groups of firms (or designers) engaged in activities of HIS design for the context of developing countries, multiple socio-technical actors have affected the process and outcome of generification. National and international policies such as MDG targets, WHO standards and guidelines, funder priorities and specific requirements, available infrastructure and others were some factors that shaped the trajectory of the DHIS2. Focus on a particular sector allows to identify these players, get a sense of their contents, craft groundwork, envision architectural modeling and high-level design blueprints. Organizational field, discussed earlier in the open generification framework, is a key conceptual resource to facilitate identifying the particular sector or target problem area.

**ii. Adopt open and collaborative design approaches**

The phenomenon of generification is not a one-supplier show. There are multiple stakeholders involved – customers, financers, consultants, competitors, regulators, industry standards, infrastructures and others. Yet, the number and type of these actors evolves through time. It is problematic to start with a predefined list or focus on some and shut-off others. There needs to be an approach to manage and get the best out of the influencing socio-technical actors. To achieve this, I suggest for an open and collaborative approach – an approach to accept new
ideas, methods, changes, and embrace distributed decision-making processes recognizing the impact and potential of stakeholders.

This has impacts on both actors and the contents of generification (or user needs to be served). With contents of generification, the implication is to bring a system that is open enough to fit into the needs of multiple users. This is beyond the sharing of source codes in open source software development. It also includes leaving open the data, language, organizational structure, cultural values and infrastructure that needs to be supported by the generic system. For example in DHIS2, the tasks of defining what to report, when, by whom and how are left open for users to decide based on their sociotechnical realities; users also have full control on the hierarchy of reporting organizational structures. Internationalization and localization programming strategy is used for managing language where no particular language is taken for granted, except for providing an easy to use interface for translations. These practices also implicitly indicate the participation of actors, other than suppliers, in the generification process – users, third party implementers, consultants, trainers and others. From the infrastructure perspective, DHIS2 is a platform independent system open to run on multiple platforms, including hardware, operating systems database systems and different means of communication.

For collaboration, a number of approaches exist – for example participatory design, networking and open source software development. In DHIS2, these are key practices used to establish collaboration between global and local level actors. Beyond passive participation, users in DHIS2 are actively supported to participate in local level design practices – regional trainings are going on (including Masters and PhD level educations), researchers are nurturing local capacity through action research, discussions are going on through email, Skype, and other platforms. From the onset, there is an understanding that sitting in Oslo and providing a “ready-to-click” solution that works for many countries is not the option – there simply is not enough capacity, knowledge of multiple realities, and expertise. However, there is capacity and expertise in the area of Java, architectural design, modularization, meta-design and other technological matters at a global level. At the same time, there is no one better than the local users themselves to outline the what, when, and how of reports, if we take reporting in HIS as an example. By providing an open system, it was possible for the global team to engage local actors and enable them with documentation, capacity building workshops and other resource to design for their local needs. Local actors are not to be left alone in the design process –
they were helped by a halfway-completed meta-solution that came with resources encouraging for further design. It was also the same for global designers. They are not to be left alone to shoulder the full task of developing a generic system that fits into the needs of multiple countries – local teams have greatly helped towards the final solution. A key implication of this is the need for serious attention to establishing collaboration platforms and mechanisms that allow situated actors to exercise the agency they value and possess.

6.2.2.2 Operational level

i. Follow incremental and iterative development

The aim in generification work is to design for requirements coming from a diverse user base. In the course of this work, a challenge is requirements do not all come at the same time; it is simply not possible to bring owners of the requirements to a round table discussion and reach a consensus. It is also a futile exercise to accumulate requirements from all corners of use and start design after developing a full grasp of them. What is best is to establish a shared medium of communication, for example an online forum, and coordinate requirements elicitation and analysis processes. Results from face-to-face requirement collection and analysis should also be input to this shared medium in order to increase transparency, deliberations and consensus at wider level. For example in DHIS2, requirements are collected through face-to-face meetings, action research engagements and email conversations which are transcribed into an online forum that is made accessible for all. Often, users are also encouraged to go directly to the forum and record their requirements – this allows them to see what has already been reported, compare with their needs, track progresses and get a feeling of the overall process. The common-pool of requirements also allows designers to decide on prioritizations based on a number of factors – there is no single formula for this, other than being pragmatic.

Once a platform is established and requirements start to circulate, work for design and development should start in an incremental fashion. There is no need to accumulate requirements, nor wait for an absolute consensus of one-size-fits-all solution. Programming should start with the current understanding and resources (knowledge, infrastructure and other constraining resources including time). There is no need for designers to over-engineer the solution either. Software is never a finished product; there is always the next iteration. What is best is to bring a working release as early as possible, establish trust and involve users early in the process. It is better to engage users in alpha versions than in hypothetical mockups. Even
if it is not a finished piece, users react more to what they see and experience. The point here is not to stick to some form of iterative process and sequence of steps; the point is to get close to users, bring more interactions and feedback, and be pragmatic in creating the channels of communication.

Releasing early also allows an opportunity to reconcile differences that might exist between users of similar requirements. For example in DHIS2, it is a common thing to see discussions that have this notion of “oh really, is that how you it … but we do it this way … why do you do it that way … if you could do it this way, you have this and that … no we need to do it this way because …” This takes the quality of requirement understanding and design to a new improved level. It allows designers to be part of the discussions, listen to users’ stories, get a deeper understanding of the needs and devise new ways of supporting the perspectives under discussion. With early releases, it is possible to handle these issues in shorter cycles. For example in DHIS2, there is new release every three month. It could be possible to make it shorter; however, shorter release cycles can be problematic for users as they have to cope with implementation, training, and the use of new releases. A longer one is could also be frustrating, as users have to wait more to see a new feature. There needs to be a sensible plan to balance on the timing and frequency of releases.

**ii. Inscribe a flexible logic**

In generic system design, it is very important to see requirements as representation of work practices that users expect to accomplish than as a long list of specifications that needs to be ticked off at the time of programming. There is a fundamental difference between these two perspectives. The moment we detach requirements from their contexts and put them as list of specifications, we lose sight of heterogeneity and dynamicity that is prevalent in users and the execution of their work practices. Given a work practice in a particular setting, there are multiple trajectories of executions from the start to end. This is even more, when we consider multiple users performing the practice in their situated socio-technical realities. The iterative approach and discussion of user stories, that they perform practices in their own particular ways, is an opportunity to get a feeling of the trajectories. The point here is not capturing the trajectories as such; it is about stressing the inherent flexibility that exists in work practices or user needs and devise a matching programming strategy that supports multiple pathways.
For example, I got a requirement from a health worker from a State of India – she asked for a new feature inside DHIS2 that helps her track pregnant women (due date, stage of pregnancy, address etc) in order provide them required services and collect corresponding data. To get a sense of what is required, I teamed up with a medical doctor who explained me what the tracking and service provision is all about. I also studied a WHO standard document that recommends for five checkups at different stages of the pregnancy. I also visited outreach clinics in two other States in India to see how they run the pregnancy care program. What I learned was: WHO recommends for five stage checkups; some States of India follow seven stages practice, others four; even within a State there are differences depending on the status of the pregnant woman where the high risk ones require more frequent checkups. During the stage checkups, health workers provide services and collect data, which is again different from State to State. Drawing from the observations, one approach would be to inscribe a logic representing each observation. However, this is problematic. Firstly, it is obvious that the observations are limited. Secondly, it is a norm and not an exception for any of the observed practices to change. And thirdly, inscribing multiple logics will make the system cumbersome and confusing for users as they will face features and menus they do not need. Working for groups of high risk, low risk and no risk could also be another approach, though not efficient. An effective approach is inscribing a flexible logic – where the intention is to design for a single logic that allows for instantiating multiple trajectories.

In the pregnancy case mentioned above, after analyzing the trajectories observed, I extracted a pattern and formed a logic flexible enough to give way to multiple trajectories (even for the ones not observed). Key in the process was stripping the contents of the trajectories (only temporarily) and developing a structure of objects and relationships. I formed three objects (program, program stage and data element) and outlined a relationship between them and finally provided a graphical user interface allowing users to reconstruct a trajectory that they felt represented their work practices. Using the program object users were able to create a health program they wanted (currently this is being used for Pregnancy, Immunization, Malaria, Tuberculosis and HIV/AIDS) to associate services with, associate any number of program stages to the program they created (could be one stage or multi-stage, for example ANC first check up to Fourth check up) and finally attach any number and types of data elements they planned to collect during each program stage visit. This helped to create a single logic – a flexible one – that worked for multiple health programs and for different countries.
iii. Follow practices of embedding and disembedding

A consequence of flexible logic inscription is that it leaves us with a system not ready to run “off the shelf” at the outset. Running the system requires a considerable work – users are at least required to populate their contents and instantiate trajectories of their work practices drawing from the flexible logic. I call this embedding; a different process than customization. Customization is a process of modifying a software package in order to make it meet a particular set of requirements. The notion of modification comes with an implicit assumption that the software, to endure change, was meant for something else in the first place, giving the impression that the customization is a workaround or an unintended effect as far as the original designers are considered. This is not the case in embedding. What we have at the start is an empty software package not meant for any particular use case. The software comes to life following the course of embedding, which are the practices of instantiating particular use case or work practices, filling space-time situated contents, and giving life to the empty structure left open intentionally.

In HISP, embedding is the obligatory passage point to make the DHIS2 work in a context. For example for any health program that users want to collect data and generate reports and analysis, they have to go through the “Maintenance” stage of DHIS2. It is a stage with rich set of user interfaces which allows users to define what their program is, content, form of analysis and display formats that they prefer to have. It is only after they are finished the “Maintenance” stage that they move to the “Services” stage to do the actual reporting and analysis for the health program they have defined. This has key implications in the actual design and development process – that a space is dedicated for users to have their say, which limits the global level designer from going all the way to provide a complete and closed system. What goes in the system, the one that gives life to the system, is not in the hands of global designers but in the hands of those locally situated users. This is one way of conducting embedding. There is also a second way of practicing embedding. When those resources available in the “Maintenance” stage are not enough to satisfy user needs, users have the option to conduct actual design, deep down at the source code level, and bring a system that works for them, often only for them and through fork outs. The fact that DHIS2 is a FOSS greatly facilitates for such local innovations. But since the whole idea is to bring a single generic DHIS2 that works across countries, not tied to a specific context of a country, this involves a practice of disembedding – a process of lifting out local innovations from situated
socio-technical realities. The design practice of DHIS2 mobile is a fitting example. Initially there were custom mobile applications each tied to a particular set of requirements. During disembedding, we evaluated the custom applications, understood what the applications do, and conducted restructuring at the code level and developed architectural level design that allowed to support not only the tasks of the custom applications but also others. One thing is crucial in the disembedding process though, while removing local references away from the system and conducting restructuring, it is also important to establish a local expert team that populates the local contents back to the restructured system.

In summary, these five principles orient practitioners how to approach generic technology design. In particular, the principles sensitize practitioners on how to approach design of generic software, coordinate users and designers at global and local levels, elicit and inscribe requirement, move from local inscriptions to generic design. A key message from the principles is generic software development depends on the interaction and collaboration of social and technical elements at global and local levels. For each of the principles an empirical example, demonstrating a particular mechanism, is provided.
CHAPTER 7  CONCLUSIONS

The aim of this thesis was to develop theoretical and practical understanding to processes of designing generic HIS in the context of developing countries. This was addressed by conducting an action research investigation in the settings of HISP and DHIS2. Practically, I have designed generic modules inside DHIS2 that supported data recording, tracking and reporting in the public contexts of developing countries. Drawing from the empirical observation, I have developed the framework of open generification. Chapter six has detailed discussion of the framework including its theoretical and practical implications. Here, in this chapter, I would like to make a conclusion by reflecting on the broader implications of the thesis and its conceptual framework, open generification.

As pointed in the previous discussions, the hallmark of open generification is open and collaborative engagement between global and local level actors through mechanisms of embedding and disembedding. I see this crucial in the contemporary context of globalization where most of our things are connected and shared – we are moving from compartmentalized information systems to shared, open and enabling information infrastructures (Ciborra & Hanseth, 1998; Monteiro et al., 2012). In these situations, I see neither actions of a single actor nor solitary and differentiated solutions effective strategy to answer the ever complex and emergent demands for information systems that we are confronting. I see a collaborative and negotiated approach, where concerned stakeholders are participating, as an effective strategy. An important implication of this is recognition and acknowledgement of the agency of stakeholders. It is obvious that stakeholders are not on the same level or type of agency, for that matter everyone might not be participating. There will be distortions from the ideal forms of openness, collaboration and participation for a number of reasons; however, the very first recognition brings an opportunity to refocus efforts, create platforms, organize resources, build capacities and allow stakeholders exercise the agency they value (Sen, 1999). This, I believe, is crucial especially in the context of developing countries, where topics such as development, local participation, empowerment and sustainability are high in the agenda.

With its focus on setting up social and technical means than ends (tailored products fixed in time and space), the thesis points for the need to shift from design-implementation dichotomy to co-evolution of social and technical assemblage. Often, we are consumed in listing factors that led to implementation failures – we keep uncovering social, technical, cultural, political,
institutional and other factors not considered during design. This is well and good as it brings sensitivity and perspective to the matter. But, it is also important to recognize that it is impossible for designers to arrest all the factors at the time of design. In this connected world, the social and technical factors keep coming thick and fast. Even if it is possible to consider “all” the factors at some point in time, they keep changing through time and space. To cater for this, we also need to bring theoretical and practical understandings that enable us to generate open systems that allow situated actors to perform various reframing and recasting operations. In these situations, the issue is not about implementation, it is about establishing a fitting socio-technical assemblage, moving from one assemblage to another and staying proactive in the process. For example, the Internet is a typical example one could mention when talking about a generic system – it fits the needs of multiple actors and purposes. Users are not installing it, or implementing it as in the case of software systems, rather they tap to it by establishing a working configuration of social and technical elements.

Probably the Internet, being the one and only without a replica, is a bad example. However, the existence of similar systems, but on a different level, such as software-as-service, cloud computing, web 2.0 functionalities, web APIs, web service computing and others represent strong phenomenon that requires our attention. As a user, we are not implementing these systems; instead we are subscribing, specifying or defining our needs to the shared, open and enabling generic systems behind them. How do we subscribe to such systems? What are the governing rules? What forms of contractual agreements exist? How is openness interpreted and manifested in the systems? What about security and privacy? It is important we understand these issues both theoretically and practically, and I believe the framework of open generification is a starting point for further investigation of these issues.

Speaking of the Internet and similar systems (but on a different level), what is being discussed is the property of generativity, which represents technology’s capacity for adaptability, accessibility, ease of mastery and usability across a range of tasks and heterogeneous actors (Nielsen & Hanseth, 2010; Remneland-Wikhamn et al., 2011; Zittrain, 2006). While such discussion of generativity looks at desired outcomes of generic systems, the discussion on generification looks at how to actually design such systems. The open generification framework, in particular the embedding and disembedding mechanism, points to an interesting new potential research area – the relationship between generification and generativity. When drawing from an existing generic system and generate a particular system
or perform a task by associating situated sociotechnical realities and values, we are going through processes of embedding. With the process of disembedding, we are feeding back the outputs of generativity to generification. This, I believe, is an interesting phenomenon to investigate how to enable conditions of innovation nurturing (from generification to generativity) and harnessing (from generativity to generification). I also see investigating mechanisms that shape the openness for actors and contents of generification as possible areas of future research. While this thesis has the opportunity to investigate the issue using FOSS development practice, what are the enabling and constraining conditions of openness in other forms of software development? These and other themes are potential areas for future research.
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APPENDICES


Interplay of Institutional Logics and Implications for Deinstitutionalization: Case Study of HMIS Implementation in Tajikistan

Abstract

This article describes the efforts to reform the Health Management Information System (HMIS) of Tajikistan. The authors were involved in proposing and piloting a computerized HMIS based on a complete overhaul of the current data collection tools, as well as in planning for the scaling up of the system. One of the recommendations was to support local decision-making through a flexible, decentralized system to collect, process, and analyze essential primary healthcare data. The institutional logics underlying the current HMIS in Tajikistan were heavily influenced by the tenets of central planning from a deeply embedded Soviet system that was alien to the ideas proposed. This article explores the different institutional logics arising from what already existed and from our proposals, as well as the interplay among them over the course of the project. Clearly, a complete deinstitutionalization—amounting to a paradigm shift—is necessary to overcome the differences in institutional logics. However, this is a remarkable challenge, given a centralized control context. This study makes interesting contributions to the domain of IS/HMIS research in two ways: (a) by reporting from a country that until now has been almost invisible to the IS community, and (b) by adding to the debate around IS and organizational change through the lens of institutional logics and deinstitutionalization.

1. Introduction

Tajikistan is a Central Asian country about which little, if anything, has been published in the mainstream information systems (IS) and development communities. Gaining independence after the downfall of the Soviet Union in 1991, Tajikistan has experienced an extremely rocky period, with a prolonged civil war and the loss of the supporting Soviet financial and social infrastructure. The country faces further challenges that include an extreme climate, a long and porous border with war-ravaged Afghanistan, a recent food and energy crisis of gargantuan proportion (Antelava, 2008), and the exodus of many trained people due to weak employment and decreasing social opportunities at home.

As do other Central Asian countries, Tajikistan confronts urgent public health problems. The demise of the Soviet economic base, followed by civil war, has led to a surge in various communicable diseases in the last two decades. According to the World Health Organization, life expectancy...
has decreased through poor nutrition, polluted water, and increased incidence of diseases (WHO, 2008).

Acknowledging the key role that ICTs can play in development and public health management, the Asian Development Bank (ADB) established the Health Sector Reform Project (HSRP) in 2005, with the aim of creating various reform initiatives, including those relating to Health Management Information Systems (HMIS). One of the four authors of this article was invited by the ADB to participate in the HMIS-related reform efforts. He enrolled the three other authors to create a joint team responsible for the design, development, and pilot implementation of the national HMIS. However, carrying out these tasks was fraught with immense challenges, most of which were related to countering the policies of the existing institutions left behind by the Soviet legacy, which favored a large manual system based on a centralized planning model. The research team’s key efforts revolved around understanding and addressing these historical conditions and trying to create new institutions that were based on a computer-based HMIS and favored local analysis and use of information. These efforts resulted in two key research questions:

• What are the key institutions that challenge the introduction of ICT-based HMIS reforms in the context of a post-Soviet economy?

• What theoretical concepts inspired by institutional theory could help us to understand deeply the nature of these challenges, and how may these be addressed?

The remainder of the article is organized as follows: In section 2, we propose key theoretical concepts from institutional theory that help to develop our analysis; section 3 provides a brief summary of the research methods used; section 4 discusses the details of the case study; and section 5 presents the case analysis, based on institutional theory. That is followed by a concluding section on discussions and contributions.

2. Theoretical Perspective: Institutional Logics and Deinstitutionalization

The theoretical aim of the article is to develop concepts that can identify existing institutions that shape the deployment of computer-based HMIS and their associated processes. The concepts of institutional logics and deinstitutionalization provide a framework for this by helping us to categorize actions and artifacts as belonging to underlying themes that represent the various forces in play, as well as to analyze the interplay among them. First, though, we present an overview of institutions and institutional theory, as applied to the information systems field.

The basic building block of institutional theory is the concept of institutions, which has been diversely defined within the domains of economics, political science, and sociology. For example, economic historian Douglas North defines institutions as human-devised rules in a society that shape human interactions, or the “rules of the game” (1990, p. 3). While formal rules include political rules, economic rules, and contracts, informal rules include taboos, customs, and traditions (Jepperson, 1991). Both formal and informal institutions help to give pattern to human or organizational behavior by enabling and constraining their activities.

In the context of sociology of organizational studies, the definition of institution has been expanded by DiMaggio and Powell to include the unintentional activities of human beings, an aspect not covered in the definition of North. “While institutions are certainly the result of human activity, they are not necessarily the products of conscious design” (1991, p. 8). From a sociological perspective, Jepperson elaborates on institutions as follows:

[In]stitution represents a social order or pattern that has attained a certain state or property; institutionalization denotes the process of such attainment. . . . [O]rder or pattern . . . is conventional to standardized interaction sequences. . . . [W]hen departures from the pattern are counteracted in a regulated fashion, we refer to a pattern as institutionalized. (1991, p. 145)

In trying to reconcile the multiplicity of definitions given by various researchers, Scott defines institutions “as multifaceted, durable social structures, made up of symbolic elements, social activities, and material resources” (2001, p. 49). In a subsequent publication, Scott elaborates on the distinctive properties of institutions, as they are resistant to change and tend to be transmitted across generations through different mechanisms, by argu-
ing that “institutions are comprised of regulative, normative and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life” (2008, p. 48). This article draws from Scott's definition, further articulating how conflicting institutional logics erode what are seemingly stable institutions and contribute to the creation of new ones.

**Institutional Theory in IS**

In IS research, an increasing number of studies have adopted an institutional perspective to examine processes of IT development, implementation, and use, with a focus on institutional influences on technological changes (Orlikowski & Barley, 2001). For example, an early study by Kling and Iacono (1989) shows how a computer-based IS with stable structures was difficult to change. However, Fountain (2001) criticizes IS studies for ignoring the role of IT in shaping existing institutions, and for not acknowledging the reciprocal effects between institutions and technology. In a similar vein, Averou (2002) argues that IT, on its own, can be considered as an institution that can be seen to account adequately for the processes of transformation of organized activities in a society. From the perspective of HMIS, Noir and Walsham (2007), drawing on empirical material from the Indian healthcare sector, describe the ceremonial roles that “ICT for development” plays in legitimizing development initiatives. Similarly, based on their work in Ethiopia, Mekonnen and Sahay (2009) discuss how a computer-based IS with stable structures was difficult to change. However, Fountain (2001) criticizes IS studies for ignoring the role of IT in shaping existing institutions, and for not acknowledging the reciprocal effects between institutions and technology. In a similar vein, Averou (2002) argues that IT, on its own, can be considered as an institution that can be seen to account adequately for the processes of transformation of organized activities in a society. From the perspective of HMIS, Noir and Walsham (2007), drawing on empirical material from the Indian healthcare sector, describe the ceremonial roles that “ICT for development” plays in legitimizing development initiatives.

**Institutional Logics**

The concept of institutional logics was initially introduced by Alford and Friedland (1985) to describe contradictory social practices, though it was subsequently expanded by others (e.g., Thornton & Ocasio, 1999, 2008; Scott, Ruef, Mendel, & Caronna, 2000). For example, Thornton and Ocasio define institutional logic as “the socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality” (1999, p. 804). These logics inscribe the “organizing principles” that supply practice guidelines to field participants, guiding both the means and ends of individual behavior (Friedland & Alford, 1991). Institutional actors, then, can be viewed as agents and carriers for producing and reproducing the logic within a specific institutional environment (Scott et al., 2000).

Institutional logics work at different levels, both within institutions, such as health services, and between institutions, such as the various professions engaged within health services. In addition, actors are part of other institutions that are apart from, though not independent of the institution in question. For example, religion, marriage, cultural, and ethnic boundaries carry their own logics to govern behavior (North, 1990; Ingram & Klay, 2000), and people engaged in the health sector also operate within the boundaries of these institutions. Decisions are thus not only based on individual agency, but are greatly formed by the institutions in which actors operate, and from which they draw legitimacy and identification (Jackall, 1988; Friedland & Alford, 1991).

Institutional logics are never homogeneous; within an organization, multiple logics may be simultaneously in play, contributing to institutional contradictions (Friedland and Alford 1991). For example, in the context of Geographical Information Systems (GIS) use in the forestry sector in India, Sahay and Walsham (1999) elaborate on two logics in play. The first concerns how foresters make decisions on forest management based largely on political and social considerations, such as the Minister of Environment and Forests wanting to implement water conservation activities in his political constituency. The second concerns the contradictory logic inscribed in the GIS, which is itself based on making such decisions (of locating forestry interventions) via scientific modeling enabled through the GIS. The interplay of these two logics, Sahay and Walsham point out, contributes to the less-than-effective uptake of the GIS in the forest department.

Such contradictory logics can also provide the potential for eventual change. Thornton and Ocasio (2008) discuss four mechanisms of change: (a) insti-
tutional entrepreneurs, who are agents of change and play a critical role, taking advantage of the position they assume in social locations; (b) structural overlap, which occurs when previously distinct organizational structures are forced into association; (c) event sequencing, or the temporal and sequential unfolding of events that dislocate and transform interpretation and meaning of cultural symbols; and (d) competing institutional logics that may facilitate resistance to change and can be pre-existent or a consequence of change. For example, Currie and Guah (2007) illustrate how competing institutional logics (the change initiator vs. healthcare practitioners) influenced an IT-enabled change in six UK National Health Services. It is also worth noting that institutional change brought on by a change in the institutional logics does not necessarily happen from the periphery. The exposure to different institutional logics may increase the awareness of shortcomings of the dominant logics and enable central actors to become institutional entrepreneurs (Greenwood & Suddaby, 2006; Thornton & Ocasio, 2008).

Deinstitutionalization

Negotiating and reconciling conflicting institutional logics may contribute to the deinstitutionalization of the existing logic and re-institutionalization of the new (Jepperson, 1991). Deinstitutionalization is “a process by which institutions weaken and disappear” (Scott, 2001, p. 182), and it “takes place when established meanings and action in an organization are discredited, either as a result of competing meanings and actions or because they are seen as failing to contribute to the institutional raison d’être” (Avgerou, 2002). Further, Oliver describes deinstitutionalization as the process by which the legitimacy of an established or institutionalized organizational practice erodes or discontinues. Specifically, deinstitutionalization refers to the delegitimation of an established organizational practice or procedure as a result of organizational challenges to or the failure of organizations to reproduce previously legitimated or taken-for-granted organizational actions. (Oliver, 1992, p. 564)

Oliver points out three key factors that contribute to deinstitutionalization: political, functional, and social. Political pressures may evolve under threat of erosion or displacement, as new and emerging practices may challenge the utility and legitimacy of existing ones. Functional pressures relate to technical or functional considerations that may compromise or raise doubts about the instrumental value of an institutionalized practice. Social pressures include increasing normative fragmentation within an organization as a by-product of other changes, such as increasing workforce diversity or addressing the problem of high turnover. There can be disruptions to an organization’s historical continuity, such as mergers, or changes in state laws that can prohibit or discourage the perpetuation of an institutional practice and its associated deinstitutionalization. For example, Nicholson and Sahay (2009) observed the role of dissensus and consensus—around both political and cultural factors—in the software exports policy-making process in Costa Rica, with the former leading to erosion of institutions, and the latter reinforcing existing institutions. Apart from intentional change processes (for example, purposely dissenting), there can be unanticipated or unintentional consequences of purposive activities leading to new institutions (Hwang & Powell, 2005). Moreover, Currie (2009) illustrates how functional pressures were confronted by normative pressures in deinstitutionalizing the existing professionally dominated UK healthcare sector to a new institution based on market mechanisms.

In summary, the focus of our theoretical analysis is to first identify the existing and proposed institutional logics surrounding the introduction of computer-based health management information systems in Tajikistan. The concept of deinstitutionalization further helps us to theoretically understand the interplay between different logics, why certain logics stay, why others erode away, and what social, political, and functional pressures contribute to this.

3. Research Methods

Research Approach

A useful method to develop and implement an HMIS in developing countries, suggested by Braa, Monteiro, and Sahay (2004), is that of action research, based on the principles of “networks of action” (p. 339). They build this argument within the context of a global interaction identified as the Health Information System Programme (HISP), which involves, among other things, the design, development, and implementation of a free and open-
source software called the District Health Information Software (DHIS). Taking their point of departure of trying to address the commonly perceived problems of lack of sustainability and scalability of HMIS in developing countries, the three authors draw on Elden and Chisholm (1993) to argue for the need to carry out action research in networks, rather than in singular units. Such an approach, they argue, provides the potential for multiple sites to learn with each other, share experiences and knowledge, and plan and implement action in a context-specific manner.

With this in mind, we applied an action research approach and addressed the question of network-building at both a global and local level:

1. Global level: Examine how the global HISnet network could be leveraged to support the process of adaptation to the local context of Tajikistan, and mutually, how the global network could learn from the Tajikistan experience.
2. Local level: Within Tajikistan, understand what kind of sociopolitical, technical, and health-related networks could be mobilized to support overall project aims of HIS-related reforms.

The specific interventions that we carried out with respect to building these networks of action at the two identified levels are summarized in Table 1.

**Data Collection Methods**

Data were collected through various means. The following two tables summarize the data collection methods applied. While Table 2 provides detail about the type of methods we used and when they were conducted, Table 3 sums up the respondents by institution, issues raised, and length of the interview.

**Data Analysis**

At the end of the intervention in Tajikistan, while organizing our material, it became clear that most of the challenges encountered could be ascribed to different mindsets. This led to a categorization of events into these conflicting mindsets. The interview transcriptions and meetings notes were increasingly seen in this light, and we distilled the underlying assumptions that led to the different views. This, in essence, led to the institutional logics discussed in this article, while the literature review was not initially focused in this direction. It increasingly became clear, however, that theories of institutional logics provided us with the language to analyze and communicate these findings.

**4. Case Study**

The project started when a University of Oslo professor was invited by the ADB (Asian Development Bank) to work with HSRP on the design, development, and implementation of a computer-based HMIS in Tajikistan. The project was carried out over an intensive period of about three months from November 2007 to early February 2008. Broadly, the project components involved an initial situation analysis and identification of local technical partners, followed by a month of systems development and the pilot testing of the first prototype, and then by two weeks of initiating pilot testing in one district (Kulyab). The case narrative is structured in two sections: (a) the existing situation that highlights institutional logics already at play; and (b) the HMIS intervention, which summarizes proposed institutional logics. In both these sections, the focus is on artifacts and processes, which are the manifested expressions of the institutional logics we studied. At the end of each section, we have distilled out the institutional logics they represent.

**Existing Situation: Institutional Logics at Play**

Central control of the HMIS was under the Medical Statistics division (MedStat), which, true to its name, treated the HMIS as an annual statistics-generating tool. The MedStat division used out-of-date software (also called MedStat) built on a FoxPro platform that basically was capable of entering data on the existing 37 reporting forms by the facilities and generating the aggregated reports by rayons, oblasts, and nationally. From the reporting forms, two were reported monthly, and the rest were done annually. MedStat was not capable of generating any indicators (such as percentages or rates per thousand that required calculation with a numerator and denominator). For this purpose, the required

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1. Rayon and oblast are the Tajikistani equivalents of district (typically 50,000 to 100,000 inhabitants) and province (10 to 15 districts), respectively.
data were fed in separately to a WHO-created program called Data Presentation System (DPS), and the generated indicators were uploaded into a national Web site. Another program, Factor, obtained data from the oblasts on five variables related to maternal health. Electronically, the three programs did not “speak to each other,” despite all being under the control of the MedStat division; the IT specialist said there were no plans to further upgrade the MedStat software.

Below the level of the 37 forms that corresponded to different health programs (with a great deal of overlap and redundancies) were another 367 recording forms used at the primary health facilities to record the provision of basic services. At the rayon level, the different health programs put their respective data on MedStat forms, which were then sent to the corresponding oblast health program, as well as to the Statistical Department at the Central Rayon Hospital. Further, there were parallel reporting systems in place, with both the health programs and the MedStat department sending the same information to their corresponding superior level. However, since the MedStat software was not compatible with other software, computer use was limited. A tuberculosis (TB) program manager described this:

Also, we have 16 computer specialists, but only in Kulyab and Dushanbe. But the problem is we cannot use the data from Kulyab and Dushanbe which is entered in Epi Info, because we have to adapt the data to be entered in MOH formats. So, to MedStat, we only send data on written form . . . this is a structure which is more than 75 years old. (TB program manager, Dushanbe, November 2007)

Further, poor IT resources in particular health divisions further impeded the use of computerized data, as related by a deputy director of the national TB program:
We want to include all data in Tajikistan, but some is always missed. Now we need one IT specialist and train him full time to work on Epi Info. How we reach the 66 centres, when we have no budget, no travel money, no nothing? (Deputy director of the national TB program, Dushanbe, November 2007)

Further impediments to the use of computers were the availability of and permission to use paper. We were told that paper was not regularly provided, and that the limited budgets did not allow for its local purchase. For instance, in the Kulyab district, the yearly budget for gasoline would be spent in just a couple of weeks of normal activity, so the purchase of paper was not a high priority. A donor agency senior official narrated how inventive methods were applied to produce reports at the local level:

When asked how the reports were prepared, he (a doctor at the rayon level) said he will tell (about how reports were prepared) if his name is not quoted. He said he bought one chocolate to the room of the specialist responsible for the data. The specialist generated the report for the whole district. We (the aid agency official) told [the director of MedStat] that this is the cost of

Table 2. Overview of Data Collection Methods.

<table>
<thead>
<tr>
<th>Type</th>
<th>Nature and volume</th>
<th>When</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviews</td>
<td>10 at national</td>
<td>Situation analysis</td>
</tr>
<tr>
<td></td>
<td>6 at district</td>
<td>Pilot implementation</td>
</tr>
<tr>
<td>Presentations</td>
<td>4 for Asian Development Bank (ADB), Ministry of Health (MOH), donor partners, and closing presentation for HSRP, MedStat, and MOH.</td>
<td>Situation analysis and at end of project</td>
</tr>
<tr>
<td>Workshops</td>
<td>Training and discussions: one for national level participants, one for province and district level, and one in pilot district for district health programs</td>
<td>Launch of Version 1: Tajikistan HMIS and pilot project</td>
</tr>
<tr>
<td>Document study</td>
<td>Previous projects reports, current reporting forms</td>
<td>Situation analysis</td>
</tr>
<tr>
<td>Informal discussions</td>
<td>Numerous with HMIS consultant, HSRP staff, local software developers</td>
<td>Daily</td>
</tr>
<tr>
<td>Participant observations</td>
<td>Use of MedStat software at national and district level. Study of information flows and practices around recording of data, use of registers, and so forth</td>
<td>Regularly</td>
</tr>
<tr>
<td>Data collection through e-mails</td>
<td>E-mails with HMIS consultant, software team, and among ourselves</td>
<td>Continuous and ongoing</td>
</tr>
<tr>
<td>Software prototyping</td>
<td>During definition of datasets, creation of reports, identification of controls</td>
<td>Continuous and ongoing</td>
</tr>
</tbody>
</table>

Table 3. Interviews Conducted.

<table>
<thead>
<tr>
<th>Institution</th>
<th>Respondents</th>
<th>Types of issues raised</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Different national health programs</td>
<td>Deputy director or director level</td>
<td>Current system and its challenges, data quality, information needs, information gaps</td>
<td>1.5 hours</td>
</tr>
<tr>
<td>Different district health programs</td>
<td>District or central district hospital program directors</td>
<td>Information flow, use of information, reporting routines</td>
<td>30–45 minutes</td>
</tr>
<tr>
<td>International NGO</td>
<td>Country representative and HMIS representative</td>
<td>Past experiences of HMIS implementation in which they were involved</td>
<td>1.5 hours</td>
</tr>
<tr>
<td>Local software entity</td>
<td>Director and staff</td>
<td>Technical and infrastructural challenges related to software implementation</td>
<td>1.5 hours</td>
</tr>
</tbody>
</table>

We want to include all data in Tajikistan, but some is always missed. Now we need one IT specialist and train him full time to work on Epi Info. How we reach the 66 centres, when we have no budget, no travel money, no nothing? (Deputy director of the national TB program, Dushanbe, November 2007)

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When asked how the reports were prepared, he (a doctor at the rayon level) said he will tell (about how reports were prepared) if his name is not quoted. He said he bought one chocolate to the room of the specialist responsible for the data. The specialist generated the report for the whole district. We (the aid agency official) told [the director of MedStat] that this is the cost of
Given the huge amount of the data to be reported (about 30,000 data elements) on a routine basis, the extremely poor HMIS-related resources, and the view that reporting was an irrelevant exercise, data quality obviously suffered. The head of the HMIS task force at the MOH admitted that the use of the ICD 10 codes for classification was fraught with errors, and he estimated that 35% of the data in this system would be incorrect from classification errors itself.

The reporting forms were poorly designed and comprised multiple subforms. For example, we found a form titled “Treatment Prophylactic Activity of Facility” that contained about 50 subforms, covering 1,836 data elements and spanning about 75 pages. This “gigantomania” fostered intermediate forms that were designed locally for local use. For example, the Infectious Diseases Department at the central district office provided what they called an “emergency form” that listed eight essential diseases (with space left for others) reported by the different rural health centers (shown as columns). This form (Figure 1) was used for local purposes in addition to the standardized recording and reporting forms that were prepared for national reporting.

Based on these findings, we identified two key institutional logics at play. They were not the only institutional logics identified, but they were dominant and stood out because they so clearly contradicted what we tried to introduce (see next section for explanation). The first was a central planning logic—perhaps a set of logics—where a curative, rather than preventive, approach was taken. This was evident by how the data were collected for top-level use only, with the focus being on collecting raw data, rather than on calculated indicators, on an annual basis. Supporting this was the HMIS-inscribed logic, where we found the system to be built for one purpose only: the provision of statistics for central planning. It was not designed to support local use, as evidenced by the extra emergency form that the Kulyab district office had developed for this purpose. Related to this is the gigantomania we mentioned earlier of wanting to cover—to the smallest detail and on a routine basis—all data that could be related to health. For much of the data, it makes more sense to do periodic surveys, rather than to aim for complete national coverage of data collection every year. The other key logic was one that linked to paper technology, in that once the forms had been agreed upon, they could not be revised before the end of the five-year planning period. Even when showing how improvements could be made to the forms, the perceived costs of such action were based on a completely paper-based system. In a computerized environment, this rigidity becomes meaningless.

The existing institutional logics we identified are summarized below:

- Central planning for statistics management (supporting curative rather than preventive health), based on:
  - Centralized structure rather than decentralized.
  - HMIS as annual statistics-generating tool.
  - Gigantomania collection of extensive data signals, seriousness, and scientific vigor.
Rigidity of paper means that decisions are final and static for the duration of planning cycles. Computers can be employed to automate paper-based systems.

**HMIS Intervention: Proposed Institutional Logics**

The proposed HMIS was a system based on a free and open-source HMIS application designed and developed under the HISP network (Braa & Hedberg, 2002). The institutional logics behind our suggestions were based on: (a) a belief that local decision-making produces the quickest and most appropriate response to emerging health issues, based on routinely collected essential data; (b) the HMIS thusly being indicator-driven, so as to be able to compare across time and space, as well as to collect data that is necessary for taking local action, which we strongly believe is the result of; (c) a much smaller data set to reduce the burden of collection, improve quality, and enable decision makers to process it adequately; and (d) technology's role being to internalize routine aggregation, increase flexibility, and decrease response time, rather than to increase the capacity and speed of a system that adhered to a paper-based design logic and five-year planning cycles.

A first step in the design process was the reorganization of the existing data forms. We proposed to organize health data in relevant health categories rather than on forms. Further, we suggested that data be organized into two broad categories: routine data (reported monthly) and semi-permanent data (reported annually).

In addition, we suggested a radical reduction of data to be collected and a shift to indicators (rates and ratios), rather than just data elements (counts). A smaller system would have a positive impact on both time consumption for data entering and ambiguities related to correct use. Hopefully, it would also help to improve the level of data quality. Through shifting the focus from counts to indicators, the data would assume relevance for decision-making across time and space.

However, our proposal for redesign based on data sets (and not forms) was rejected. We were told that the Central Statistics Authority had approved the existing 37 reporting formats, and that we were not even allowed to change or add a logo to the form. We were not even allowed to change the location of a single piece of data in the existing formats. So, we then made a design decision that each of these reporting formats would represent a data set, with groups defined in each of them, and with each corresponding to a subform. Our design approach, then, resulted in the development of a maximum data set, rather than a minimum data set. We rationalized this rather unpleasant decision to automate existing inefficiencies by telling ourselves that this one-to-one approach would allow us to input the existing data into the computer. This step could then be followed with analysis of existing data, which would make the poor data quality visible to the planners, and thus allow us to make a stronger argument for applying a minimum data set approach in the next iteration. But, as the World Bank representative noted, a smaller system was not seen as compatible with central planning, and he was skeptical about our chances of success:

> We wanted to simplify the system. When the consultant showed the MOH a system with 15 indicators, they laughed, how can it meet the needs of the health system? They laughed and did not accept it. This is the paradox—we want a huge system, but don't have the money. They are suspicious of small systems. (World Bank representative, Dushanbe, November 2007)

The issue of control rules is worth mentioning. The tabular forms in MedStat required many data items to be recorded twice. For each row item, such as Malaria, there would be columns both for age groups and gender, as well as a column for the total. Data would then appear twice, both in a specific age group and in the total. In the software application (DHIS) introduced, data items could be calculated automatically by aggregating other items; totals, then, can be produced on demand and not have to be entered at all. This could reduce the amount of data items by around 3,000. However, this automatic aggregation of totals was not to be implemented, as it was still the MedStat administration's intent to manually enter totals and then run checks on them against their various components. This function had been included in MedStat software with a set of so-called “controls.” These controls made sense in a paper system, where manual aggregation into totals could produce errors. This “paper verification logic” was applied to a computer system where the possibility of manual aggregation...
error could be eliminated altogether. The MedStat team insisted that development of the same set of controls in DHIS as in MedStat be a compulsory requirement. These examples of often-contradictory assumptions and directions point to the different underlying institutional logics in play; they also helped us to identify our beliefs and assumptions as also being rooted in certain logics.

The HMIS intervention-related institutional logics we identified are summarized below:

- Decentralized decision-making, based on routine data, specifically:
  - HMIS is indicator- and action-led.
  - Small, essential data sets best support action and improve data quality.
- Computer systems should be employed to internalize routine aggregation, increase flexibility, and decrease response time to changes in epidemiological information needs.

5. Analysis: Interplay of Logics and Implication on Deinstitutionalization

In the case study, we elaborate on the institutional logics found to be in play when conducting the situation analysis of the HMIS in Tajikistan, as well as the logics that we believed were inscribed in the HMIS-related intervention that we were seeking to introduce. In this analysis section, we will describe the interplay of these two sets of logics and how this shaped the deinstitutionalization process we wanted to bring about in the existing HMIS. Specifically, we discuss two sets of interplays:

1. Statistics for central planning and control versus using information for decentralized action
2. Rigidity of paper-based reporting formats versus the flexibility of customizable electronic forms

Statistics for Central Planning and Control Versus Using Information for Decentralized Action

The Tajik system is a historical product of a Soviet system of governance, and nearly two decades after the collapse of the USSR, the deep-rooted Soviet institutions can still be seen in play. In another context of collectivization (before WWII), this has been described by Scott (1999) as “gigantomania,” referring to the focus on trying to collect huge amounts of data as a form of centralized planning and control. In the post-Soviet system in contemporary Tajikistan, the routine health system seeks to collect data on more than 30,000 data items relating to all kinds of diverse items, such as soil samples, airplane vibrations, and cigarette smoking, as well as health programs.

Further, the Soviet system prides itself on being based on a strong scientific foundation. This historical tendency is reflected in the Tajikistan’s MOH decision to use the full version of the ICD10 system. The implication of this was that each disease was classified by various codes, and that each code had various subcodes and sub-subcodes. In the Soviet era, when there was a high level of scientific and technical experts, the data collected from the peripheral levels was subjected to a serious scientific scrutiny at the central level. Now, however, the number of such experts has been dramatically reduced. While similar levels of detailed data are expected to be collected, there has also been a simultaneous decrease in both the capacity to collect good quality data and in the skills to analyze and use the data.

In contrast to this existing system, the HISP philosophy—under which all authors have been working for years in other countries—toward HMIS development can be seen to be a historical product of postapartheid 1994 South Africa, a period of ANC-driven reform that was based on an agenda emphasizing decentralization and integration (Braa & Hedberg, 2002). Within this context, the HISP project sought to develop free and open-source software that could be installed at the local levels. Large-scale capacity-building programs would be carried out to empower health workers and compel them to use information for local action. These principles and practices of the HISP initiative were inscribed into the design of the DHIS software, which emphasized local flexibility and user control, and became part of the training material used for processes of capacity-building for the health staff.

However, adapting these principles of use of information for local action in Tajikistan would involve incorporating a whole range of HISP principles, including the creation of a minimum data set, the linking of data being collected with indicators, and the implementation of large-scale capacity
building programs of the health staff, with a focus on the use of information at the local level. However, we soon realized that these aims were unattainable in the present scenario. First, no permission could be obtained to make any changes—even the removal of duplicate data elements included in the same form. Further, the system we found was not mature enough to absorb the shock of these large-scale and radical changes. Since even the basic information processing systems were not in place, such as those for collecting quality data, it was too ambitious on our part to expect local staff to start on the analysis of data. Further constraints included the poor capacity of the health staff, very weak infrastructure, and the extreme climatic conditions that made it difficult to travel to the districts to carry out the training programs.

The interplay of the two sets of logics thus resulted in our adapting a strategy of maintaining the status quo in terms of the reporting forms, their numbers, and their design, but by translating this status quo into an automated form. We reasoned that the information inscribed in this status quo system would spotlight the poor quality and the absurdity of the current design. We believed this could help us make a stronger case for change in the future, and when changes were approved, we would be able to easily adapt the system to the flexible DHIS-based HMIS application.

Rigidity of Paper-based Reporting Formats Versus the Flexibility of Electronic Customizable Forms

For both institutional and technical reasons, the paper formats in use were inscribed with a deep sense of rigidity. Institutional reasons for this included the costs associated with the production of new formats, the logistical problems of reproduction, and the difficulty of distributing them to hundreds of facilities, some of which were located in geographically inaccessible regions. The size of the individual forms made the task of changing a paper-based form daunting. Furthermore, the existing forms had only recently been approved by the Central Statistical Authority, so no further revisions could be made for at least five years, which corresponded to the national planning cycle. The technical reason contributing to the rigidity of the form was their much-cluttered design, full of multiple rows and columns. Some of the forms had approximately 250 rows and 12 columns, making them very difficult to modify in technical terms.

Bathed in the philosophy of flexible systems and local action, HISP saw forms as something very flexible that could be modified at will, based on user needs. The entire software had been built on a modular structure, and changes could easily be made at the data entry level without affecting other parts of the system. Furthermore, some technical innovations were created by the software development team, particularly the “multi-dimensional” data element that was developed to replace the existing uni-dimensional data element. Through this innovation, previous multiple uni-dimensional data elements (for example, children in different age categories were treated as different elements) could now be treated as a single data element (children) having multiple categories (representing age groups). This innovation was combined with the development of a customized data entry screen that replicated the paper form versus having to enter data through a list of data elements organized vertically. The following screen shots (Figures 2 and 3) illustrate the two systems of data entry. The combination of these two technical innovations provided our team with a great deal of flexibility in the design of the forms.

The interplay of these two logics occurred when we started to make suggestions in the design of the screens, showing how space could be used better, or by making aesthetic-based improvements. However, we still did not get permission to make changes. When we suggested trying out some new designs on an experimental basis—we could revert back to the original design if they did not work—we were again denied permission to make these kinds of revisions.

Interplay of Logics and Implications for Deinstitutionalization

As Oliver (1992) has pointed out, deinstitutionalization arises from social, political, and functional pressures. If these pressures gain enough momentum, they can create a sense of dissensus in the existing institutions and provide the impetus for their dissipation or erosion. In the case we described earlier, the interplay of the institutional logics could show a great deal of functional dissensus and demonstrate how the existing system was operationally inefficient, based on receiving poor quality data and
providing data that could not be used. We demonstrated this functional deficiency through our analysis; for example, we showed that nearly 90% of the data was being reported as zeros or blanks on some of the forms. We also argued that while a huge amount of data was being collected, no indicators were being used. The Ministry of Health, however, insisted that all data being collected were being used as indicators. When we showed examples to the contrary, they were simply dismissed as being exceptions.

A degree of social pressure had been placed on the MOH to reform their HMIS through efforts of the World Bank and the ADB that had created specific structures (for example, the HSRP office) for guiding reform efforts. However, as the HSRP was an independent structure and had a time-bound life of three years, its recommendations were non-binding for the MOH. On the political front, we failed to create adequate momentum and pressure to trigger change. The political decision-making center was at the MOH, an organization closely aligned with MedStat, so our influence there was minimal. Our alignment was with the ADB, primarily considered a donor (and that in the form of loans) and thus not sufficiently powerful to enforce change.

In summary, it could be seen that the interplay of logics primarily occurred on the functional domain. Confronted with a strong, historically embedded system, we could hardly make a dent on the political domain. However, where we did succeed was in creating some seeds of change, primarily by building a system with an inscribed flexible logic that could be modified into a more effective HMIS in the future (when political conditions might be more favorable). Also, through our various reports and presentations, we introduced new discourses into the HMIS reform efforts, such as those related to use of information, use of indicators, and data quality and validation.

So, while some seeds for deinstitutionalization were planted, there was not adequate political pressure for deinstitutionalization to take place at the time. We should also note that institutional change processes can be painfully slow. Future efforts in this direction could focus on gathering a critical mass of supporters with enough power to influence these change processes. However, while arguing for even piecemeal change at the ministerial level, we found a reflection of our own ideas and philosophies in the pilot district of Kulyab. There, the so-called emergency form captured precisely the kind of logics with which we had become acquainted in
South Africa. The district needed a limited set of data on notifiable diseases to be able to manage and assist its rural health centers in case of an outbreak. This form was not part of the official HMIS, but the doctors and managers maintained this extra system, despite all the work they required to complete the official forms. From this, it is clear there were domestic seeds of conflicting logics, but the (weaker) district’s strategy was to avoid conflict. The training in data analysis in Kulyab, using local data, was met with a degree of enthusiasm beyond what would be found at the national level. These local-central differences in logics guiding behavior were also found in a similar study in Cuba (Sæbø & Titlestad, 2004), a country sharing some political and economic history with Tajikistan.

7. Conclusions

The interplay of the two sets of logics basically involved two paradigms, which at one level were irreconcilable and could not coexist. However, we believe that in such a historically embedded system, a paradigm shift could only come about if mandated explicitly from the top political authority—the health minister. While local level incremental efforts may be useful to create some local expertise and knowledge, these lower levels have no authority or voice to influence change. The strategy of local empowerment, which had worked for the HISP project in South Africa, was a product of the historical moment that existed, one arising from the breakdown of the apartheid system and the political agenda that mandated decentralization and integration.

This study makes some interesting contributions to the IS field. First, it brings into focus a study from a country that, to date, has been nearly invisible to the IS community. Hence, the article expands the already existing knowledge about IT-enabled HMIS change process in developing countries. Second, it contributes to the debate about bottom-up and top-down implementation models by arguing that such decisions are products of historical circumstances, and that bottom-up, though ideologically appealing, may not be always most effective. Third, the conceptual framework of institutional logics, their interplay, and implications for deinstitutionalization provides an interesting approach to study implementation experiences more broadly, not just HMIS in a post-Soviet republic. In other circumstances, there would be different forms of logics in play; studying them would provide rich insights into the implementation dynamics.

References


INTERPLAY OF INSTITUTIONAL LOGICS AND IMPLICATIONS FOR DEINSTITUTIONALIZATION


AN INSTITUTIONAL PERSPECTIVE IN SHAPING mHEALTH SYSTEMS FOR DEVELOPING COUNTRIES: CASE FROM INDIA

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Abstract: Information and Communication Technologies (ICT) are revolutionizing the healthcare domain of developing countries. Parts of these ICTs are mHealth solutions that caught the attention of multiple institutions. The current literature of mHealth has served very well in documenting existing practices and implementations experiences of mobile phones in healthcare domains of developing countries. However, there appears little reported on the role that institutions play in shaping mHealth as the focus has been on the potential of mobile phones and their technological characteristics. Trying to redress this imbalance, the focus in this paper is to understand key institutions that shape design and development process of mHealth solutions targeting the context of developing countries. The paper builds from an empirical material obtained from an ongoing action research that the author has participated. Drawing from the case, the paper provides a framework that conceptualizes the design and development process of mHealth as an organizational field that represent an area of institutional phenomenon identifying the key institutions and their interplay. The institutional analysis carried out helps to highlight the impact of institutional forces on the design and development of ICT for the healthcare domain of developing countries.

Keywords: mHealth, health information system, IS design and development, developing country, institutions, organizational field, institutional theory.
AN INSTITUTIONAL PERSPECTIVE IN SHAPING mHEALTH SYSTEMS FOR DEVELOPING COUNTRIES: CASE FROM INDIA

1. INTRODUCTION

Information and Communication Technologies (ICT) are revolutionizing the healthcare domain of developing countries. Emerging part of these ICTs are mHealth solutions that caught the attention of multiple institutions for efficient and effective health service provision. Currently, mHealth projects for the developing world are abundant and mobile phone use for development is taking off. mHealth has become an important area of collaboration interlinking various forces of institutions – an area which we haven’t understood in detail.

mHealth is a term for medical and public health practices supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices. mHealth solutions include the use of mobile devices in collecting community and clinical health data, delivery of healthcare information to practitioners, researchers and patients, real-time monitoring of patient vital signs, and direct provision of care (Germanakos, Mourlas and Samaras 2005). mHealth “involves the exploitation of the mobile telecommunication and multimedia technologies” (Istepanian and Lacal, 2003). Among the range of mHealth applications the focus, in the context of developing countries, has been on the potential of mobile phones for tackling challenges of public health services in new ways. This includes efforts to achieve some of the targets of Millennium Development Goals (MDG) – reducing child mortality, improving maternal health and combating HIV/AIDS, malaria and other diseases. In these targets and efforts, mobile phones have demonstrated a promising potential for collection and reporting of accurate and timely data and also for education and capacity building for rural community health workers (Mishra and Singh, 2008; Vital Wave Consulting, 2008, 2009).

In the mHealth literature, attention has been primarily on the technical aspects of mobile phones – for example rate of subscription, cost, geographical coverage, electricity for charging, power of computing and communication (GSM, 2007; ITU, 2008a; ITU, 2008b; Vital Wave Consulting, 2008, 2009). A huge part of the literature presents reports with fragmented and anecdotal success stories of mobile phones for data collection and reporting in most cases without a strong theoretical basis. However, what we are witnessing in mHealth is actors representing a range of institutions which we haven’t seen before. The actors range from international donors, political bodies, mobile phone vendors and telecom operators to local policy makers, commuting community health workers and health administrators. Acknowledging the respective roles of these institutions in shaping the mHealth system, this paper seeks to theoretically understand the phenomenon by investigating the following two research questions:

- What are the key institutions that shape a mHealth system for rural healthcare settings of developing countries?
- How can an institutional analysis help in understanding the shaping process of mHealth design and development efforts of developing countries?

Answering these questions arguably provides significant contribution to the Information Systems (IS) research that has limited study on the impact of institutions on design and development process of ICT targeting the developing world. The empirical material informing this paper is drawn from an ongoing action research project called Health Information System Program (HISP). HISP aims to support the improvement of healthcare systems in developing countries by increasing the capacity of health personnel to make decisions based on timely and accurate information. The author, also part of HISP, is involved in design, development and piloting.
activities of a mHealth system that targets developing countries in general (India in particular). Before presenting the empirical material, first a discussion of the theoretical framework is presented. Institutional theory is applied to identify the key institutions that shape the mHealth system. Following the theoretical framework, methodology and the case description are presented. Finally a concluding section, containing discussions and contributions, is presented.

2. THEORETICAL FRAMEWORK

Theoretically, this study intends to develop a lens that can help to understand the different institutions that interplay in shaping mHealth systems for the public health context of developing countries. The paper considers mHealth as a field that contains actors from multiple institutions and seeks to identify the major players, their playing rules, norms and values using the theory of institutions.

Scott sees institutional theory as an extension of open systems theory that got introduced during the 1960’s intellectual revolution. Open systems theory focuses on inputs and outputs insisting on the importance of the environment as it shapes systems (Scott, 2008). The environment recognized with open systems, however, was primarily a technical one composed of production resources and task-related information. Later institutionalists emerged with a holistic view that environments are not merely technical production systems, but also of strong and wider economical, political and socio-cultural forces. A number of IS researchers draw from such a view of institutional theory for example

1) to suggest its potential for a better understanding of material properties of IS and its interaction with organizing and work practices (Orlikowski and Barely, 2001),
2) to study the sustaining institutional forces of IS innovation (Avgerou, 2000) and suggest that ICT is an institution by itself (Avgerou, 2002),
3) to explain the commitments of social actors in IS development (Butler, 2003),
4) to highlight the importance of not only formal but also informal institutions (Piotti, Chilundo and Sahay, 2006) and identify key sets of institutions that influence issues related to health information system implementation in developing countries (Kimaro and Sahay, 2007).

Detailed stock of institutional theory in IS research is provided by Mignerat and Rivard (2005, 2009). Along with documenting how scholars applied institutional theory in their studies, Mignerat’s and Rivard’s research also identifies conceptual and methodological issues that researchers need to address when adopting an institutional perspective. For example, in one of their concerns regarding units of analysis, they stressed IS researchers to look beyond an organizational level of analysis and look from organizational field level to better understand institutional forces that shape design and use of technical systems. Though not discussing systems development explicitly as an organizational field, Nicolaou (1999) used institutional theory to conceptually discuss the “role of social institutions in the field of information systems development” (p. 144). Following the field level perspective, this study considers mHealth design and development as an organizational field that accounts all the producers, resources, consumers, regulators and other relevant actors interacting in the healthcare ICT domain of developing countries.

The literature of institutional theory is somewhat complex and diverse with background ranging from economics, sociology, political science, history and ecology (Currie and Swanson, 2009). However, from the point of this paper three concepts of institutional theory are fundamental – institutions, organizational field and institutionalization. North defines institutions as rules that are devised to constrain (sometimes through punishment in case of violation) and enable (at times through rewards) human or organizational activities (North, 1990). The rules are both formal such as policies, constitutions, and contracts and informal like conventions, traditions and self-imposed
codes of behavior (Jepperson, 1991). For Jepperson, institutions represent a social order or pattern that has attained a certain state or property. Family, marriage, insurance, aid, healthcare, handshaking are for example forms that represent institutions.

While institutions are some forms of structures that shape activities of actors, institutionalization is a process by which structures are habituated to accepting norms, values and rules. According to Jepperson (1991), institutionalization is the process of attaining social order or pattern in some form of state or property by following a particular reproduction process. Jepperson also pointed out that the notion of order, pattern and repetitive production process should not be considered to suggest institutionalization is only about stability or survival. For example, while trying to habituate certain forms of structure, departure from the normal forms of actions or production processes could be faced – triggering some form of rewards and/or sanctions. Assume that the departure is rewarded and succeeded in instilling the new form or pattern by eroding the old one. This implies change or dynamics than stability or conforming to order, hence institutionalization. Factors for example political commitment, environmental change and culture could assist institutionalization (North, 1990; Scott, 2008). Scott outlines three mechanisms that underlie the process of institutionalization – increasing returns, objectification and commitments (Scott, 2008). Increasing returns account for reinforcement of existing institutions and benefits of economies of scale. On the other hand, increasing objectification accounts for the social construction of reality in objectifying and habituating shared beliefs. The central point in objectification is the interaction of actors. Actors interacting together form symbolic elements and concepts which are mental representation of each other’s action and objectify them for example in the form of routines, documents, software tools and best practices.

In the process of objectification, actors – for example individuals and organizations – often scan the outside world to understand what other similar actors are doing and learn best practices and similar trends of innovations (Scott, 2008). Actors will also engage in an interpretive activity of social construction of reality. Such purposive activity of adopting, adapting, diffusing and negotiating through interpretation creates a cluster of individuals, groups and organization that share similar area of interest. The cluster, conceptualized as organizational field, contains “those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products” (Powell and DiMaggio, 1991:64). The organizational field, having a closely similar aggregation of organizations, is to mean for “… totality of relevant actors… [with] the importance of both connectedness … and structural equivalence” (p.65).

Referring back to the research questions of this paper, the focus is to identify the producers, consumers, regulators and other connected and relevant actors and their interplay that shape design and development process of a mHealth solution. The research framework that guided the focus towards addressing the mentioned research questions draw on four points that Crotty (1998) suggested – epistemology, theoretical perspective, methodology and methods. Given the nature of the research questions – understanding the multiple institutions and their interplay that shape design and develop process of mHealth – the epistemology adopted is subjectivist, interpretivist and social construction of reality. The theoretical perspective is the three concepts of institutional theory discussed above. The concept of organizational field helps to characterize the mHealth domain that enables us to identify the different players while the concept of institution helps to identify the players’ playing rules, work practices, norms and values that structure the healthcare ICT domain of developing countries. Institutionalization helps to understand the interplay. Qualitative data collection methods and action research formed the methodology followed in this research. The strength with action research is that it provides researchers an opportunity to understand what is happening and also an opportunity to make problem solving interventions. The author was involved in the design and development activities and in a position to observe how the system emerged, what influenced the system, how the system adapted to the different influences. The next section presents the research context and methods employed.
3. RESEARCH CONTEXT AND METHODS

3.1. Research context

This research was conducted within the HISP network, specifically in the context of India and in close collaboration with HISP-India. HISP, operating since 1994 and largely funded by the government of Norway, is an international not-for-profit network of researchers, designers, developers, implementers and users of open-source health management information system (HMIS) called DHIS2. DHIS2 is a software for collection, validation, reporting and presentation of aggregate HMIS data in the form of graphs, charts and maps specifically targeting the context of developing countries. Currently a number of developing countries, including India, are using DHIS2. In India more than 20 states are using DHIS2. In addition to software design and development, HISP is engaged in activities of capacity building at both national and regional levels through masters and phd programs. It is also engaged in international sharing of best practices.

India, one of the countries HISP is operating, is a country probably very well represented in the research world within the domain of IS in developing countries. However, the vastness of the country with its diverse culture, socio-economic condition and striking inequalities of health status across states and within states provides a unique opportunity and challenge for more research and interventions. Recognizing such inequality and the importance of health in the process of economic and social development and also committed towards the targets of MDG, the Government of India has launched a unit called National Rural Health Mission (NRHM) to carry out necessary architectural correction in the basic healthcare delivery system. The goal of the unit is to improve the availability of and access to quality healthcare, especially for those residing in rural areas (the poor, women and children). A technical support group to NRHM is another government unit called NHSRC (National Health Systems Resource Center) who has a technical support partnership with HISP-India.

HISP-India, together with the two government units, is engaged in strengthening the rural healthcare system of India which is structured as a hierarchy of health administrative units. To facilitate the timeliness of aggregate reporting and also improve data quality by linking aggregate figures to traceable individual records, HISP initiated a mHealth system called Name Based Information Tracking System (NBITS) in October 2008. Integrated with the DHIS2, NBITS supports for mobile supported aggregate reporting and also for individual level recording and tracking of health services that contribute towards the targets of MDGs.

3.2. Methods

The research adopted qualitative action research study (Myers, 1997) and interpretive data analysis (Orlikowski and Baroudi, 1991; Walsham, 1993). The empirical material was generated during the course of diagnostic and therapeutic stages of action research (Baskerville and Wood-Harper, 1996) that the author had fully participated. During these stages the author assumed a helping role and engaged in collaborative activities of the NBITS design, development and piloting together with other members of HISP. The collaboration formed a “client-system infrastructure” (Baskerville, 1999) and this provided an environment to specify, propose and try out the mHealth solution. During the collaboration, actions were directed towards actively trying to address an existing challenge by introducing new tools and ways of doing things and hence going through a change process (Avison et.al, 1999). Outcomes of activities were recorded, studied and interpreted along views of technological, political, economical, administrative and socio-cultural institutions to develop a body of knowledge about the phenomenon.

Data was collected through a variety of means including observations, document analysis, formal and informal interviews, discussions and meetings both face-to-face and virtual using conference

calls, chats, emails and collaboration tools like Google Docs\(^2\). In the diagnostic stage, the author made four visits to rural health administrative units of India located in three different states namely Haryana, Andhra Pradesh and Kerala. The purpose of these visits was to understand existing situations and also to demonstrate a mobile based reporting system and assess the views and feedbacks of rural healthcare workers on mobile supported solutions. During these travels report generation and on-site data collection (by following health workers in their house-to-house visits) were observed. Rural community health workers and supervising medical officers were also involved in interviews, meetings, pilot demonstrations and feedback collection process. Various paper documents and copy of diary-notes of community health workers (sometimes through pictures) were also collected. Following these travels, discussions were made between members of the HISP network leading to meetings, conference calls and many email discussions for analyzing requirement specifications, design models, development approaches and other related issues. These discussions have also continued following issues that came from pilot and training activities. Two seminars, conducted one in India (Goa) and another one in Norway (Oslo), were also the other sources of data that enriched the empirical material. Table 1 presents a summary of data collection methods employed in the research.

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\(^2\) Google docs is an online and real-time sharing and collaboration medium from Google (http://docs.google.com)
<table>
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<tr>
<th>Data Collection Methods</th>
<th>Description</th>
<th>Time</th>
</tr>
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| Interviews, observations, meetings and feedback collection for a mobile supported reporting system prototype | • Health administrative unit from state of Haryana:  
  o on both occasions a female health worker was followed in her house-to-house visits to understand how she indentify, locate and meet individuals and also how she perform on-site data collection on her diary-note  
  o back to her office, observation was also made how she transcribe from diary-note to register books including routine report generation  
  o interview with 2 female health workers and a medical doctor  
  o meeting with a district medical officer | October 20, 2008 & February 12, 2009 |
| • Health administrative units from state of Kerala  
  o interview with a health worker and her assistant how they perform their daily routines  
  o meeting with rural community leader, health worker supervisor and female health workers,  
  o interview with a medical doctor |                                                          | February 13 – 17, 2009 |
| • Health administrative units from state of Andhra Pradesh  
  o interview with a district medical officer  
  o meeting with health workers (both male and female), a pharmacist, health education supervisors and medical officers |                                                          | February 18 – 21, 2009 |
| Seminars                                                                                       | • Goa (India): **International workshop on integrated eHealth architectures**  
  o discussion on design and development issues of NBITS | July 26 – 30, 2009 |
| • Oslo (Norway): **Developing Health Service Networks through Mobile Solutions in Low Resource Settings**  
  o demonstration and feedback collection |                                                          | August 30- 31, 2010 |
| Chats, emails and online collaboration with members of HISP network | Analysis of computer generated logs, emails, personal dairy-notes that arise from discussion of issues related to design, development and piloting of NBITS | Since October 2008 |
| Document Analysis                                                                             | Documents such as reporting and recording formats, dairy-notes of rural community health workers, national and state level policy documents as well as related HMIS and mHealth documents from literature were analyzed | October 2008 – August 2009 |

**Table 1: Summary of data collection methods**
4. CASE DESCRIPTION: Shaping NBITS for rural healthcare settings of India

The mHealth NBITS project started in October 2008 after a discussion between HISP members out of a concern that aggregate figures reported by DHIS2 are not traceable to specific individuals that actually got the service reported. Though started, the pace of the project was not fast enough for the team of HISP-India. The head of HISP-India wrote an email saying:

“[designer/developer A], can we have a clear idea of where we are on this and what are the time lines...there is frequent demand coming from states to see what we are doing on this... if we let it move at the rhythm of [your phd] ... the system will not be needed anymore here” (email conversation April 28, 2009)

The pressing demand from states of India was so high that it puts a huge pressure on the HISP team. The need to act on the issue became so urgent when the health minister of India, the highest political body in the HMIS structure, raised a similar issue on a public newspaper:

“Why is it that despite high [Routine Immunization] coverage, we are failing to eradicate diseases like polio? We have to start double checking immunization numbers being [reported] to us by states ... once vaccination data becomes name based rather than number based, we will be able to account for the exact number of children actually vaccinated”

There were also similar concerns in relation to targets of MDG, especially for proper service delivery and tracking of pregnant women from rural India. These concerns of data quality, together with issues of workload on health workers and delays in reporting, and also the huge pressure from states and higher level decision makers formed the pace of the project.

The project continued first by eliciting requirements. A number of issues were considered in the process. The first one was the work practices of health workers and sub-centers (SC). SCs are the most peripheral and first contact health administrative units between primary healthcare systems and the community. Each of these units are manned by one (sometimes two) community health worker (in most cases females), called Auxiliary Nurse Midwives (ANMs). ANMs are charged with the responsibility of building interpersonal communication among community members in order to bring about behavioral change and also with a responsibility of providing health services related to maternal and child health, family planning, nutrition, immunization, diarrhea control and communicable diseases including drugs for minor ailments. Though SCs focus on similar services that target towards MDG, there are differences across states based on local needs.

Healthcare in India is the responsibility of states and union territories. The Constitution of India under its article 47 charges every state with “raising of the level of nutrition and the standard of living of its people and improvement of public health as among its primary duties”. This has resulted in differences in reporting formats that SCs should adhere to. For example, early in the process, we (HISP) made a simple reporting prototype to assess the uptake of mobile enabled services; during a demonstration one ANM said:

“It is good that you have this report on mobile phone. I can now send reports from my office. But what about the other reports, this is not the only report I am sending”

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4 The name ANM is only for consistency, otherwise health workers in India have different names some states, like Kerala, call them Junior Public Health Nurse (JPHN). Haryana and Andhra Pradesh use ANM. There are also other group of health workers called Accredited Social Health Activist (ASHA), engaged in the public health service delivery
This made flexible and scalable support of reporting formats a serious undertaking during design and development processes. Together with reporting, name based individual recording was the other requirement we addressed. On average a single ANM maintains more than 20 recording books. Each book, also called a primary register, represents a single health program and is organized as rows for names of individuals and columns for details of services in the program. ANMs fill these registers according to services they delivered.

To handle these registers, initially we thought of adopting standard service procedures of health programs by consulting specifications from WHO, but we found out that there is a different local practice. For example in a typical MDG related program of pregnancy care, a specification from WHO suggests a 5 stage care model of first, second, third, fourth and postpartum visits\(^6\), but SCs of India follow a 7 stage care model of first registration then four subsequent visits followed by delivery and postnatal visits. This lead us to focus on understanding the details of programs and their stages to have a broader picture, and we found out that though all SCs follow similar programs-stages cycles, there were differences across states in the details of what is actually collected during each of the program stages. And this influenced us to outline a program-stage model that allows SCs to define their programs, stages and related details in a flexible manner.

ANMs were also eager to have a system that could relieve them some part of their work loads. One ANM asked

\[
\text{“More than a reporting system, I also want a system which can tell me when a due date is for my pregnant woman; it is difficult to calculate delivery dates by hand”}
\]

We also found out that due date scheduling functionality is required for other programs like immunization and house-to-house visiting. At the start of every month, an ANM gets a singed letter called “advance tour program” containing range of house-holds that she is expected to visit. Departing from this tour guide and also consulted by register books, the ANM makes visit plans organized in terms of villages, list of houses, names of individuals to be visited and the type of service to be delivered, including delivery dates. Computerizing such practice was one of the biggest challenges we faced in the process as we had to identify and consider a number socio-cultural norms of the rural community. From the socio-cultural side, issues for example the way individuals were identified, the way they build house and also migration were factors that influenced computerizing visit plans.

For house-to-house visits, a pregnant woman, in addition to her name, is identified using an attribute called “Wife Of” with a value of her husband name. Identifying a pregnant woman through her husband name was very easy for ANMs, as it is the males who are assumed head of a house-hold. For immunization, newly born babies were also identified through their “Son Of” or “Daughter Of” attributes as they are not given “proper” names until they are three of four years old. It is also in the culture of the community that a pregnant woman moves to her mother’s or mother-in-law’s place to give birth. The way individuals settle in the villages was also another factor that influenced the sequence of house-to-house visits. In most cases, a newly married man builds a house on a free space next to his family – sometimes in the compound of his family, and this made linear-sequential numbering of houses impossible and forced ANMs to number houses using custom prefixes.

Once we got a sound understanding of the situation, we made a design model sketching different components required from NBITS. The components on the model were abstract diagrams representing practices of ANMs and SCs – figure 1 shows the major components while table 2 provides description for these major components. The model got distributed to all members of HISP through the common mailing list of designers, developers and users that HISP had. It was also shared on Google Docs so that others can work on it. Once the first model was distributed, we made a Skype conference-chat on May 26, 2009. Though the model distributed was purely based

on requirements from India, one of the agenda in the discussion was how to make the system more generic so that other countries of HISP can use the system. There was a clear message from lead designers and top decision makers of HISP that stressed the unavailability of funding and other resources for building context specific systems for each and every developing country HISP is operating. As most funds of HISP are for developing countries in general, its decade-long system design and development strategy is to build a system that is globally generic to cater multiple contexts but also flexible enough to fit into local settings (Braa et al., 2007). We followed this flexible standards strategy of HISP to further shape the design model. Currently the model stands in its version 133.

We also studied other related systems to have an understanding of best practices and trends of innovations. We studied health information systems that have experience in building individual level medical records and also mobile supported HMIS solutions for the context of developing countries (OpenMRS and JavaRosa are examples of systems we studied). DHIS2 was also a huge influence in the process. As most states of India are using DHIS2 for their routine reporting, we didn’t want to introduce a new system with a different look and use pattern. As a result we made the NBITS to have the same look and use-pattern of DHIS2 so that issues of installation, training, use and support become less problematic. It took us more than 3 month to release the first prototype. Since the release we conducted two seminars, one in India and another one in Norway, where different actors – for example from donors, government health ministries, and regional WHO offices – participated and provided feedback.

The mobile technology – especially phones and available telecom services – was also the other major issue in the process. Prior to the release of NBITS, there were some states of India that have bought a very low-end, like Nokia 2330c, mobile phones. Assuming these states to be potential users, lots of discussions were made based on the consideration of Nokia 2330c that come with limited storage capacity and display screen. All our tests and demonstrations were made using this phone. In addition to capacity of phones, communication services provided by telecom operators were the other points of consideration. We sent a public mail requesting feedback for the type and coverage of communication services available, including cost. We considered the responses in the design and development process.

![Components of NBITS](http://example.com/nbits_components.png)

**Figure 1: Components of NBITS**

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7 http://openmrs.org
8 http://www.javarosa.org

## Work practices of ANMs

- Keeping record of individuals
- Maintaining health status of individuals for specific health programs

## Components of NBITS

<table>
<thead>
<tr>
<th>Description</th>
<th>Components of NBITS</th>
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| - Person Register  
- Health Program Register  
- Enrollment  
- Encounter  
- Work Flow  
- Generating activity plans  
- Engine (Visit Plan)  
- Data Collector  
- Engine (Import/Export and Aggregation)  
- Reporting | These are the entry points in NBITS. Using these modules ANMs (in general users) can register individuals who will be treated in a particular health center. The person register can capture as many details as possible using the person attribute module. It also provides functionalities to define relationships and representatives among individuals. Health programs being serviced in a given SC can also be registered using the program register. While registering programs, users can also define the different program stages a health program might have. For each of these health program stages, users can then define any data they will be interested to collect using the data element functionality.  
Each and every enrollment that an individual makes to specific health programs is treated as a specific health program instance. And each instance of a health program will have its own health program stage instances. The combination of these two instances, program and program stage, will dictate the whole process of an individual’s encounter in any health service delivery.  
Depending on work flows, visit engine will generate visit plans containing list of individuals and the type of service they need including due dates for the services. The visit list can be sorted/grouped using different person attributes. The visit plan also provides functionality for customizing due dates for efficient scheduling.  
Using visit plans, ANMs can manage their house-to-house service delivery. Observations during service provision can be collected using either the mobile interface or the desktop interface – depending on the location of the service provision.  
Collected individual records can be aggregated and exported to other systems, for example DHIS2, using import/export engine. |

### Table 2: Components of NBITS
5. ANALYSIS AND DISCUSSION

The design, development and piloting process of NBITS had brought together human and non-human actors from multiple institutions. The key actors in the process were – HISP and its funding; government units and international bodies; rural health administrative units and their health workers; rural communities and their norms; and finally artifacts together with their trends of innovations and associated services. The concept of organizational field formed the basis to identify these actors. The field, containing the producers, regulators, consumers and other related organizations, formed a recognized area of institutional life. Participant in the NBITS organizational field were – the resources (funding, mobile phones, telecom services, DHIS2 and other software systems); the producers (HISP, ANMs, SCs); the regulators (the funding policy of HISP, the Constitution of India, targets of MDGs, recording and reporting formats and the rural community); the consumers (ANMs, SCs, the rural community) and other related organizations that set best practices and trends of innovations. These actors, including their institutions, played a big role in shaping the NBITS. Figure 2 presents a summary of these actors and their institutions. In the figure, the key institutions that shaped the design and development process are conceptualized as economical, political, administrative, socio-cultural and technological institutions.

From the socio-cultural perspective, we have the community – families and individuals – living in rural areas with a reality of poor health status and scarce resources. These families and individuals, close to their own culture, belief and way of life constituted a high percentage of the total population that formed a context too high to get the attention of many – the government of India, the health minister, the states, MDGs, HISP, and Norwegian funding agency. The rural community, characterized by its practices of settlement, migration, naming and identification, exerted a huge pressure in shaping the NBITS. These practices, norms or codes of behavior, are in the culture of the community and form an institution that Jepperson conceptualizes as an informal institution. The NBITS supported these institutions to get legitimacy and acceptance in the overall health service delivery.
Beyond getting attention, the rural community was also strong enough to exert its own pressure in shaping mechanisms of intervention – for example healthcare providers focusing on preventive care and providing community health services such as family planning, pregnancy care, and immunization by employing ANMs through SCs. SCs were established for a goal to improve the availability of and access to quality healthcare to people, especially for those residing in rural areas, the poor, women and children. The commuting female ANMs have the legitimacy in the culture of the community and were well accepted to go house-to-house and meet individuals in need of health service. However, the commuting pattern was very much affected by the culture and way of life of the community. Migration of individuals and also the way houses are built and numbered was a huge factor that affected visit plans and tracking. In general, identifying and tracking individuals was as per the norms and conventions of the community.

In addition to health service delivery, ANMs and SCs were engaged in routines of data collection, aggregation and reporting that are crucial in informing decision makers with the exact health status of the community. From their very creation, SCs were charged with a task to administer service delivery for health programs including family planning, pregnancy care and immunization. The administrative procedures of these programs – for example the reporting and recording formats, the way health programs and their stages were outlined including the “advance tour program” – have put their mark in the objectified components of the NBITS. The NBITS provided a flexible and scalable Enrollment component that helps SCs to administer health programs according to their needs. The engines (import/export, aggregation and visit plan) also work as per the requirements the SCs and ANMs. SCs, forming the bottom of India’s HMIS hierarchy, were also under the scrutiny of the country’s national reporting practice that is being made through DHIS2. Politically, as specified in the Constitution, states are independent to administer their health status; however, there is a requirement for upward reporting up to the national level which is addressed in the NBITS. The major health programs supported in NBITS – immunization and pregnancy care – were also programs stressed in the MDGs and objectives of the national and state governments of India.

Institutions from the technological perspective account for the whole set of players and playing rules that are engaged in the technology production process. At least four sets of players were involved in the process – HISP; telecom operators; mobile phones and their manufacturers and retailers; and the bigger open-source community of designers, developers and users including those engaged in similar areas of interests. These players negotiated through their practices and objectified symbols in forming the NBITS mHealth system that fitted to practices. Scott’s mechanisms of institutionalization – increasing objectification, commitment and return – also provided an analytical framework to understand the NBITS shaping process. For members of HISP and DHIS2, who have a knowledge of aggregate logic and related technologies, understanding and taking best practices from other innovations for example OpenMRS and JavaRosa was key in the objectification of NBITS. The HISP members scanned the outside world and got an understanding of how things are done. However they didn’t develop the components of NBITS on top of the other systems they analyzed. Instead they developed NBITS as per the look and use-pattern of DHIS2. This showed the commitment that HISP members have to their DHIS2. The reason to shape NBITS the DHIS2-way was also more than an issue of increasing commitments; it was also an issue of increasing returns through learning effort and time and also benefits of economies of scale from the already installed DHIS2 all over India.

Funding was also the player in the overall process. For example, SCs brought their recording and reporting formats defined inline with state rules and official languages while communities brought their culture and norm of for example identifying individuals through their relationships and representatives. However, despite the widely acknowledged emphasis for the importance of tailoring technology to local contexts, the NBITS followed the globally generic strategy of HISP. The reason to follow the globally generic and yet locally flexible solution strategy was due to the limitation of resources to develop specific system that are closely tied to local contexts. The
NBITS developed in line with the flexible standards strategy enabled SCs to define and specify programs, stages, relationships and representatives that fit to their needs including working languages.

6. Conclusions

This paper showed how an mHealth system is shaped by taking an empirical evidence that surfaced from an ongoing action research project in the context of developing countries (India in particular). The research identified mobile phones (in their potential for recording, reporting and communication) as one of the actors that affected the mHealth system. However, beyond mobile phones and their communication service providers, there were also other actors from a range of institutions for example from that of political, economical, social, health and ICT. Institutional theory provided a conceptual framework to identify these actors and their structuring institutions. By doing so the paper makes an empirical contributions for the IS field. It complemented the technology focused existing literature of mHealth by providing a holistic view that accounted not only for the technical but also for the social, economical, political and cultural perspectives. The paper also demonstrated an interesting approach to study design, development and implementation phenomenon of information systems by considering the phenomenon beyond a single organization level or point of view. It looked the phenomenon from an organizational field level that accounted for multiple organizations and their interplay.

7. REFERENCES AND CITATIONS


UNDERSTANDING DESIGN-USE INTERACTION: THE CASE OF NAME BASED HEALTH INFORMATION SYSTEM IN INDIA

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ABSTRACT
Responding to the current call of information systems research towards theorizing the materiality of technology to a level as specific as possible, this paper presents a process that covers design, development and implementation aspect of (health) information system, called DHIS2, from the context of India. The paper builds from empirical case obtained from an ongoing action research project that all authors have participated in. We draw up on ensemble view of technology to understand design and development of materialities of DHIS2 – recording and tracking – and their embeddedness and interdependencies with context, focusing on how social processes, work practices and organizational structures are constituted in them. The interdependency, between the social and the material, is a constitutively entangled one that is shaped by an emergent and situated agency of both the human and the material. Understanding this mutual process and being flexible in the design process to proactively respond to changes is, we argue, at the heart of getting the design right – arguably the basis for an effective information system.

KEYWORDS
Materiality, design-use interaction, health information system, recording, tracking.

1. INTRODUCTION
Information Systems (IS) research engages on understanding the relationship between technology and the social. Understanding this relationship requires to be specific about the various components of technology and how they relate to various organizational issues (Monteiro and Hanseth 1995). However, study of the different components of technology and their interplay with organizations, work practices and social processes is largely ignored in the literature. Following an investigation of a decade long IS literature,
technology, considered to be at the core of IS research, is found to be either taken-for-granted, unproblematic or unspecified sometimes even non-existing (Orlikowski and Iacono 2001). This demonstrates a larger focus on the social with little attention paid to the technology. As a solution to address this imbalance, Orlikowski and Iacono urged IS researchers to theorize technology by having a deep and serious engagement with it, including its various features and functionalities.

Leonardi and Barely (2008) took the discussion for the importance of the various features, functionalities and components, or what they call the materiality of technology, further by outlining a guiding ontological stance. For them, the reason for not having detailed and serious discussion about materiality is the danger of slipping into technological determinism. It is possible to discuss the materiality of technology with a non-deterministic, but voluntaristic ontological stance, that recognizes the agency of humans and their ability to shape their environments\(^1\). As a way forward to advance materiality discussion, they outlined four research agendas one of which is investigating the interplay between development and use using an ontological stance which is both materialistic and voluntaristic.

Building on this identified need for research, we focus on Health Information Systems (HIS) that are being used for collection, reporting and presentation of health management data. HIS, if appropriately designed and implemented, can help improve reporting and recording practices, which can then provide the basis for improved decision making at different levels, especially at the health provider level who are the primary users of HIS. Appropriate design and use, which are the keywords here, require a deep understanding of the interplay of work practices, organizational settings, and social norms and how these interact with the design and materiality of the technology. It is towards these aims that this paper is focused; specifically the aim is to understand the nature of mutual interaction between the process of designing an HIS—called District Health Information Software Version 2 (DHIS2)—with requirements, work practices and uses. This interaction is viewed as a process with mutual effects. As we understand the work practices and uses better or as the requirements modify (as is often the case) the design gradually evolves, which may also then require the work practices and uses to be reconfigured. Understanding this mutual process and being flexible in the design process to proactively respond to changes is, we argue, at the heart of getting the design right—arguably the basis for an effective use of HIS.

We study this process based on an active engagement with processes of design, development and implementation of two new materialities of DHIS2, namely recording and tracking, in the healthcare context of in India. These new materialities, designed and developed as a module (or component) inside DHIS2 are aimed at allowing community health service providers to record, track and report on individual beneficiary based information for pregnancy care and immunization related services for the mother and child respectively. Getting DHIS and its materialities right can potentially have significant implications for improving the informational support for interventions relating to maternal and child health—issues which are of deep concern to the Indian public health system, currently as they pursue their Millennium Development Goals (MDGs).

The rest of the paper is organized as follows. In the next section, we outline some of the key concepts that we draw upon in analyzing the interaction between the processes of design and use. This is followed by a brief overview summary of the methods used, and then a detailed description of the case study itself. In the analysis section that follows, we take stock of the empirically established design-use interactions to make some general inferences on how this process can be understood and managed better. Some brief conclusions then follow.

2. THEORETICAL FRAMEWORK

In order to understand the interplay of work practices, organizational settings and social norms with that of design and development of IS, we draw up on ensemble view of technology (Orlikowski and Iacono 2001) that focuses on the interaction of people and IS in both development and use. Key to this is to understand the materiality of technology that acknowledges the affordances and constraints they provide towards human agency (Leonardi and Barley 2008). These views allow us to unpack the black-box of technology and

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\(^1\) See Leonardi and Barely 2008 for detailed discussion of deterministic and voluntaristic ontological stances on technology.
understand the dynamic interplay between technology and social in a given context and how that evolves over time.

The ensemble view encourages us to understand the design and development aspects of technology and its embeddedness in contexts, focusing on how social processes are constituted in them. It helps to analyze the mutual interdependencies between the social and the technical including the role of the social in shaping the material and functional forms (Orlikowski and Gash, 1994). At the same time, the technology, being a medium for human action, is analyzed to understand its influences on the social through its material and functional affordances and constraints (Orlikowski and Robey 1991). The interplay is a reciprocal engagement where the two are enmeshed in a situated context.

The reciprocal engagement, between the social and the material, should not be considered as two independent processes, rather as one that is constitutively entangled privileging neither the social nor the technical but focusing on the entire sociomaterial (Orlikowski 2007) ensemble that integrates social and material elements in a way that reveals their inter-penetration. The inter-penetration – situated in practice, emergent and sometimes unintended – emerges through human and technology agencies and their mutual interplay. Human and technical agency are qualitatively different, while the former is endowed with a reflective and knowledgeable aspect considering moral and ethical aspects (Giddens 1984), the latter is inscribed with assumptions that the designers have introduced. These design inscriptions then shape the materiality of technology and the affordances and constraints that provides to human action. For technology, specifically for a software artifact, examples of the implications of such materiality come in terms of features such as searching, storing, and displaying that the technology provides to its users (Leonardi and Barley 2008).

Conceptually, this paper draws upon these ideas to firstly understand the mutual nature of the entanglement between the design process of particular materialities of DHIS2 and the social as analyzed through the requirements process of recording and tracking functionalities. An important aspect of this analysis is that it adopts a dynamic process where both design and use processes are seen as evolving based on understandings of both the technology and work context as they come more refined and coherent. These dynamic processes help to create a constellation of features of technology which were not possible to predict and predetermine. Capacity is then continually generated for both the technology and the humans who are expected to use it in their work contexts.

3. RESEARCH METHODS

The four authors of this paper have been deeply and directly involved in design, development, training and implementation of the recording and tracking functionalities of DHIS2 in India, where the empirical material for this paper is drawn from. While the first author of this paper has been a primary designer and developer of these functionalities, the other three have had a long term engagement in the development, training and implementation of health information systems in India in general, and over the last two years with respect to the new functionalities in particular. This engagement has helped in developing an understanding to the business logic of the recording and tracking practice, conveying that to the developer, and then ensuring the logic is incorporated in DHIS2 in a manner that is easily accessible to users. The combination of the four authors and their individual understanding has helped to trace the interactions between the design and use contexts.

The research approach used in this study falls within the framework of larger action research initiative of HISP (Health Information Systems Programme) that is constituted of two components – research and action (Braa et al. 2004). HISP is a global research and development network originated at the Department of Informatics, University of Oslo in 1994. This network has contributed to the design and development of the DHIS2 which is currently being implemented in various countries across the world, including in India. The initiative of the recording and tracking functionalities was seeded and bloomed under the activities of the not for profit, non-government organization called HISP India which serves as an implementing arm of HISP Global within the Indian context.

We engage in action research as a way to both build theory and knowledge and also to contribute towards practical action by engagement with the world in the context of practice itself (Whyte 1991; Braa and Vigden 1999). Action research seeks not to primarily look for theoretical generalizations but concentrates on
solving real life problems while creating new practical and theoretical knowledge. Action research is often structured as a cyclical process covering diagnosing, action planning, action taking, evaluating and specifying learning (Susman and Evered 1978). The study presented here could be loosely structured into these phases but not in sequential terms, rather with processes overlapping and taking place in iterative fashion. The diagnosis relating to the need for strengthening and supporting community health worker practices was conducted in different states of India, involving the research team following closely the practice of health workers. The diagnosis was also deeply complemented by the prior engagement of two of the authors in the routine health information systems for a number of years, which has helped them to gain a deep understanding of the health information systems.

The diagnosis phase also involved understanding the various technological options available for recording and tracking functionalities by making a detailed analysis of the features available and those functionalities that need to be incorporated. Design and development of the various prototypes for the required functionalities, which in the action research terminology can be described as the “Action Planning phase”, is a key focus of this research, especially with respect to the processes of requirement analysis and design interaction, and through this how new understandings develop. These understandings lead to both the evolution of the prototypes design with implications for the reconfiguration of the work practices. Action taking in the research has involved the actual configuration of the new functionalities, customization of the paper formats and conducting some trial trainings in field settings which involved providing orientation on the paper formats, information flows and use. Processes of evaluation and on-site understanding of the feasibility the designed system has led to learning that has again contributed to the evolution of the design.

Data collection has taken place through various means. From the requirement analysis side, it has been primarily related to conducting interviews and participant observation of the community health workers, study of various paper based recording registers, and also involvement in training and support. From the design and development side, in addition to have participated in the field level learning, the developer has been deeply engaged in discussions and research around understanding the different technical solutions available, and being part of workshop discussions. Interaction between the requirement and developer teams have taken place primarily through email and chat, supplemented by three research visits of the developer to the field site. Reports prepared on situation analysis, data models developed, and discussions around them between the team members have all been other useful sources of data.

4. CASE DESCRIPTION

4.1 Motivation for designing the recording and tracking functionalities

The research setting for the two functionalities is focused towards the work practice of community health workers called Auxiliary Nurse Midwives (ANM) and their organizations called Sub-centers. In India, ANMs are responsible for providing outreach health services to a catchment population of 3000 to 5000 depending on the topography of the area and access. In the beginning of every financial year, an ANM is expected to conduct a survey and update her house hold register book which contains detailed information such as name, age, caste, relationship of family member of each household. This register acts as a master book through which she draws up a list of eligible couples (women within the reproductive age group of 15-49 years), pregnant women and children and maintain them in separate registers called, respectively, Eligible Couples, Antenatal Care and Child Register. Along with these registers she also maintains registers for immunization, delivery, birth and death, and family planning.

Throughout a month, the ANM maintains a record of services that she has provided on corresponding registers organized as rows for names of individuals and columns for their demographics and details of services provided. At the end of every month, the ANM aggregates the services she has provided into monthly routine reports which are then submitted to the responsible primary health center. Various problems have been identified by different studies (Chilundo and Aanestad 2004; Littlejohns et al. 2003; Piotti et al. 2006) around the implementation and use of health information systems, which are also seen to inhibit the quality of services provided under the maternal and child health programmes (Raghvendra and Sahay 2006).
With just under five years to the 2015 deadline for achieving the MDGs, India is far from meeting a majority of targets, including those in health. India’s MDG-5 target of reduction in maternal mortality rate is expected to reach 109 by 2015 (was 301 in 2001) and MDG-4 for reduction in infant mortality rate to 28 (was 60 in 2000), the current figures are respectively 254 and 53 (Source: Registrar General of India, Ministry of Home Affairs, 2009).

Acknowledging this poor progress, the Government established a unit called National Rural Health Mission in 2005 to try and achieve architectural corrections in its public health systems including the supporting HIS. HIS corrections include the re-designing of formats in which data is collected, and strengthening the focus on indicators and the use of information for supporting action. A key intervention with respect to HIS, which is the focus of this paper, is the introduction of the recording and tracking functionalities for the tracking of individual pregnancies and children for immunization. There is an increasing recognition both in India (especially in the unit established) and within international agencies that strategies for strengthening institutional measures (such as increasing immunization coverage, pregnancy tracking and strengthening home based care) need to be supported by effective HIS at both the level of the facility and the individual beneficiary. A public statement by the health minister of India also echoed this:

“Why is it that despite high [Routine Immunization] coverage, we are failing to eradicate diseases like polio? We have to start double checking immunization numbers being [reported] to us by states ... once vaccination data becomes name based rather than number based, we will be able to account for the exact number of children actually vaccinated”

2 The Times of India, September 15, 2009. “Azad doubts data on child vaccination”.

A higher level of maturity of the HIS requires the individual and Sub-center level data to be seamlessly integrated, for example the individual cases of immunization are aggregated and imported into the corresponding catchment area Sub-center to generate aggregated immunization coverage indicators. By being able to develop these aggregation mechanisms we expect to get more reliable data to generate and monitor the MDG4 and MDG5 indicators. By comparing these indicators across Sub-centers and time periods, resources and action may be directed toward areas with the poorest coverage – which need maximum support - and help the attainment of the MDG targets.

4.2 The interaction between processes of use and design

We trace this interaction within a framework of 4 discernible phases. These are:

1. Phase I: Initial design based on existing work practices – focus on recording and reporting.
2. Phase II: Evolving design to accommodate tracking – focus on more improved tracking.
3. Phase III: Modifying design to reflect further changes in modes of tracking/searching and recording – focus on improving specificities
4. Phase IV: Making design compliant with national identification number standards – focus on national standards.

The methodology we used to trace these interactions follows a “sociologically informed data modeling technique.” This implies that we use the data model and trace changes in it as the analytical focus to understand the populating of it with understandings relating to requirements and work practices. These phases are now described below.

Phase I: Initial design based on existing work practices – focus on recording and reporting.

Conventionally, public health systems have been recording and reporting aggregated data of the services provided across various health programmes. Though this is crucial in monitoring “reach” and “availability” of public health services, it lacks recording of beneficiary data relating to their interaction with the health system of specific individual level care such as the pregnant mother receiving required number of iron folic tablets or the child getting proper immunization vaccine. Historically, all this data is recorded by ANMs, but the difference is that it was done so in primary registers maintained in the Sub-center and now the government wanted this data to be sent upwards so that the required indicators could be monitored from the top. The second difference was the government also wanted some additional data to be recorded (for example, the phone number of the beneficiary and the ANM), which were not being recorded earlier. In this regard, the government issued in late 2009 a list of data elements (one each for pregnancy and immunization containing 28 and 26 number of elements respectively), that needed to be captured under the recording and

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2 The Times of India, September 15, 2009. “Azad doubts data on child vaccination”.
tracking functionalities inside DHIS2. This list then became the basis for the first version of the data model which is depicted, in its simplified form, in the figure below.

![Diagram of first version of the data model facilitating recording and reporting practices](image)

Figure 1. First version of the data model facilitating recording and reporting practices

The data model, shown in figure 1, is an extension of the DHIS2 data model to incorporate recording and reporting of name based data. Right from the start of design, the focus was to make a generic system which could be used in multiple contexts and incorporate different health programmes. HealthProgram object contains the description of health programmes that a Sub-center can provide and depicts the links between the person and the health facility (the Sub-center) which provides the services required under this program. A program object can have one or multiple program stages each containing one or many parameters (data elements) along with the start period for that stage. To illustrate, Mother care can be treated as a program and antenatal care first trimester, second trimester and third trimester can be treated as program stages under this program. Date of examination, Tetanux toxoid vaccine dose, number of iron folic acid tablets provided are parameters (or data elements) under each program stage. Each stage has a start and end period.

One of the key outputs of the first prototype was to produce an activity plan from the enrolled individual. Activity plan is a list containing names of beneficiaries who are due for specific health services such as pregnancy care first trimester, second trimester and third trimester. The data model focuses on the program and activity plan, where each individual can enroll to multiple health programmes and each recording and reporting organization unit (Sub-center) can provide multiple health services. And an organization unit can generate activity plans for various health programmes.

**Phase II: Evolving design to accommodate tracking – focus on improved recording and tracking**

An initial prototype of set of data elements were created in Excel sheets and discussed with various states to understand whether they had additional needs to be captured. This interaction between the HISP team and the state took place in various states. Various comments were made for changes, mostly at the level of additional data elements to be captured. Customizations and additions in the system implied including all the data elements into the system which contributed towards generation of the national standard report. While this was the national standard report mandatorily required by the Ministry of Health, states also started to make requests to have their own custom reports which implied incorporating additional data elements required for generating such reports. The system supported for this by providing a graphical user interface that allowed states to define any number and type (text, number, boolean and date) of data elements.

There were also certain inputs which had implications on the modifications of the system’s data model. This included suggestions for changes in mode of tracking such as addition of objects and models that capture relationships – for example husband/wife, parent/child – between individuals. It was important to have these relationships because for example during house-to-house visiting a pregnant woman was identified through her “Wife of” attribute that contained her husband’s name and address as it was the husband who is assumed the head of a house-hold. Similarly, children for immunization were identified through their “Son of” or “Daughter of” attributes that contained their parent’s details as they tend not to be given “proper name” until they are 4 or 5 years old.

Along with this, there were various discussions on maintaining uniqueness of each service provision and defining program enrollment and program stages. Initially the model assumed all pregnant women to start and follow the standard pregnancy care protocol. But it turned out that the rural community has a different practice and individuals were coming for health service at different stages of their pregnancy. This meant defining programmes and their subsequent stages corresponding due-dates uniquely for each and every
encounter between an individual and a health program. This brought two new objects in the data model called HealthProgramInstance and HealthProgramStageInstance that capture unique instances for each and every individual-program encounter and these changes lead to version 2 of the system. These unique instance objects, together with the relationship object, brought an implication on the activity plan that hugely influenced the house-to-house visiting of ANMs.

**Phase III: Modifying design to reflect further changes in modes of tracking/searching and recording – focus on improving specificities**

Deeper understanding of the work practices of the health workers helped us to discern between the subtle differences between recording and reporting from the point of service provision. And this contributed towards version 3 of the system. For example it was a common cultural norm of the community for a pregnant woman to move to her mother’s or mother-in-law’s place to give birth. In addition there was also migration due to seasonal works. Due to these ongoing issues of migrations it was important to capture the service details at the different points where the mother or the child receives the service.

Further, discussions with the health staff and also a detailed study of the register books helped to identify the various kinds of common data quality problems in recording. This then raised the need to develop a rather sophisticated validation engine that could incorporate various validation rules to allow conducting data quality checks and developing alerts. All these informational demands led to the need for more sophisticated search functions, and sorting to be able to generate activity plans in formats that could be easily understood by the ANM.

A person can now be registered only under one recording/reporting organization unit but he/she can take services from different health facilities (those recording/reporting organizations). To avoid duplication in the reporting practice, a health facility should register only those services provided at that facility only. To incorporate this in the system, person object was made independent of location for receiving health care services, meaning that a person could be searched from any health facility, who could provide services with or with out that person been registered under that health facility. In the data entry screen, highlighted sections in figure 2, a check box was provided for each data field which defined whether the service was provided in that health facility or not. Any checked data field would be omitted for aggregation from that health facility in the monthly report. Through this, only services provided by that facility would be reported to the higher institution, thus meeting the reporting principle that a health facility should only report the service that it provides.

**Phase IV: Making design compliant with national standards – focus on plugging in with national identification number standards.**

Another important consideration was the incorporation of the system of identification for individual beneficiaries. The Government of India had issued certain guidelines for the same which is depicted in the table below for a 16 digit code.

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**Figure 2. Data recording screen supporting migration**

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Another important consideration was the incorporation of the system of identification for individual beneficiaries. The Government of India had issued certain guidelines for the same which is depicted in the table below for a 16 digit code.
Table 1. National Identification number guideline

<table>
<thead>
<tr>
<th>Digits (Numbers)</th>
<th>Item Description /Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>01-02 (2)</td>
<td>State Code As per Census codes</td>
</tr>
<tr>
<td>03-04 (2)</td>
<td>District Code As per Census codes</td>
</tr>
<tr>
<td>05-07 (3)</td>
<td>Block Primary Health Center or Community Health Center Code As per Census codes given to Block Headquarters</td>
</tr>
<tr>
<td>08-09 (2)</td>
<td>Health Sub-centre Code To be serially given by Block Headquarters.</td>
</tr>
<tr>
<td>10-10 (1)</td>
<td>Health program Code Pregnant Woman – Code 1, Child – Code 2</td>
</tr>
<tr>
<td>11-12 (2)</td>
<td>Year Code Last 2 digits for the year is to be given, for example, for the year 2009, “09” will be entered and so on</td>
</tr>
<tr>
<td>13-16 (4)</td>
<td>To be given serially to each mother / child from 1st December, 2009 starting from 5000 From 1st April each year, the codes will be given afresh starting from 0001.</td>
</tr>
</tbody>
</table>

However, some states were not satisfied with the specified scheme, table 1, as they had local ones in use such as the use of the eligible couple number, or the election card number. While it was impossible to take all possible requests, we decided to allow for multiple identification numbers where states can specify their own, including the government of India’s 16 digit code which was to be taken as mandatory. All these requests and changes lead to version 4 of the data model and its prototype.

5. ANALYSIS OF DESIGN-USE INTERACTION AND THE EMERGENCE OF NEW CONFIGURATION

We start this analysis section by first summarizing, in table 2 below, the different versions of the data models and prototypes, and how they corresponded to ongoing understandings of requirements, work practices, organizational structures and social norms and also to changes in the system itself.

Table 2. Summary of design-use interaction for recording and tracking functionalities

<table>
<thead>
<tr>
<th>Recording and Reporting Functionalities</th>
<th>Work Practices, Organizational Structures and Social Norms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version1: Recording, reporting and tracking</td>
<td>Register books, reporting formats and standard health protocols (for example pregnant women following their pregnancy checkup starting from the first day of their pregnancy) deep understanding of rules and work practices</td>
</tr>
<tr>
<td>– Individuals</td>
<td></td>
</tr>
<tr>
<td>– Programs and program stages</td>
<td></td>
</tr>
<tr>
<td>Version2: Improved recording tracking</td>
<td>Identifying individuals not only through their names and other attributes but also through their “Wife Of”, “Son Of”, “Daughter Of” attributes</td>
</tr>
<tr>
<td>– Relationships</td>
<td>It is a “norm” that pregnant women do not come for service at the start of their pregnancy – they come late during the stage, missing/distorting standard/protocol workflow Need to track each individual’s case – unique instance of enrollment/program and subsequent stages</td>
</tr>
<tr>
<td>– husband/wife</td>
<td>Activity plan that shaped house-to-house visiting deep understanding of socio-cultural norms and organizational structures and also shaping of work practices</td>
</tr>
<tr>
<td>– Parent/child</td>
<td></td>
</tr>
<tr>
<td>– Instances</td>
<td></td>
</tr>
<tr>
<td>– Programs and program stage instances</td>
<td></td>
</tr>
<tr>
<td>Version3: Changes in mode of tracking/searching and recording</td>
<td>Registering (from the point of view of service provision) organization unit should not necessarily be the registering (from the point of view registering individuals) organization unit Pregnant women were migrating from their village/organization unit to another village/organization unit emerging socio-cultural context and refining functionalities</td>
</tr>
<tr>
<td>– Reported-by feature</td>
<td></td>
</tr>
<tr>
<td>– Searching for migrated individuals during recording</td>
<td></td>
</tr>
<tr>
<td>Version4: Compatibility with national standard</td>
<td>Integration with national identification digit infrastructure emerging standards and organizational structures</td>
</tr>
<tr>
<td>– Individual Identifier</td>
<td></td>
</tr>
</tbody>
</table>
The first version of the system was based on a rather simple understanding of what data elements are required to be reported under the two programmes (mother and child) and what is the data being currently recorded (based on the recording registers). As we discussed these formats with the state staff, we understood the data being identified for recording needs to be put into context representing both the socio-cultural and health contexts. The first helped us to identify the need for capturing the relationships (such as “wife of” or “son of”), and second to identify how the social practice of migration requires to understand the difference between the point of registration and that of service provision. Building on this recognition of differences between registration and service provision, there was the need to refine the searching functionalities, and allow ANMs with different possibilities to search beneficiaries which could be useful for physical tracking. Finally, the last version represented our attempt to make the tracking system compliant with the national effort for giving personal identifiers to all Indian residents.

The above analysis represents the ensemble view to understand how the technology development and use and also process of social understanding are enmeshed with each other. We trace this from the perspective of work practice, organizational structure and socio-cultural process. From the work practice perspective, it was evident how the requirements and practices of ANMs’ data recording on primary register books, that were maintained at Sub-centers, shaped the first version of the system. What followed from this was better tracking practice that was shaped by activity plans that were generated by the system. The activity plan itself was a functionality that resulted following deep understanding of social process – for example the relationships and unique program and stage instances that reflected the socio-cultural norms. This functionality (aiding house-to-house service provision through activity plan) can have implications of the work practice, as the ANM can now search by village or name, and the new kinds of lists can allow her to structure her house-to-house visit trips differently. As the requirements themselves shifted, for example states wanting to have their own custom reports and recording of dataelements that feed to these requests in addition to those they were required reporting for the national level, these new demands needed to be inscribed in the technology. The emerged materiality and its inscription played an important role in supporting the required organizational structure. The case with identification numbers (that states wanting their own formats and also the government forcing specific formats that were mandatory) was also another organizational structure that was reflected in the materiality of the system. The technology and the social (that includes work practices, organizational structures and socio-cultural norms) thus mutually constituted each other. It was impossible to separate one from the other – in other words the design process for the two functionalities was a constitutively entangled one that favors neither the social nor the technology but their constitutive entanglement. In addition, the process was a non-linear one that emerged through time. If our design has been based on a more straight and linear process of freezing specifications and then development, subsequent understanding of requirements (such as of the identification system) would never have become part of the design specification. This points out that the whole design, development and implementation process was so enmeshed with the context, as demonstrated with the evolving versions of the model.

The DHIS2 technology has certain materiality inscribed including its functional features and material form to support practices of reporting, recording, and tracking. The affordances provided by the technology can both enable and constrain certain practices. For example, initially there was no functionality of DHIS2 for recording and tracking and this clearly put a constraint forcing the health minister to demand functionalities that specifically allow recording details of individuals and the services provided for them. Then the emerged functionalities – specifically the recording, the tracking, the activity planning including the searching and sorting features – enabled ANMs to perform a practice that contributed towards better attainment of MDG targets.

In general, material and human agency interacted with each other giving rise to different constellation of features which also allowed improvements in the practices of recording, reporting, and tracking that had implications on how the ANMs could perform their different jobs, thus shaping human agency. We hope this agency could then be directed towards improving individual care under the maternal and child health programmes. The other interesting insight from this is to see how the design evolves over time and why? Such an understanding helps to realize the futility of trying to freeze specifications, something that never ever happens in reality. In other words, agency, both technical and human, is not a static attribute but a generated capacity that results from negotiation in specific context.
6. CONCLUSIONS

In brief, the paper makes some key theoretical and practical contributions. Theoretically, the paper applies the ensemble view to a particular context of health information systems in developing countries. Given the richness and dynamic nature of this context, we argue the ensemble view to be most appropriate to study these processes. Practically, we believe we have evolved a design which would give birth of a system that is appropriate and more closely based on socio-cultural context, thus significantly increasing the potential of user acceptance. Further practical implications arise in the form of building deep design-use understandings that can be drawn to more effectively support implementation of health information systems.

REFERENCES

Scaling as a process of managing sociomaterial assemblage: cases about health information systems for developing countries

Abyot Asalefew Gizaw; Sundeep Sahay

Abstract

This paper presents a sociomateriality inspired analysis of scaling in the context of Health Information System (HIS) design and implementation in the public health context of developing countries. Scaling, in existing research, has been treated primarily as a technical process of expanding the scope and size of HIS across time in a particular settings and its spreading across space in multiple settings. This focus on the outputs of the scaling process has come at a relative neglect of the actual process of scaling that bridges different time-space contexts. This paper tries to redress this imbalance by taking a holistic view of scaling as a process of managing sociomaterial assemblage, representing a focus not restricted to the technology, but including also the social and contextual linkages around the technology. Focusing on the process of scaling, we identify four key mechanisms: embedding which refers to the efforts to make a HIS work in a particular time-space context; disembedding to take the working HIS from a particular to a new time-space context through material restructuring; and reembedding to make and embed the HIS work in the new time-space context. Empirically, the paper draws upon HIS design carried out in India and Ethiopia and study its process of scaling (or not) within the wider global framework of the Health Information Systems Programme initiative that has been going in multiple developing countries.

Keyword: scaling, sociomateriality, health information systems, developing countries
Introduction

With health information systems (HIS) regarded as key enablers for socioeconomic development in developing countries (WHO, 2000; AbouZahr & Boerma, 2005; Chetley, 2006), numerous national and international interventions are applying them as a component of health sector reforms. However, many of them have ended with premature deaths unable to live beyond their pilot stages (Heeks et al., 1999; Heeks, 2006), representing a challenge of scalability of making a HIS solution first work over time in a particular setting and then successfully spreading it to other settings (Braa et al., 2004; Kimaro, 2006). Investigating this scalability challenge is an important area for further research (Walsham & Sahay, 2006; Walsham et al., 2007).

In the context of information systems (IS), scale refers to size or scope of an IS, including the patterns of use covered (Monteiro, 1998), number of users served, geography covered (Sahay & Walsham, 2006), and type and volume of data maintained (Shaw et al., 2007). Scaling refers to the “process through which [the IS] is taken from one setting and expanded in size and scope within that same setting and/or also incorporated within other settings” (Sahay & Walsham, 2006, p. 185). Specifically for HIS in developing countries, scaling “implies transfer of the ICTs, associated approaches and techniques from one setting to another to be implemented or developed there” (Kimaro, 2006, p. 5-6). This necessarily calls for a time-space perspective to understand scaling (Sahay, 1997), which also takes into account the emergent needs and sociotechnical realities of a setting.

Some suggested scaling mechanisms include flexible standardization with an emphasis on managing complexity (Braa et al., 2007); step by step transition with an emphasis on growth (Monteiro, 1998); and mindful cultivation with an emphasis on type and volume of data (Shaw et al., 2007). While these are valuable concepts to understand and guide the process of scaling during expansion, these have been limited to single rather than multiple settings. In addition, during the course of spreading to another setting, we have not studied processes of “de-scaling” which may be required to match a system to the sociotechnical reality of the setting, and avoid the pitfall of a design-reality gap (Heeks, 2006).

Successful spreading of HIS artifacts across settings is an important strategy to learn and build upon earlier efforts, and avoid reinventing the wheel. Braa et al (2004) have developed the
concept of “networks of action” as a means to spread HIS across nodes in the network with ongoing processes of customizations and adaptations. These processes need to be sensitive to the materiality of technology and the affordance it provides, as these will directly influence the ability of the technology to be transferred for other settings. This helps to address the challenge of scaling which sensitively considers both the material and social dimensions (Braa & Sahay, 2012). Specifically, our aim is to understand and analyze the challenges of moving HIS from a particular time-space context to others, and the associated design challenges. Flowing from this analysis, we draw implications for design practice – or how design choices can both enable and constrain scaling processes across time and space.

With our emphasis on scaling processes that are sensitive to both the social and the material, we subscribe to the emerging research perspective of sociomateriality (Orlikowski, 2007; Orlikowski & Scott, 2008). Sociomateriality follows a relational ontology privileging neither the social nor the technical, but focuses on understanding the situated entanglement of the two. HIS designed for a certain setting, necessarily needs to be specific and embedded in the reality of this setting. This represents a working of the socio-material assemblage specific in time-space, its disembedding from its old setting and reembeddeding in the sociotechnical realities of the new settings. The sociomateriality perspective allows for distinction, albeit temporarily and analytically, between the social and material (Orlikowski, 2007) to go through these simultaneous process of embedding, disembedding, material restructuring and reembedding. Drawing from this analysis we conceptualize scaling as a process of managing sociomaterial assemblage in time-space through these above identified simultaneous processes.

Empirically, our analysis is informed by an action research study involving design, development and implementation of a HIS artifact (called District Health Information System - DHIS2), being managed through the Health Information Systems Programme (HISP) initiative being implemented for developing countries. Understanding how the DHIS2 artifact moves or not from one time-space context to other provides the basis for our analysis. We continue the paper as follows. In section 2, we discuss related literature and conceptualize scaling from the perspective of sociomateriality. An overview of the research methodology and methods used is presented in section 3. Section 4 presents a detailed description of two empirical cases of DHIS2 related scaling processes. Analysis and discussion follow in section 5 with conclusions in section 6.
Theoretical perspective: informed by sociomateriality

Scaling of information systems is a major area of concern for both practitioners and researchers. It is “an important issue in IS, especially in the contemporary context of globalization, as attempts are ongoing to expand IS in the same context as well as take it into other contexts” (Sahay & Walsham, 2006, p. 185). Often, discussions IS of scaling are detailed along two dimensions – across time when expanding in scope and size in a particular setting (Walsham & Sahay, 2006) and across space when spreading a working solution to multiple settings (Braa et al., 2004).

Along these dimensions, the actual process of scaling involves “aspects of geography, software architecture, processes, infrastructure, technical support and political support” (Sahay & Walsham, 2006, p. 188). In health care, there is this particular demand of HIS scaling that implies all or nothing. For example, for a district or state manager, the need is for information to come from all facilities in the relevant catchment area, rather than from single or limited pilot sites. In the face of this demand, the HIS artifact needs to be spread across all facilities of the country, garner institutional and political support and establish alliances with various stakeholders and situated sociotechnical realities (Braa et al., 2004). Furthermore, the different facilities will neither have the exact same sociotechnical setting at a point in time nor will they remain with unchanged settings over time. Responding to such emergent and varying settings requires for a scaling mechanism that is both dynamic and continuously evolving.

In addition to the above time and space perspectives of looking at scaling, also called vertical and horizontal scaling (Braa and Sahay, 2012) respectively, Shaw et al (2007) discuss the extent to which the system under scaling is rooted in people and work practices. This perspective emphasizes how the success of the scaling is dependent on the extent of the embeddedness of the HIS in work practices, data and technology (ibid.). This, arguably, requires for the artifact and its materiality, as specific and as detailed as possible, to be aligned and fitted with the sociotechnical reality of the setting (Monteiro and Hanseth, 1995). What brings success is not as such the artifact, but the combination of its materiality with work practices, organizational structures, social processes and other contextual factors (Leonardi and Barley, 2008; Zammuto et al, 2007).

Drawing from these perspectives, we turn attention of scaling from spreading or expansion or
size, to forming a working constitutive entanglement of the social and the material in time-space – which we conceptualize as the sociomateriality of scaling. Sociomateriality (Orlikowski and Scott 2008) emphasizes an analytical focus on the relation between the social and the material; how the entanglement between technology and settings unfolds, which aspects, modules, functions, or materiality of technology enable or constrain the scaling process. Braa & Sahay (2012) also argue against looking at scaling just in terms of boxes of technology being taken from one site to another, but as the adoption of certain design principles of scaling along qualitative and quantitative dimensions. While the quantitative dimensions reflects the materiality of technology supporting services, work practices and requirements; the qualitative dimension represents the soft and process aspects such as the ability of people to learn the new systems and organizational capacity to adapt.

Think of no scaling for the moment, what is required is to have a working HIS for a certain context at a particular time – a point in time-space. Assuming space and time as our reference; requirements, work practices, institutions, people, social process, politics, technology and other factors that surface represent the sociotechnical reality of our context in the time we are concerned. For the HIS to be effective, it needs to be entangled in time-space with the sociotechnical reality of the context (Berg & Goorman, 1999; Orlikowski & Scott, 2008). The entanglement is nothing but the embeddedness of the materiality of the HIS artifact, as specific and as detailed as possible, into the existing context. The represents a sociomaterial assemblage which is inherently inseparable, except temporally and analytically (Orlikowski and Scott, 2008).

Now think of scaling, or spreading the HIS in our time-space reference, to another context. At this point, we don’t have the HIS sitting as a black-box to be transported to the new context. What we have is an entangled ensemble which makes the transporting “as is” inherently ineffective, and would require a complex work of disentangling (Berg & Goorman, 1999) the material from the social and from the context it is embedded. Once disembedded, the technology may not be directly applicable to the new context as its materiality may need restructuring and reembedding so fit the sociotechnical reality of the new context, and creating a new sociomaterial assemblage. This process of making it fit requires “generification work” (Pollock et al., 2007) to enable the technology to work for multiple settings. Scaling is often an emergent and bottom up process that goes through step by step transitions of growth (Monteiro, 1998) and escalating
complexity (Braa et al., 2007) which makes prior generification a difficult task. A technology designed for generification will facilitate for easier disembedding and (re)embedding across time-space contexts as a process of scaling.

Scaling across time will be subject to similar challenges as scaling across space or contexts, as it is unlikely for a context to have identical sociomaterial assemblages in two different time frames. There will necessarily be variations across work practices, organizational structures, technology, policy and others, and the scaling process would involve managing these different assemblages. Here again process of disembedding, material restructuring and reembedding are crucial.

In summary, the focus of our theoretical analysis is to understand the challenges of moving HIS from particular time-space contexts to others, and the associated design challenges. The sociomateriality perspective emphasizes scaling is not about only moving a box of technology ready to be dispatched across contexts, but involves managing a sociomaterial assemblage across time-space contexts. This requires a complex work of disembedding, material restructuring and (re)embedding.

**Research methods**

The research is conducted as an action research study (Baskerville, 1999) under the umbrella of the Health Information System Programme (HISP), a global research and development network coordinated within the Department of Informatics, University of Oslo, Norway. A key activity in the HISP network, and also for the authors of this paper, is the design, development and implementation of DHIS2, software to support HIS work, across multiple contexts of developing countries. Since its first release in 2006, the DHIS2 has gone through various enhancements of functionalities and spreading to various African and Asian countries. Our study concerns with two cases where we had an active and primary involvement. The first case is analyzing the scaling of the DHIS2 to support multidimensional reporting following the request of Ethiopia and the second concerns a dashboard module that was designed in and for India but failed to spread to other countries, forcing it to be replaced by a “global” module.

In both cases, our involvement was guided by the framework of action research with two broad objectives - solving existing practical problems and contributing to a body of knowledge, in our
case related to HIS scaling. Often, action research is structured as a cyclical process covering sequential stages of diagnosing, action planning, action taking, evaluation and specifying learning (Susman & Evered, 1978; Baskerville, 1999). Though, our research has been involved in these stages, they have not been sequential, but, rather been overlapping and iterative. Table 1 summarizes our activities for the two cases.

Empirical data was collected through a variety of means, including actual development of one of the authors in the development process; analysis of requirement and design documents; interview of designers; participant observation in discussions and design activities; and various email exchanges with the respective team members. Data analysis was conducted iteratively, commencing with examination of empirical data, followed by identification of key themes, and finally moving to development of theoretical interpretations drawing from the sociomaterial perspective which emphasized the interplay of the social and the material in shaping the scaling process. Field notes were categorized along dimensions of both the social and the material, and their inter-linkages. This helped to build the perspective of scaling as a process of managing sociomaterial assemblage in and across time-space. The concepts of (re)embedding and disembedding have provided a language to analyze and communicate our findings.
<table>
<thead>
<tr>
<th>Action interventions carried out</th>
<th>Multidimensional reporting</th>
<th>Dashboard module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis:</td>
<td>• Evaluation of DHIS2 for the purpose of making it fit to requirements and sociotechnical realities of Ethiopia</td>
<td>• Investigating problems that arise from the integration of local dashboard module with global DHIS2</td>
</tr>
<tr>
<td>Action planning:</td>
<td>• Design blue print on how to answer the needs of Ethiopia</td>
<td>• Plan for refactoring (Fowler, 1999) software code of the dashboard module</td>
</tr>
</tbody>
</table>
| Action taking:                  | • Implement the design blue print through programming inside DHIS2  
• Extending the design blue print of Ethiopia for more generic needs  
• Remove context specific programs of Ethiopia and replace them with generic and abstract objects  
• Take the generic design to Tajikistan  
• Provide trainings for users on how to use the abstract objects when defining custom dimensions | • Refactoring the local dashboard module  
• Analyze the remaining code base  
• Recommend local dashboard is not suitable to be taken to settings outside India  
• Evaluate if dashboard module released by a global team from Oslo can support the needs of India |
Case description: scaling of DHIS2

The two cases - the multidimensional reporting of Ethiopia and the dashboard module of India – are now described.

Multidimensional reporting: born in Ethiopia and spread to multiple countries

The need for the scaling

DHIS2, first created by a global HISP team located in Oslo in 2005, is a generic tool for collection, validation, analysis and reporting of aggregate statistical data to support public health practices of developing countries. It was based on a data model that rests on the logic of collecting and processing single data value per data element – for example what is the total number of malaria cases in a district which can then be aggregated across a state or country. However, when the DHIS2 was introduced to Ethiopia late 2006, it faced the socio-technical need to support “multidimensional reporting”, which is now described.

Embedding specific needs of Ethiopia inside DHIS2

Ethiopia is one of the poorest countries plagued with high morbidity and mortality rates. To address this public health challenge, the Ministry of Health collected and processed disease cases based on age and gender breakups to help identify specific vulnerable groups and regions. This involved collecting multiple data values per data element. For example, for the data element “malaria”, data values represented total number of malaria cases in a district, state or country; of the total how many were male, female, and within these groups how many were under the age of 4, between 5 and 14; and above 15. This reporting had to be done under the framework of the Integrated Disease Surveillance Reporting (IDSR) programme, and also in line with the needs of various international agencies such as the WHO, CDC and USAID who are heavily funding the healthcare system of Ethiopia. A high percentage of the Ethiopian health system budget is supported by donor funds, making their reporting needs a high priority.

Positioning DHIS2 appropriately within the national and global politics and institutional demands of diseases and funds, it became crucial to support the required reporting practice of
multidimensional disease cases. The global DHIS development team delegated the task to the local HISP Ethiopia team based in the Department of Informatics, Addis Ababa University. As a part of this team, one of the authors became engaged in understanding reporting practices by analyzing information flows and the existing paper forms. Since the local team had already been working in the context since 2005, they helped the design team to understand the existing sociotechnical realities of the public health system, including the morbidity and mortality reporting practices. A number of discussions took place between the team and officials of the Addis city health office towards building this understanding.

Once a sound understanding was developed, we started programming inside the DHIS2. However, working in DHIS2 from Ethiopia turned out to be a difficult task. DHIS2 is a free and open source system designed using numerous Java plug-ins and frameworks that are available for download from the Internet. Like many open source projects, programming inside DHIS2 is a globally distributed activity where programmers are required to maintain current and historical versions using version control systems over the Internet. However, internet connectivity in Addis Ababa University was very poor, restricting downloading the required plug-ins and frameworks. In addition, the connection was configured for email and basic web browsing denying the use of the online version control system and other synchronizing tools. This made it difficult to directly work with the DHIS2 global team, who then sent the source code and required plug-ins through email to enable asynchronous development.

With this in place, we started to investigate the internals of DHIS2 which revealed a layered architecture consisting of core, business and presentation layers. We started programming on our local version which we named it as “MM” (for Morbidity and Mortality). Because of internet restrictions, we couldn’t synchronize the MM copy with the global version on our laptop. Inside the MM copy, we introduced changes to the three DHIS2 layers – at the core layer we extended the data element object with age and gender dimensions representing the specific break-ups of Ethiopia (for example male, female, 0-4 years, 5-14 years, above 15 years). At the business layer we introduced logic to process the breakups and their combinations. At the presentation layer we introduced a graphical user interface that displays reports as in paper forms as shown in figure 2.
We completed the first alpha release in February 2008, and demonstrated it to the Ethiopian Ministry of Health. The prototype was appreciated, leading to another presentation and then the release of the final solution.

**Disembedding the specific needs of Ethiopia from DHIS2**

After the demonstration, one HISP Ethiopia member brought on her laptop the MM system and showed it to the global team in Oslo. A coordinator appreciated the solution saying:

“Looks like you've done a great job… really heartening to know that we can now handle morbidity and mortality” *(February 2007, Coordinator from the global team)*.

However, designers from the global team were not happy with the embedding of morbidity and mortality requirements in the core of DHIS2, which was used in multiple countries and many did not have morbidity and mortality requirements. The lead global designer sent an email that said:

“This works fine, but not for countries which don’t need the MM functionality. At a workshop in Cape Town we concluded the MM system should take care of its data by reusing core objects of DHIS2. By doing it this way the core of DHIS2 wouldn’t have to be changed at all, and there would be no need for changing the aggregation and indicator functionality. Also countries not needing MM functionality would not be affected at all…The implications of this, compared to your code, is you extract all your code from the DHIS2 core modules and make a separate project” *(February 2007, Lead global designer)*.

The email was a turning point in our development, and we stopped working further and started discussions with the global team. The global team tried to convince the Ethiopian team the importance of designing the MM system in a generic fashion with no “hard-coding” of specific needs. The Ethiopian team tried to emphasize to the global team the importance of restructuring the core of DHIS2 to support new reporting practices like the morbidity mortality of Ethiopia.
Restructuring the internals of DHIS2 in a generic fashion

After these rounds of discussions, one of the authors of this paper then joined the global team and started discussing how best to restructure DHIS2 so that it supports multi-value reporting in a generic fashion suitable for multiple countries. Following this, we made changes to the earlier work starting from the name – renamed the system from MM to multidimensional which represented both single and multivalued reports in a generic fashion including the morbidity and mortality of Ethiopia. At the core layer, we extracted all the additions of the specific age and gender breakups of Ethiopia and extended the data element with more generic categories and option objects. For example categories represented different dimensions such as age, gender, in-patient, out-patient and many others that users could think appropriate. The option object represented break-ups such as male and female under gender category; 0-4, 5-14, above 15 under age category; and morbidity and mortality under in-patient category.

At the presentation layer, we provided a graphical user interface that allowed users to define as many dimensions and break-ups as possible. The business layer was also changed significantly, with changes in the indicator processor, validation rule processor and aggregation engines that enabled processing the extended data element with its multiple dimensions.

Reembedding the generic DHIS2 in sociotechnical realities of countries

With the new multidimensional DHIS2, there was no specific “hard-coding” of the dimensions and the break-ups as in the previous MM case. Instead, the category and option objects were used as simple place holder templates allowing users to define their own dimensions and break-ups. Though the design was initiated based on the needs of Ethiopia, it was Tajikistan who first utilized this new design. The case of Tajikistan was particular; they demanded data collection for about 30,000 data elements involving multiple disaggregations of gender and age. The Ministry insisted on us to replicate the paper forms in totality, including the total columns which could ideally be computer generated. Given the socio-technical reality where permissions for change were not forthcoming, the newly designed multidimensional reporting module was very apt to replicate the paper forms.

In Tajikistan, in February 2008 we first established a local HISP Tajikistan team and provided them with trainings on how to define dimensions and break-ups using the generic category and
option objects. The team then managed to design complex multidimensional reports, validation rules and indicators, in Tajik and Russian languages. Since Tajikistan, the multidimensional reporting module has been put to use in various countries including Sierra Leone, India, Vietnam, Sri Lanka, Kenya, Tanzania, Zanzibar; each country customizing for its own dimensions and break-ups ranging from disease classification to profiling of healthcare staff. Currently, the DHIS2 is in use in more than 20 countries and 15 states of India; and in each instance, the multidimensional module is a central piece.

Summarizing, the need for the multidimensional module was born in Ethiopia, emanating from the socio-technical realities of diseases and donor funding arrangements. The infrastructure conditions and restrictions of internet access in the University, forced the local team to work asynchronously from the global team, which potentially contributed to some of the hard coding in the application. Working with the global team, the Ethiopian developer could value the importance of generic solutions, and through a reworking of the core DHIS2 created a module that was generic. This module found an apt home to be tried out in Tajikistan, given the reality of large numbers of data elements and their break ups which did not favor a single data element approach. The module was first embedded there, and given its design for flexibility and absence of hard coding, could easily then be transported and used in multiple contexts thereafter.

Dashboard module: born in India, stayed in India

In the early days of DHIS2 in 2006, key functionalities included data reporting with validation checks and indicator processing which were put into use in a few states in India. As the DHIS2 usage increased, States wanted to strengthen data analysis and visualization of the data already collected. In the end of 2006, a Health Commissioner from one state of India strongly insisted for a “dashboard” that would support graphical analysis, pull important data, convert data to indicators, perform analysis and display results in various formats for easier access. This was the origins of the “dashboard module.”

Embedding specific needs of an Indian state inside DHIS2

The request came only from one state in India, an early or even first adopter of DHIS2. At the time of the Commissioner’s request, the global team was not dealing with such functionalities, as the concern was still on getting the data entry functionalities right. Given this limited response
from the global team and the increasing pressure from the Commissioner to deliver, HISP India initiated the development process locally. The Commissioner, a senior officer from the civil services, was a visionary person with a strong personality and very IT savvy. He initiated a process of development where he would call the HISP India developers to his room and give requirements at a very detailed level. With this, the local team crafted three basic sets of features, including; period wise charts for values of data elements and indicators; reporting organization unit wise charts for values of data elements and indicators; and a third feature for displaying data entry status to view how much data was entered by a reporting organization units. The development approach, as explained by the Indian DHIS2 lead developer, was to start the design work “as an independent module without using the existing DHIS2 code base but using its database”. The justification given was, they only needed to pull, process and display data already stored – hence the need to focus on the DHIS2 database.

However, later the developers found it difficult to maintain two separate links, one for the dashboard and the other for the DHIS2, and started to integrate the independent module as part of DHIS2. During the integration, they did not put the source code of the dashboard module inside the global DHIS2 code base. Instead, they created a local branch from the global DHIS2 trunk and used it as their working code base. They justified the need for local branching as a strategy to provide utmost flexibility for their day to day design and programming without affecting the global code base. By working on their local branch, they improved the dashboard module with many interesting features that included integration with Excel reports and analysis of null reports. With these new features, the demand for the use of the dashboard in the states started to increase manifold, and the Indian team started providing trainings for different DHIS2 users. The popularity of the dashboard brought in new requests, leading to new developments and to a further increase of popularity. The rapid spread of DHIS2 in India, in 2009-2010, to more than 20 states, saw the dashboard module becoming deeply embedded in the reality of the Indian states.

**Failure to disembend the dashboard from settings of India**

Looking at the usefulness and success of the dashboard in India, the global HISP members started discussions on how the module could become part of the core, to be taken also to other countries. A global designer forwarded a public mail asking:
“what is the status of this module now? Isn't it way past [test branch] status now? Is it ready to become an integrated DHIS 2 module?” (October 2007, Global designer)

All designers, including the Indian lead agreed on the importance of integrating the local branch with the global DHIS2 trunk that was spread across African and Asian countries. The Indians also did this integration, which displayed incompatibility problems during compilation. From the compilation error report, a global designer traced the problem to the dashboard module and recommended to remove it from the global trunk until the problems were rectified. However, correcting this became a huge challenge, also contributing to friction between the two teams – with the global team accusing the Indians that their solution was “a poor workaround and a hack”, and the Indians feeling that the global team did not understand the pressure and situated needs they had to deal with. With the two branches kept apart, both teams went their own ways in the design process – the global team towards improving DHIS2 with latest technology for improved speed and functionalities, and the Indians towards improving the dashboard module for use in their own setting based on the demands from the rising base of state users.

However, the separation became a concern for the coordinators who were forced to maintain two branches, resulting in each side missing out important functionality. The global DHIS2 could not have the graphical analysis and visualization features provided by the dashboard, and the Indians were not able to take advantage of the updates and other functionalities that were introduced through new DHIS2 releases. Technical attempts to integrate the two solutions failed repeatedly, as reported by a developer from Vietnam:


The lead global designer then replied back saying:

“The dhis-web-dashboard has been moved out of dhis-2 and to trunk/local/in. If you need it, go to trunk/local/in/dhis-web-dashboard and install it. If you don't need it, uncomment it from the portal. General chart functionality has been implemented in the reports module” (December 2008, Global designer)

His response was out of frustration as the dashboard appeared to be a continuous source of error. He also announced that the global team had started working towards a generic dashboard solution that could work for multiple countries and potentially would replace the Indian module.
We attempted to reach a pragmatic solution by reusing the existing Indian solution with minimal duplication of efforts. We started discussing with the Indian team following an evaluation of the source code of the dashboard module. In the process, we identified a list of tasks to be completed - including the “refactoring of the dashboard and report module of India” and “performing testing for all modules”. We set task break downs and allocated them to team members. When communicating this to the global team, one member asked:

“why do we want to refactor these modules?” (January 2009, Global designer)

while another member requested for:

“Has there been any consideration of using the new global modules (also/instead)?” (January 2009, Global coordinator)

From the conversations, it was clear the global team was not keen with the refactoring process as the Indian module was not compatible with the generic DHIS2. However, we continued with the refactoring process but found out the source code was unnecessarily complex, unstructured and spread all over the layers of DHIS2. Since the objective of the Indian team was to fetch, process and display already stored data, they did not follow the systemic layers already in place inside the DHIS2. When evaluating the code we found out MySQL database specific code snippets embedded in the presentation and business layers and also specific custom Excel report templates referred to in the source code. These were all against the design practices of DHIS2 which aimed for greater flexibility enabling use in multiple settings with no specific assumptions of particular database platforms and reporting templates. Removing all the specific conflicting code snippets from the module code left us with no dashboard functionality but with thousands of lines of code with little coherence or abstract Java objects to reuse later. This then would imply the need to re-programme the entire module with almost nothing to reuse. This convinced the global team to abandon the refactoring process in favor of a generic dashboard. One member from the refactoring team concluded the effort by saying:

“...right now I don't see the modules, that we have in the global trunk, would fit seamlessly into the Indian requirements - they have quite a complex and huge excel templates. The best for the time being is to remain with what they have. But the code for it is quite messy and a source for most of the errors, exceptions and complaints from users ... as to replacing the dashboard ... I am not sure whether to go for the new one. may be we can decide after the full module testing is done. because the dashboard
An Indian team member wrote in response to the global team decision to make a new dashboard:

"[we would] like to stay with the Excel reporting module and dashboard as they are...it has been rolled out and training has been given to hundreds of people on that" (January 2009, Head of HISP India)

In the end, the local dashboard module remained in India and the global designers completed a generic solution which currently has been adapted to many countries, and is under constant improvement. The Indians have explored its advantages and adapted the same in 2011, as without it they would not be able to access the new features coming with the new releases of the DHIS2. The head of HISP India admitted the generic dashboard solution from the global team will soon completely replace the local solution as it has used the latest technology and improved functionalities, such as Google Maps. Also, hanging on to the local module would also exclude the Indians from getting technical support from the global team which exclusively focused on the global module. However, this would involve a huge challenge of disembedding the users from the existing module which they are used to, for another module whose use would need to be newly established. Making this transition for tens of thousands of active users in India is indeed a mammoth task.

In summary, we see that the Indian dashboard module was extremely particular and designed initially for the specific needs of the Health Commissioner of one state in India. Being a strong personality and a visionary public health specialist, he had clear views on what he needed in the dashboard. These views were then inscribed into the design of the dashboard by the Indian team who were put under strong pressure to deliver in short time cycles. There was little time and space for the Indian team to brainstorm ideas, reflect and work towards the development of more generic features. Further, as the dashboard became popular and adopted by more and more users in states, there was increasing pressure on the Indian developers to respond to new requests coming in, all of which were needed to be completed yesterday. Given that there were large volumes of data to be processed for analysis in the dashboard given the scale in India, the Indian teams adopted the approach of directly accessing the database rather than following the three layered structure of DHIS2 which separates the database from the business and presentation layers. As a result, the module became increasingly well embedded in the Indian context, and
simultaneously distant from the global core. This led to a breakdown situation with the global team explicitly disbanding the Indian dashboard and building something from scratch. The Indians were left with the difficult option of continuing with their dashboard at the cost of being excluded from global updates and new releases. After initial reluctance, they were forced to adopt the global module.

**Analysis and discussion: scaling as a process of managing sociomaterial assemblage**

In the previous section, we presented two contrasting cases of DHIS2 scaling – one related to the multidimensional module which started for Ethiopia and spread to many countries, and, two of the dashboard module which started for and in India but failed to spread outside that context. The two cases, together with the design and development of the global dashboard module that came as a replacement for the module from India, provide insights into aspects of the scaling process. They demonstrate both the expansion and spreading aspects of scaling, while also illuminating why applications don’t scale.

In the Ethiopian case, the expansion was in terms of taking the DHIS2 from a level where it supported only single value reporting to a level of multidimensional reporting supporting different forms of dimensions and options. This is in line with scaling on the functional dimension, representing and expansion in scope and size (Sahay & Walsham, 2006). Originating from Ethiopia responding to specific needs to support Mortality and Morbidity reporting, the module was then adopted and reworked by the global team, to first be tested and adapted in Tajikistan. The success achieved there led to further enhancements, and the subsequent transporting of the module across various countries and also Indian states. There was an expansion of the module across both the time-space dimensions.

The Indian example also illustrates scaling across the functional dimension, as the dashboard provided new features for processing, analysis and graphical visualization of data which did not exist before. There was a scaling across also various uses and users in the Indian context in different states. However, it was found to be technically inadequate to be moved to other countries as it was not technically compatible with the global core. Ultimately, the module “died” and was replaced by the global module. In retrospect, the module could not scale both in time and
in space.

In this analysis section, we analyze these cases with the contrasting outcomes within the same DHIS2 software, by taking a closer look at the process of scaling. Our analysis reveals that scaling is a complex process of managing sociomaterial assemblage in time-space whose success (or not) is affected by the outcomes of the processes of embedding, disembedding, material restructuring, and reembedding. We now elaborate on these different facets of the scaling process.

The embedding process in scaling

Take the multidimensional reporting case for example. The scaling was initiated because of the gap between what was supported in DHIS2 and what was required to support the existing public health practices in Ethiopia. For the DHIS2 to be useful in Ethiopia, it was important to fill this gap by taking DHIS2 to a level where it supports morbidity and mortality reporting practices. When local designers were delegated with the task of filling the gap, they were faced with two sets of interconnected challenges related to the social and the material. From the material side, they needed to engage with reworking an existing code base of existing functionalities, data model, source code, and DHIS2 layers, but within an environment with extremely limited internet infrastructure. As a result, they needed to access the code base through email, and then carry out the development on local laptops, which excluded inputs from the global team based in Oslo. From the social side, they were faced with challenges in understanding work practices targeted for reducing morbidity and mortality. Very particular demands from the Ministry of Health and other donors made the task challenging. The team managed to find its way in reaching a working assemblage of the social and the material by embedding local reporting needs in the core, business and presentation layers of DHIS2.

It was a similar process in the dashboard case of India. There again, the expansion was a result of local needs from a state in India, design work of the team of HISP India and available technology which includes MySQL, Excel and the DHIS2 itself. Here again, the local needs for the dashboard was urgent, and response from the global team not so forthcoming. The Indian team started the development, but technically they could not appreciate the three layered architecture in the DHIS2, as it was not part of their experience, and resorted to a rather hard coding of the needs. Socially, the team had to engage with responding to the needs of a very large base of
users, deal with high volumes of data processing demands, and sharp time pressures which gave little time to brainstorm ideas and reflect on approaches. The apparent disconnect between the Indian and global teams for reasons of both geography and culture, excluded the possibility of external review and comments on the code.

When looking at both cases, we see two levels of the sociomaterial assemblage corresponding to different realities before and after the expansion. The assemblage can be seen as a heterogeneous collection of the social and the material ranging from reporting paper forms, organizational demands and their practices, leadership environment, to available Internet infrastructure and programming styles. In both cases, the designers managed to achieve the first level of functional scaling and embedding the DHIS2 within their respective contexts. This process of embedding required the developers to understand both the social and the technical, and construct the assemblage in the manner in which they best understood and were capable of. For example in Ethiopia, the local team had to deal with the limited internet infrastructure and restrictions to its use, the paper forms that resulted from health system reforms carried out through a collaborative process involving various stakeholders including the international donors such as the WHO, CDC and USAID. In India, the assemblage was constituted initially from the strong vision of the state Health Commissioner and the various needs from states within short time cycles. Lack of prior experience of the Indian team to work within a layered architecture meant that they tried to deal with the social pressures by hard coding reports through direct access to the database. In trying to accommodate and manage within these various socio-technical realities, both teams were able to embed the applications in their respective local contexts by establishing a working constitutive entanglement between their settings and the DHIS2.

The challenges started to arise, as the global team needed to disembed these modules from their respective local contexts, restructure them materially and make it part of the core, and then enable their reembedding in multiple other time space contexts. From the other side, the local teams would also want this integration to take place as they firstly have the status of creating something for the global, but also they need to be able to take advantage of global updates coming through new releases. Spreading a working solution to other time-space contexts is not a luxury; it is rather a prerequisite to sustain the very first existence of the solution that worked in the particular context (Braa et al., 2004). This requires the ability – technically and socially – of the application
to be disembedded for enabling material restructuring.

The disembedding process

Once the DHIS2 was embedded in the respective contexts, of Ethiopia in the first case and that of India in the second case, what we had was no more a box of DHIS2 that could be lifted out from Ethiopia or India and put it into another country. What we had was a sociomaterial assemblage that only made sense in its entirety in the context it was established. Moving the entire ensemble “as is” and planting in another was impossible as no two countries come with identical settings. That was what happened for example with the first case – “this works only for Ethiopia but not for other countries” was the response for the MM module from Ethiopia. It was a similar case with the dashboard module from India – a solution that worked for India couldn’t work for others outside India, and technically resulted with numerous errors. The specific skills of the Indian developers which kept their dashboard module up and running would also have been difficult to replicate in other settings.

However, this does not mean it is totally impossible to spread a technology from one context to another. This rather demonstrates the challenges and “(im)possibilities” (Berg & Goorman, 1999, p.51) of spreading across contexts. We even experienced this – managing to spread the MM out of Ethiopia but failed to do the same for the dashboard from India. This was possible with the disembedding of the module from Ethiopia, something which could not be done in the Indian case. In the Ethiopian case, the developer came to Oslo, together with the module, allowing the team to then explicitly think about the redesign. The urgent demand from Tajikistan for the multidimensional module, further facilitated the process. The Indian case was different, as the Indian developers were based in India and extremely busy dealing with the everyday demands of users from states. They did not have the space or the possibility to work on the remembedding process, a task which could not be done exclusively by the global team because of the structure of the code.

The restructuring process

It was important to follow the disembedding with a process of material restructuring. Because what remained after the separation, was some form of materiality devoid of its meaning and a context that lacked required features for users to use. For example, when we removed all the
specific additions of the Indian team from the DHIS2, we were left with thousands of lines of codes that made no sense and a context that had no dashboard functionality. The same had happened with the MM module from Ethiopia but we managed to bring sense to it through a complex process of restructuring based on the demands for the specific case of Tajikistan.

The restructuring process in both cases was affected by the outcomes of negotiations between designers and also by the affordance and constraints of the materiality itself. For example with the India case, the two groups of designers were not on the same perspective when approaching design. Those designers from Oslo were guided with the global perspective and the practice of approaching design in terms of layers, flexibility and generification with no specific assumption of countries as they were not tied to any country. On the other hand, those from India were under the pressure of responding to immediate local requirements and into the practice of embedding specific codes and reports inside the DHIS2. It has also been argued by others that Indian developers are good at carrying out structured coding tasks rather than creating an overall design and a product (Sahay et al 2003). Changing such practices, including related to software development, is a non-trivial task, as these are historically shaped through processes of education, family and social relations which may emphasize hierarchy and various other social conditions (Sahay and Walsham 2005). These shape the way humans perceive things and think in their contexts. This was reflected in the materiality, affecting affordances and constraints for restructuring – sitting with thousands of lines of codes with no layering, modularization and limited coherence and possibilities of reuse. These characteristics surely affected our restructuring process.

For the Ethiopia case, it was possible for the two groups of designers to share a common perspective. Local designers from Ethiopia were able to discuss with the global team and reach a consensus on design. As a result, it was possible to carry out a full restructuring starting from the renaming of the system from MM to multidimensional reporting to extracting specific age and gender breakup codes and replacing them with more generic and abstract category and option objects. This helped to reach a stage of materiality that could be devoid of its meaning (only generic and abstract) but ready to be easily transported and (re)embedded in a particular context and to be useful there. This reflects the process of reembedding which is described next.
The reembedding process

In sociomateriality, separating the social and the material is only temporal and analytical; the two need to be seen in their ensemble in time-space. For example, for the multidimensional solution to make sense in Tajikistan, we had to reembed it back into a new local setting. The process was a similar one with that of embedding – that required the involvement of the locals, understanding of their needs, building their capacity to allow them to use the generic and abstract multidimensional solution in a way they see it fit into their local context, including language.

Such reembedding process brought the scaling of DHIS2 for multidimensional reporting to a successful completion. It was a different case for the dashboard module from India. Since it had been difficult to disembed and materially restructure the module, it could not be made appropriate to reembed into multiple other time-space contexts. These difficulties arose primarily due to the materiality of the dashboard module including the coding style followed, and other social factors including the pressing needs from the states of India that inspired quick fix solutions. Geographical and cultural distance between the Indian and global teams also did not help matters in trying to enable the scaling processes. This then contributed to the creation of a generic alternative solution, based on modern technologies, that came from the global team. As a result, the dashboard module couldn’t scale outside the settings of India. However, the module continued to be a success in the Indian settings, living a life of its own.

In summary, the case analysis emphasizes two key aspects relating to scaling. Firstly, scaling is better understood as a process of managing sociomaterial assemblage across time-space rather than just as a technical process of expansion or spreading. Such a perspective highlights the interconnected roles of the social and the material in the success (or not) of scaling processes. Secondly, the scaling process is not one large step of moving from point A to B, but involves smaller steps, which we identify as embedding, disembedding, material restructuring and reembedding. Seen in these smaller steps, it becomes more possible to understand the sociomaterial constraints that may arise at different stages of the process, and how these may be addressed.
Conclusions

This study, with its analysis of scaling as a process of managing sociomaterial assemblage brings important practical and theoretical contributions to the literature of IS research.

Theoretically, the study extends our understanding of the concept of scaling with due attention to the interplay of the social and the material in time-space. By doing so, the paper addresses some limitations from existing conceptualization of scaling. First, there exists limited discussion around the interplay of the social the material in scaling, which IS research has emphasized in other domains. Second, when we introduce a system to a new setting during spreading, it may not always be necessary to increase the size, numbers, type or volume of the IS. Depending on the nature of work practices, organizational structures, social processes and other factors of the new setting we are moving into, we may be required to do some form of “de-scaling” in terms of reducing technology materiality (or functionality), software or hardware capacity and other aspects and bring a working system. Thus, with a focus on the constitutive entanglement of the social and the material in time-space, the paper brings attention more to the process of establishing a working assemblage than on the output of achieving an increase in size or scope.

As a practical contribution, the study offers practitioners a strategy to design for scalable systems. During system design, practices are often targeted to addressing immediate organizational requirements and reach a problem closure with little attention to what comes after a while or what consequence the local focus brings to other organizations and time-space contexts. With scaling seen as a process of tracing multiple heterogeneous sociomaterial assemblage across time-space, chances are that we will be encountering multiple organizations and various practices that would require different forms of materiality. Thus, the processes of embedding, disembedding, material restructuring and reembedding, discussed above, offer practitioners mechanisms to design for more scalable systems, with a focus on the process through which this is done.
References


Open generification: a design strategy for health information systems in developing countries

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Abstract

This paper addresses the seemingly implausible project of developing ‘generic’ software to be used in the health care sector of developing countries. Based on the findings from a longitudinal case study of an open source Health Information System developed ‘globally’ and implemented ‘locally’ in more than 30 developing countries, this paper challenges and extends Pollock et al’s (2007) concept of generification. Emphasizing the inherent contradiction between generic solutions and the diversity of local contexts, we describe a generification process that is different in the sense of being open and collaborative. This process is not about managing the community of users attached to a software package by homogenization or segmentation, but instead concerning how to manage the diverse needs of the community the software is expected to serve. We suggest calling this open generification. Through a continuous interplay between generic and specific software and continuous cycles of embedding (implementing the global in the local context) and disembedding (taking local innovations into the global) by global and local level designers, we show a viable alternative to the single supplier approach. It is a complex task to keep this network and process running, and considerable challenges lie in material restructuring, architectural innovation, making global out of local innovations, avoiding local fork-outs, and negotiating priorities. At the same time, the approach yields substantial benefits because those innovations taking place in local settings and their close proximity to use offer opportunities to advance the generic software.

Keywords

generification, embedding, disembedding, health information system, developing country, free and open source software
Introduction

Many Information Systems (IS) interventions in developing countries during the last two decades have been reported as total or partial failures, a challenge attributed to arise from a mismatch between technology and context (Heeks, 2002; Heeks et al., 1999; Lind, 1991; Rajapakse & Seddon, 2005; Soh et al., 2000; Yen et al., 2011). Health Information Systems (HIS) are no exceptions; they commonly exhibit a mismatch between design and reality (Heeks et al., 1999; Heeks, 2006) and required and available capacity (Kimaro, 2006; Jayasuriya, 1999). In all the above mentioned studies, a-contextual technology that often come with donors but does not fit to the socio-technical realities of the developing country where it is to be implemented is perceived to be the main underlying problem.

A key characteristic of the healthcare sector in developing countries is its dependency on donors (OECD-DAC, 2009; 2011; De Maeseneer et al., 2008; WHO, 2006). Often, the donors work globally and bring with them the same technology across the multiple countries they operate in (Baark & Heeks, 1999). When operating globally, it is practically and economically prohibitive to conduct independent design for each country (Braa et al., 2007b; Rolland & Monteiro, 2002). Instead, a more pragmatic design strategy is required, which helps to develop a generic solution by striking a balance between what to transfer globally and what to cultivate locally (Bjørn et al., 2009). However, beyond the general advices of being pragmatic, we need to develop deeper insights and articulate a particular design strategy that incorporates the very nature of contexts where generic artifacts are developed at the global level and implemented in multiple local contexts. One promising perspective to look into this issue is the concept of generification work suggested by Pollock et al. (2007). Generification is defined a design strategy followed by software suppliers when developing a single artifact that fits into the needs of multiple customers. While the notion of generification work appears promising for addressing challenges of the technology-context mismatch pointed above, it has not so far influenced practices of IS design in general, and HIS in particular in the context of developing countries. Widely discussed innovation mechanisms such as transfer and diffusion and social
embeddedness (Avgerou, 2008), has proven insufficient in offering appropriate IS design practices in developing countries.

We believe that the generification approach offers an alternative strategy, perhaps a more adequate one; but in order to make it useful we need to establish a deeper understanding of it in the context of developing countries. For example, being conceptualized in supplier/customer relationships where business values and profit maximizations are the norm (Pollock et al., 2007), it is not clear how it plays out in the public sectors of developing countries where aid and international donors are the key institutions. Similarly, while successfully employed in commercial organizations practicing closed and centralized software development processes, it is not clear what form of generification exists in distributed and open source software development processes often seen in the interactions of donors and developing countries. In this paper we seek to understand these and related issues and develop an alternative framing of the generification process. Our investigation is guided by the following research question: How can the generification approach be extended in order to be applicable in the context of health systems in developing countries?

Our investigation is based on empirical data from a case study on the Health Information Systems Programme (HISP), initiated by the University of Oslo. HISP is a long-term project conducting activities of HIS design, development and implementation in multiple African, Asian and Latin American countries. Our analysis focuses on the design practices of HISP, in particular how it achieves technology-context fit locally in the multiple countries while maintaining a generic core at the global level. Based on the analysis we offer two contributions. Theoretically, we extend the generification research by the concept of open generification, which we describe as a dynamic between embedding and disembedding processes. Practically, we articulate an open generification strategy to guide practitioners when designing HIS artifacts in particular, other organizational IS artifacts in general, that are expected to work in the context of multiple different developing countries.

The paper proceeds as follows. In the next section, we review related research and introduce our key concept of generification. Following this, we outline our research approach. Then, in section 4, we present our empirical materials from the case study.
Discussion follows in section 5, and in section 6 we offer conclusions and suggestions for further research.

**Literature review: generification processes**

Discussion of IS design that works for multiple contexts is not new; it has been widely reported in the literature of large-scale global technological systems. The literature argues for the importance of articulating and balancing between the global and the local (see for example Bjørn et al., 2009; Keen et al., 1982; Rolland & Monteiro, 2002). In this literature, a key recommendation is a pragmatic design strategy that helps to identify and standardize common and core elements of the global system while at the same time being sensitive towards the needs of local contexts. This aims at managing the tension between the standardization needed at the global level and the flexibility needed at local levels (Hanseth et al., 1996). Contributing to this discourse, and with a particular focus on HIS design for developing countries, Braa et al. advances the notion of “flexible standards”, claiming “if they are well defined and simple, they will be able to adapt to the frequent changes that are experienced in the complex health environment” (Braa et al., 2007: 382). However, pointing out that standardization in healthcare is a complex process, Hanseth et al. warns against the danger of “overestimat[ing] universality of work practices, thus seeking order by simplification and abstraction” (Hanseth et al., 2006: 577).

**Generification by suppliers**

Designing a standardized as well as flexible technology that adapts to diverse contexts is indeed not an easy task of simplification and abstraction; it is a complex process of managing both the technology and community of users attached to the technology (Pollock et al., 2003; Pollock et al., 2007). The key evidence used to underpin this argument is the design process of Enterprise Resource Planning (ERP) systems (Grimm, 2009; Pollock et al., 2003; Pollock et al., 2007; Wang, 2007). ERP systems are globally generic artifacts designed by suppliers through a process conceptualized as “generification work” (Pollock et al, 2007).
The concept of generification refers to “the supplier strategy of taking a technology that has worked in one place and attempting to make it work elsewhere, and, in principle, ‘everywhere’” (Pollock et al., 2003: 318). Technology working in a particular context is fixed in time and space (Berg, 1997) and hence transporting it to another context requires a complex work of disentanglement (Berg & Goorman, 1999). This calls for “a process by which software packages are successively emptied from references to local details to become standardized, generic solutions ready to travel globally” (Kallinikos, 2009: 915). Subsequently, at the local level a process of re-embedding is needed, where the ‘emptied’ generic solution is aligned with local details.

We believe that Gidden’s concepts of embedding and disembedding are useful to understand the time-space distanciation that is critical in generification. In his discussion of globalization Giddens defines disembedding as “the lifting out of social relations from local contexts of interaction and their restructuring across indefinite spans of time-space” (Giddens, 1990: 21). Embedding (or re-embedding) is defined as “the appropriation or recasting of disembedded social relations so as to pin them down to local conditions of time and place” (Giddens, 1990: 21: 79-80). We use these terms as our analytical lens to understand the dynamics of generification.

**Mechanisms of generification**

Three mechanisms are suggested for generification. These are management by community, management by content and management by social authority (Pollock et al., 2007). For management by community, it is suggested for suppliers to move design “from the private domain of each user site, where only particular needs could be articulated, to a public setting, where community or generic requirements could be forged” (Pollock et al., 2007: 263). This essentially brings a burden to the suppliers, as they could be flooded with diverse requests. To overcome this, an alternative strategy of management by content is suggested, where diverse requests are shaped and smoothed out using configurable templates while those not compatible across sites are “rejected or sifted from the process” (Pollock et al., 2007: 265). For management by social authority, the suggestion is to have a segmentation strategy where customers are clustered according to their commercial importance. Once
segmented, suppliers respond to needs of only those considered commercially important. Those ranked less important “[are] pushed to the margins of the shaping process where they [are] not consulted or involved in design” (Pollock et al., 2007: 269).

However, Franke and von Hippel warn against the strategy of segmentation for serving diverse users needs as it “leaves many seriously dissatisfied” (Franke & von Hippel, 2003: 1119). By offering an innovation toolkit, they argue, it is more effective to serve diverse user needs by transferring the task of meeting local needs to the users compared to doing it globally from the producer side using segmentation. Similarly, raising the awareness of systematic marginalization of vulnerable groups and communities, research in the context of developing countries suggests strategies based on user participation that involve locals in design and decision making (Braa et al., 2004; Puri, 2007; Titlestad et al., 2009).

The challenge then is to generify a minimum common core that can be used by multiple users and allow the users to generate a working solution of their own based on the common core. Generative design is one strategy useful in this regard, emerging as an alternative to traditional system design that aims at producing technology that fits multiple contexts (Avital & Te’eni, 2009; McCormack et al., 2004). In generative design, the focus is not on the final product per se but the incorporation of rules, system dynamics and other resources into mechanisms that lead to the final solution (McCormack et al., 2004). Such a focus on the means is central in meta-design (Fischer & Giaccardi, 2005). By creating the means, the goal is to create a design space where users are provided with resources, including a common core, so that they can perform a variety of activities ranging from simple customizations and configurations to advanced design and programming tasks. Embracing users as co-designers is also a strategy central in open source software development (Fischer et al., 2004; von Hippel, 2001). In open source software development, a software package is publicly available with its source code for anyone to use, study, change, and further improve. This has been argued as useful for designing innovation toolkits that serve heterogeneous user needs (Franke & von Hippel, 2003). In addition, for the context of developing countries, open source development is regarded a useful
strategy especially for coordinating global and local level design processes (Staring & Titlestad, 2008).

In summary, the concept of generification seems promising as it offers an attractive and alternative design strategy, which should be investigated in the context of health systems in developing countries. It should, however, be extended to cater better for collaborative and open approaches and the facilitation mechanisms of embedding and disembedding that are considered vital in time-space distanciation. To support this discussion, we see generative design and HIS based on open source software development as suited candidates for theorizing and empirical investigation. Though considered strategic to serve diverse user needs, generification has not been applied in the discussion of technology design for developing countries – which we believe is a unique setting and with an opportunity to bring a deeper understanding of the concept of generification. Unlike commercial ERP systems, HIS for developing countries must be based on an open platform that forms the foundation for a range of (re)configurations generated by local and situated users in their respective contexts. With a common core generated from the global side and specific needs generated from the local side, the aim should be a working solution for diverse contexts developed in a global-local open and collaborative manner.

Research approach

Our empirical investigation of designing globally generic software for a diverse user base draws on the design practices of the Health Information System Programme (HISP). HISP, whose major source of funding is the government of Norway, is a global project that has been running since 1994 (Braa et al., 2004). Key activities in HISP are design, development and implementation of a software package called District Health Information Software version 2 (DHIS2). DHIS2 is intended to support recording, tracking and reporting practices across the different level of public healthcare in developing countries. A global team based at the Department of Informatics, University of Oslo and local teams in each implementing country manage the software. Currently, the software is in use in more than 30 countries in Africa, Asia and Latin America ranging from pilot projects to nation-wide system. The countries using the system include, India (more than 10 states), Vietnam,
Bangladesh, Sri Lanka, Tajikistan, Sierra Leone, Nigeria, Ghana, Kenya, Uganda, Zambia, Colombia and Paraguay – all using it in their official language. Some are running DHIS 2 on a Windows platform, while others on Ubuntu, on Linux and in some case on Mac. In some countries, it is run independently by the Ministry of Health, while others are using a ‘cloud based’ approach, where the servers are hosted by national or international partners and managed by partners or by members of the global team.

Considering this case a fruitful ground to investigate our research question, we conducted an in-depth case study (Gerring, 2007) in HISP and DHIS2 over a period of 7 years from 2007 to 2013. Following the biography of a software artifact over many years is crucial to understand the generification process (Williams & Pollock, 2009). In addition, one of the authors has the experience as a local designer of the DHIS2 at one point and later as a global designer. This has provided us an invaluable insider perspective, enriching our understanding of the design processes and practices related to DHIS2. With a focus on global and local design processes, we followed the case from three different angles. First, we followed the activities of those global level designers who have the overall responsibility of designing, coordinating, maintaining, and releasing the global core. Second, we followed the activities of local level designers working with the global core to make it fit to their local requirements and situated use-cases. Complementing these two, with our third angle we followed the interaction between global and local level designers.

Data Collection

For data collection, we used interviews, participant observation, and document analysis of both published and unpublished documents including electronic archives of emails, chats and Skype conference calls. We interviewed seven designers: two from Oslo, two from India, and one from Tajikistan. For the interviews, we used face-to-face conversations supported by an email questionnaire. We relied on interview notes and email archives to capture the data from the interviews. The second technique we used for data collection was participant observation where we actively participated in design workshops and implementation seminars. In addition, one of the authors participated in DHIS 2 design both at global level in Oslo and at local
levels in India, Ethiopia, Tajikistan and Vietnam. The same author also participated in Skype conference calls that had DHIS2 design agendas. In our document analysis, we used a significant volume of data from design blueprints, training manuals and electronic archives from the HISP website, DHIS2 designers and users’ mailing list and Google Docs that are frequently used as a medium to share design documents and blueprints among designers. Table 1 provides further details about our data collection.

Table 1: Summary of data collection and methods used

<table>
<thead>
<tr>
<th>Data Collection</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview</td>
<td>Face to face and email questionnaire interview of global and local level DHIS2 designers located in Oslo, India, Tajikistan.</td>
</tr>
<tr>
<td></td>
<td>o 2 designers each from Oslo and India, and one from Tajikistan</td>
</tr>
<tr>
<td>Participant</td>
<td>Diary notes, in some cases presentation slides, were collected from the following list of activities</td>
</tr>
<tr>
<td>observation</td>
<td>o participation in 7 seminars/workshops/trainings session (3 in Oslo, 2 in India, 1 in Vietnam and 1 in Tajikistan)</td>
</tr>
<tr>
<td></td>
<td>o participation in DHIS2 designers and implementers Skype conference calls with participants from Oslo, India, Vietnam, Tajikistan,</td>
</tr>
<tr>
<td></td>
<td>Tanzania, Malawi, Sierra Leone and Zambia</td>
</tr>
<tr>
<td></td>
<td>o participation in group and private email conversations regarding design, implementation and use of DHIS2</td>
</tr>
<tr>
<td></td>
<td>o participation in meetings of recording, tracking and reporting modules design including support for mobile phones</td>
</tr>
<tr>
<td></td>
<td>o participation in activities of design for recording, tracking and reporting modules of DHIS2</td>
</tr>
<tr>
<td></td>
<td>o participation in activities of design for extending the DHIS2 to mobile phones</td>
</tr>
<tr>
<td>Documents</td>
<td>Design blueprints and data models</td>
</tr>
<tr>
<td></td>
<td>Requirement documents</td>
</tr>
<tr>
<td></td>
<td>Training manuals</td>
</tr>
</tbody>
</table>
Data analysis

For data analysis, we used a general inductive approach (Thomas, 2006), which helped us to structure our analysis in three broad steps. These were: summarizing our raw data into brief summary formats; developing relationships between our research objectives and summary findings; and finally formulating a conceptual framework that captures the phenomenon we observed.

We started the first step of our data analysis by mapping out the case material as data displays (Miles & Huberman, 1994). We then moved to condense the extensive raw data into a brief summary organized around key events shown in Table 2. We organized the key events based on design processes that either created new modules or changed existed modules in DHIS2. We also took the initiation of DHIS2 as a key event as it has set the roadmap of the overall design process. Leaving the details aside and taking a broader view, we observed one, ‘generic’, DHIS2 being used in many countries. This convinced us to focus our analysis around the design process of DHIS2 by asking how the designers managed to keep one generic package – the generification process. This helped us to move into the second stage of our analysis by making a connection between the empirical data and our research objective – which is investigating a generification logic that overcomes technology-context mismatch in the context of developing countries, in particular in healthcare settings.

In the second step of our analysis we identified central themes from each of the key events that contributed to the generification process. We facilitated this through data reduction by repeatedly asking ourselves “how do all the codes and themes relate to each other? What is the big picture, and how does it relate to each theme or code?” (Miles & Huberman, 1994: 69). The bottom up coding procedure helped us to observe the unfolding DHIS2 generification process as it emerged from the ground. The concept of generification and its associated mechanisms from the literature
provided us a lens to further analyze, code and abstract concepts as they became apparent. Table 3 was the output from the second step of our analysis. Finally, we developed a conceptual framework that captures the underlying generification processes as observed in the empirical data. Figure 1 presents the conceptual framework we developed.

**Case description**

We now present the design process of DHIS2. Four key events, with a time line shown in Table 2, constitute our case description. To put the design process in context, we start by presenting the early history of DHIS2 based on published and unpublished documents.

**Table 2: Case timeline with key events**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Since 2005</td>
<td>Shift to generic, distributed, and collaborative design</td>
<td>In 2005, global designers of HISP initiated a shift from an earlier version of DHIS to a new version – the DHIS2. The aim was to replicate existing functionalities of the old version using free and open source technology.</td>
</tr>
<tr>
<td>2007</td>
<td>Upgrading the specific to a generic</td>
<td>Faced with technology-context mismatch in Ethiopia, local designers extended the DHIS2 as per their needs. Later, a team of global and local level designers re-designed the local DHIS2 in a generic fashion that proved useful for many countries outside Ethiopia.</td>
</tr>
<tr>
<td>2009</td>
<td>Replacing the specific with a generic</td>
<td>In 2006, a local team in India extended DHIS2 for dashboard functionality. After failed attempts to make it useful for other countries, the global team came with a new generic solution in 2009 that replaced the specific solution.</td>
</tr>
<tr>
<td>2009</td>
<td>Overhauling the specifics with a generic</td>
<td>A local team in India designed DHIS2 mobile reporting for a specific report. Requests for different reports resulted with multiple mobile applications. Considering designing an application per report unsustainable, the global team overhauled the multiple applications with one generic application as part of the DHIS2.</td>
</tr>
</tbody>
</table>
Shift to generic, distributed and collaborative design

Prior to DHIS2, HISP had an older version (DHIS1) designed in 1998 for a province in Western Cape by a small team based in South Africa (Braa & Hedberg, 2002). The older version runs as a standalone application using proprietary Microsoft Access and Visual Basic Scripting technology. From Western provinces, the system went to Eastern provinces late in 1998. In 2000, with funding from the Norwegian and US governments, the software became a de-facto reporting system for the entire country (Braa & Sahay, 2012).

After South Africa, HISP took the system to Cuba, Mozambique, Malawi and India. Cuba rejected it because of the use of US based Microsoft technology (Braa & Sahay, 2012). Though the software was free of charge, Mozambique and India requested a web-based system without proprietary technology. At the same time, with the user base growing, HISP wanted to have a more robust and distributed design practice beyond the small circle in South Africa. This led a team of students and researchers at the University of Oslo to initiate a process for migrating the functionality of DHIS1 to a web-based and free and open source software (FOSS) based DHIS2 in 2005. The team initiated the design following a layered architecture and using platform independent Java tools with an internationalization and localization programming strategy for supporting multiple languages. The new design further followed an open and distributed development strategy using Internet based code synchronization and coordination tools. With designers in Norway serving as a global team, local teams emerged from India, Vietnam, Ireland, Ethiopia and Tajikistan.

DHIS2 is available publicly as a free download and online demo (http://dhis2.org). When running the software, users encounter two sets of menus – Maintenance and Services (see figure 1). Under Maintenance, users are provided with interfaces that allow them to design the type, format and size of data they want to process – for example what to report (data elements), in what format (data set), how often (period) and by whom (a hierarchy of reporting organization units). Under Services, it is possible to access those items designed under Maintenance and perform the actual data collection, reporting, analysis and presentation. Localization is also part of the
Maintenance menu, enabling users to specify in what language they communicate with the system or store their data.

![DHIS2: The home interface](image)

**Figure 1: DHIS2: The home interface**

In the user documentation of DHIS2 it reads:

"[DHIS2] is a generic tool rather than a pre-configured database application, with an open metadata model and a flexible user interface that allows the user to design the contents of a specific information system without the need for programming"

Claimed generic, the software comes with no specific content when released globally. A member from local HISP Zambia team explains this as:

"... from an implementation standpoint ... when new users attempt to use DHIS2, it is blank. There is nothing there. We have tried to fill this gap a bit with by answering questions over the public mailing list and also through the documentation..."  *(September 2011, Local HISP Member from Zambia)*

Through the public mailing list, global and local HISP members exchange best practices, ask questions and request for new features. For example in one mail, a local member asked:
“Any suggestions for partner reporting in DHIS-2? Our HIV team works with civil society organizations and local partners to track a very simple list of services provided to persons living with HIV/AIDS. The data elements themselves are all numeric so it would be easy to do in a regular data set, except that partners don’t fit well in the reporting hierarchy which goes from Province -> district -> sub-district -> sector -> health facility” (Local HISP Member from Rwanda, March 2013)

He continued to explain his use-case by outlining a way in which this could be solved with existing DHIS2 functionality:

“…we can create the report using the Single Event Without Registration feature in Individual reports, using an option set to maintain the list of partners, but unfortunately we can’t seem to use any of this data in the dashboard, data visualize, maps or standard reports.” (Local HISP Member from Rwanda, March 2013)

A member from the global team replied by suggesting:

“…on this issue there are lots of opinions – my recommendation would be to stick with the aggregate part of the system and leave out the individual records module” (Global HISP Member from Oslo, March 2013)

The global member went to explain his suggestion by guiding the local HISP member:

“… set up a category and category combination called “Partners”… create data elements for each service and assign them to the partner category combination … create one dataset per partner … for each data set you create a custom form… you create user roles for each partner … you assign the partner data sets to the corresponding partner user roles ….” (Global HISP Member from Oslo, March 2013)

In another discussion, another local HISP member sent a mail for the entire HISP team asking for a best approach to define population data from which he could extract important indicators. He received two replies from local HISP members of different countries outlining their best practices. His responses went like: “I guess we are in the same step…”, and for the second one he said “… your solutions seems to be easiest one it reduces the amount of data …” Another local member joined the discussion saying, “Each country has specific population categories … that they are always looking for based on their strategic direction…” and continued the discussion outlining his experience from Kenya.
In addition to discussions of the use of existing functionality in the DHIS2, there were also discussions where local HISP members were encouraged, though cautiously, to make changes in the core source code if this was the only way to satisfy their needs. For example, one local member asked:

“Hello there, Is there a simple way to add sections or pagination to a custom form? The goal is to avoid scroll when dealing with long forms” (Local HISP Member from Mozambique, April 2013)

Then a member from the global HISP team replied:

“Hi [name_of_the_requesting_member], there is way for developers. Don’t try this at home. In custom form editor, view the source. Wrap the HTML contents that you want to appear as a section in a div and add a class "formSection" to it, something like: <div class="formSection"> // Stuff that makes up a section here </div>. You should now be able to use the section drop-down that appears for section forms in data entry.” (Global HISP Member from Oslo, April 2013)

There were also some discussions that went on between specific and generic designs. Below, we describe three such cases.

**Upgrading the specific to a generic**

When DHIS2 was introduced to Ethiopia in 2007, it faced a problem of technology-context mismatch. DHIS2 was designed based on one-dimensional data model that allowed storage and processing of single data value per data element – for example, what is the total number of people with malaria. However in Ethiopia, reporting is based on multidimensional data – for example what is the total number of people with malaria; of the total how many are male, how many female; of those male how many are under the age of 4, between the age of 5 and 14, above 15. Trying to overcome this mismatch, a local HISP team started to design for multidimensional reporting by downloading the freely available source code. In the process, the local team introduced major changes to the core of DHIS2 by embedding the age and gender breakups required in Ethiopia. When communicating their initiative and proposed changes to the global team, the local team received a mixed response. A coordinator from the global team sent an email saying: “Looks like you’ve done a great job… really heartening to know that we can now handle [multidimensional]”. However, the lead designer from the global team said:
“This works fine, but not for countries which don’t need the [multidimensional] functionality. At a workshop in Cape Town in October we concluded that the [multidimensional] system should take care of its data separate from DHIS2…. By doing it this way, the core of DHIS2 wouldn’t have to be changed at all… also countries not needing the [multidimensional] functionality would not be affected at all…. the implications of this, compared to your code is that you extract all your code from the DHIS2 core modules and make a separate project.” (Global HISP Member from Oslo, February 2007)

The local team acknowledged the changes made were relevant only for Ethiopia, but argued against the idea of not changing the core as it had limitations for complex reports of multidimensional nature. The local team was persistent, and pursued the global team to discussions focused on extending the DHIS2 so that it supports multidimensional reporting in a generic fashion. Later, the two teams reached consensus by agreeing to change the core data model by replacing the age and gender additions using Category and Option objects based on the assumption that they could be used for any dimensions and disaggregation units. For example, gender can be considered as a category with male and female represented as options along the gender dimension, and age can be represented as category while under 4, 5-14, and over 15 are options along the age dimension.

While working on the changed multidimensional data model, HISP got the opportunity to implement DHIS2 in Tajikistan in November 2007, based on an invitation from the Asian Development Bank to participate in the computerization process of the health care sector of Tajikistan. While working on the needs assessment, the Ministry of Health of Tajikistan presented specific paper forms and ordering the HISP team to computerize them in the exact same look:

“…since these forms are approved by the Central Statistics Authority, you are not allowed to make any change to the forms, even adding a logo.” (Tajikistan Ministry of Health, January 2008)

The forms requested were multidimensional, and more complex than the age and gender dimensions observed in Ethiopia. After accepting the request, four global HISP members left Oslo to Tajikistan to work on the computerization process. After two months of work in Tajikistan, the team completed the design supporting both one-dimensional and multidimensional reports. For one-dimensional reports, the software takes default dimensions where local teams do not have to design a
dimension. For multidimensional ones, the new design offered menus allowing local team to design their own dimensions and units using the Category and Option objects. While in Tajikistan, the global team also formed a local HISP team and provided trainings and guidance enabling the Tajiks to design their own data collection, reporting, analysis and presentation formats. The local team helped in translating to Tajik and Russian languages. In February 2008, the global team demonstrated a working system in a workshop organized nationally by the Ministry. On the approval of the Ministry, the global and the newly established local team piloted the DHIS2 in one district. After completion in Tajikistan, the multidimensional solution became part of the DHIS2 core and is useful for many countries implementing the DHIS2, all defining their own dimensions.

**Replacing the specific with a generic**

In the end of 2006, a Health Commissioner from a state of India asked for a dashboard module where he could pull important data of his choice, convert them to indicators, perform analysis, and display the result in various formats for easier access. However, the global team was reluctant to develop what they understood as an advanced feature, at the time the concern for the global team was on getting the data entry correct and complete the migration from DHIS1 to DHIS2 started in 2005. With limited response from the global team and increasing pressure from the Commissioner, the local HISP India team initiated their own design process.

As the leader of the Indian local team explained, they approached the design “as an independent module using only the DHIS2 database without using the core”. The justification given was, they only needed to pull already stored data and conduct processing, analysis and display. With this approach, they manage to come up with a quick fix that satisfied the Commissioner’s request. However, later they found it problematic to maintain two separate links, one for the dashboard and the other for the DHIS2, and started merging the two together at the source code level. When merging, they created a local test branch from the global DHIS2 trunk as their working code base. The approach, they claimed, provided them greater flexibility and independence from the more slow moving global trunk. While under the test branch, they improved the dashboard with additional features for supporting integration with
Excel reports, analysis of null reports and “Top 10 indicators” display. The new features made the dashboard module popular in India, and many States adopted it. Looking at the usefulness and popularity India, global designers started discussions to make the module part of the global core. One member asked:

“what is the status of this module now? Isn't it way past [tests] status now? Is it ready to become an integrated DHIS 2 module?” (Global HISP Member from Oslo, October 2007)

The Indians agreed with the request and started the integration work. However, testing the integration result outside India ended with compilation errors. From the compilation report, one member from the global team traced the problem to the dashboard module and recommended to remove it from the global trunk until the problems were rectified. Correcting the problem failed repeatedly leading to a friction between the teams – the global team deeming the efforts of the local team as “a poor workaround and hack of the DHIS2 database”, and the local team from India accusing the global team from Oslo for not understanding the pressure and immediate need they had to deal with. With the two branches kept apart, both teams went their ways in their design roadmaps – the global team improving the DHIS2 in terms of speed and new functionalities, and the Indians improving the dashboard in their own setting based on demands from local States.

However, this quickly became a concern for some members of the global team as it forced them to maintain two branches, each missing out important functionalities from the other. When one local HISP member from Vietnam attempted to combine the two, he ended with error and reported his error asking for help:

“Couldn’t build dhis2. BUILD ERROR. org.hisp.dhis:dhis-web-dashboard:war:2.0.1-SNAPSHOOT” (Local HISP Member from Vietnam, December 2008)

The lead global designer replied back saying:

“The dhis-web-dashboard has been moved out of dhis-2 and to trunk/local/in. If you need it, go to trunk/local/in/dhis-web-dashboard and install it. If you don't need it, uncomment it from the portal. General chart functionality has been implemented in the reports module” (Global HISP Member from Oslo, December 2008)
Following the announcement of the coming of a general chart functionality in the DHIS2, another global designer left Oslo to India in order to sit together with the Indian team and exhaust possible ways of rectifying the problem so that the module from India could be useful for others. However, when evaluating the source code, it was found unnecessarily complex, difficult to maintain, filled with MySQL database code pieces and specific Excel reports in the presentation and business layers of the DHIS2 source code. These were all against the modularization, generic and meta-principles of DHIS2 that assumes no specific database platforms and reporting templates. When this was communicated through the public mailing list, another global member suggested the possibility of replacing the local module, by asking:

“Has there been any consideration of using the new global modules (also/instead)?” (Global HISP Member Oslo, January 2009)

and the global designer in India, who conducted the evaluation, replied back saying:

“…right now I don't see the modules, that we have in the global trunk, would fit seamlessly into the Indian requirements - they have quite a complex and huge excel templates. The best for the time being is to remain with what they have. But the code for it is quite messy and a source for most of the errors ... as to replacing the dashboard ... I am not sure whether to go for the new one. may be we can decide after the full module testing is done. because the dashboard module, from India, is quite "stable" at least it is in the field for quite some time and users are” (Global HISP Member from India, January 2009)

The head of HISP India also responded to discussions of replacement by saying:

“[we would] like to stay with the Excel reporting module and dashboard as they are...it has been rolled out and training has been given to hundreds of people on that” (Head of Local HISP India Team, January 2009)

In the end, the Indians stayed with their local module and the global designers completed a generic solution that has proved as well working for many countries. Later in 2011, the head of HISP India also commented that the generic dashboard solution from the global team will soon completely replace the local solution as it uses the latest of technology and offers improved functionalities not available in the local module.
Overhauling the specifics to a generic

In addition to computer based data processing and analysis, HISP also embarked in utilizing the potential of mobile phones in developing countries. With mobile phone coverage rising, health practitioners in developing countries demanded mobile-based solutions for efficient and timely processing of health care data. In 2009, the National Rural Health Mission Director of India requested the local HISP team to extend the DHIS2 to support mobile reporting. Following the request, the local team designed a SMS-based mobile application for processing a monthly report on the request from the mission director. The application went to pilot in five health administrative blocks, each from different states of India. Following the pilot, the state of Punjab asked for a state-wide implementation for three different reports, using 5000 mobile phones. The local team responded positively with three different applications for the three reports requested.

With State-wide implementation activities in Punjab, the global HISP team received a request to implement mobile based reporting for Gambia and Tanzania. The global team delegated the task to the local team from India and they developed two different applications adapting their Punjab application. Another HISP member from Zambia also created his own application following the approach from India. As a consequence, seven separate DHIS2 mobile applications distributed in India and Africa. This also became a pressing concern for the global team. With mobile phone usage increasing in developing countries, the global team anticipated numerous requests coming from countries using the DHIS2 and found maintaining a separate design for each country as unsustainable. The team wanted a single mobile application as part of the DHIS2 that caters for all the reports. In a meeting to consolidate the different applications, one global designer suggested for delegating the task of managing reports to local teams. He said:

“...we shouldn’t meddle with reports of local users at the code level; we just need to leave that for the users. All we need to do is provide a platform that allows them to deal with their own reports.”
(Global HISP Member from Oslo, June 2010)

The team then developed new mobile reporting system based on client/server architecture using the DHIS2 as back-end server and mobile phones as front-end
clients. From the server side, the new design provided functionality for users to design reports in the language of their choice using the Maintenance menus of DHIS2. From the mobile side, the solution provided menus for downloading reports from the server. Once reports are downloaded to mobile phones, local users have the option to complete and send reports back to the server, including the opportunity to update, remove, and add reports, which was not possible in the earlier design.

**Analysis and discussion**

Our case presents an ongoing generification process of DHIS2 by the HISP team. In this section, we assess the implications of these findings, summarized in Table 3.

**Table 3: Generification of DHIS2: Key themes and Findings**

<table>
<thead>
<tr>
<th>Event</th>
<th>Data</th>
<th>Generification Mechanism</th>
</tr>
</thead>
</table>
| Shift to generic, distributed, and collaborative design | – DHIS2 structured as FOSS, multi-layered and open meta-data.  
– When users first start to use the DHIS2, it is blank.  
– Users of DHIS2 are required to first design (with or without programming) their contents. | Disembedding |
| Upgrading the specific to a generic | – DHIS2 failed to support multidimensional reporting practices of Ethiopia.  
– Local team from Ethiopia redesigned the DHIS2 to make it support multidimensional reporting.  
– DHIS2 core changed inline with the needs of Ethiopia.  
– Global team disputed changes to the core and urged the local team to remove the specific additions.  
– Negotiations between global and local team resulted with removal of specific additions from the core and restructuring of the core to support multidimensionality in a generic fashion. | Embedding  
Disembedding |
Replacing the specific with a generic

- A state from India requested for DHIS2 to support dashboard functionality.
- Local team from India responded for the request by designing a dashboard module inside DHIS2.
- Additional requests for the dashboard came from other states of India and local team modified the design as per the needs of the states.

- Looking the success in India, global team wanted to transport the dashboard to other countries.
- Repeated attempts and negotiations to restructure and modify the source code of the dashboard module failed.
- Global team designed new generic dashboard module that replaced the local module from India.

Overhauling the specifics with a generic

- Seven different DHIS2 mobile applications designed by locals.
- One application per report.

- Global team argued that differentiation is unsustainable and rejected the different mobile applications.
- Global team designed new DHIS2 mobile application that supports any report defined by users.

Disembedding

Embedding

Generification of DHIS2

Our case material presents an ongoing design process that has made a particular software, the DHIS2, working as part of HIS in several developing countries. A notable outcome of the process is the DHIS2 matching the needs of multiple countries and thus different contexts. Following the process, it was possible to match the requests of Mozambique and India on web and non-proprietary technology; multidimensional reporting needs of Ethiopia and Tajikistan; and mobile reporting needs of India and some African countries. We regard the success of the process as being attributed to a certain configuration of social and technical actors. From the technical side we regard the configurations of the DHIS2, being Java and web-based,
FOSS, platform independent, multi-language and meta-design, contributing to its generic aspect. From the social side, we believe that the presence and collaborations of designers at global and local levels were crucial for its success.

During the initiation of the design process, designers went from a traditional and centralized system development strategy to an open and distributed FOSS development strategy. FOSS is a strategy often followed for building and deploying large-scale software systems on a global basis (Scacchi et al., 2006). In particular, this strategy supports the functioning of a heterogeneous community of users and developers. This is similar to the community management strategy in the generification process of ERP system where designers focus on larger community than a single organization. The shift to a web-based approach is another strategy that contributed to the generification process – web is a cross-platform technology and accessible from anywhere. The choice of Java, a programming language called “write once, run everywhere” (Kramer, 1996), further brought the cross-platform nature to the DHIS2. The internationalization and localization programming strategy was another strategy that proved vital for the DHIS2 to be generic in accommodating local languages of the implementing countries. With the broader design framed as FOSS, web-based, platform independent, multi-language and layered architecture, the actual design was based on an abstract meta-data model that provided menus and other resources open for further design. By following this approach, the global team effectively opened up the design space for local teams so that they can perform local innovations and establish a match between the DHIS2 and local contexts. In this way, it was possible for the DHIS2 to work in diverse contexts.

Though the DHIS2 was able to match the needs of multiple countries, the design process was never a smooth ride and simply top-down from global to local. Rather it was an evolving process that went back and forth between global and local or respectively between generic and specific designs. In some instances, it was relatively easy to establish a match between DHIS2 and situated needs, in other it was more challenging and complex especially when attempting to take local innovations to other countries. To make the DHIS2 generic and transportable to multiple countries, global designers had to remove specific additions from the core following extensive discussions with local teams and through material restructuring.
For the global designers, it was easier to have a broader perspective and commitment for a generic DHIS2 that has no country specific additions. This is in particular because they are not attached to a particular country or use context more than sporadically, and not over time. However, this is not the case with the local designers. The local teams are tied to a particular context that has immediate requirements; and their commitment is to address these requirements and make the DHIS2 work there and then. This gives them few incentives to look beyond their local contexts at least until the first working solutions is established.

With DHIS2 being FOSS, local developers were able to download the source code and make local innovations by changing the core to their specific needs with no considerations of other contexts. The global team disputed these activities, in several cases they considered as attempts to implement country specific functionality in the core of DHIS2. As evident in both the multidimensional and mobile modules, the global team clearly rejected the modules out of a concern that they were specific, and limited to work only in those contexts considered during design. An important point here is that the global team did not reject the local modules as such; they only rejected the design approach for the modules. In both cases, the global designers went through discussions with the local developers and seek better ways of incorporating the functionalities of the local modules without compromising the generic aspect of DHIS2. The dashboard module represented a similar case.

The design process also demonstrates that organizations, being inherently dynamic and emergent (Truex et al., 1999), require software that allows for various reconfigurations and adjustments. For example, the global team did not engage with specific reports of the locals; instead they provided resources (a demo site for simulations and exercises, menus, functionalities, trainings, documentations and mailing list) to ensure that the local level designers were not prohibited from doing local innovation, i.e. reframing and recasting multiple solutions, matching their needs. For instance, the initial mobile application came with a solution for a specific report, but there was no way for users to change or define what to report. Every time a report was changed or a new report was required to go mobile, an application had to be designed. Overcoming this, the global team had to come up with a generic solution following a client/server architectural innovation that allowed users to design
and specify reports depending on their needs. There was also a similar case with the multidimensional reporting. Initially, it was implemented in order to satisfy Ethiopia’s specific age and gender dimensions; later the specifics were replaced with meta-objects allowing local teams to design their local dimensions, resulting at times in complexity not imagined by the global team, as evidenced in Tajikistan. These cases demonstrate the importance of providing mechanisms and allowing local teams to perform situated design in their contexts without affecting the ability to meet future needs and generic.

Unlike the generification strategy of ERP systems where some actors are marginalized from the design process or told to curb or smooth-out their requirements, the generification in DHIS2 was open and collaborative with the opportunity for all to participate. In DHIS2 users were not only customers, but also encouraged to design by making changes to the source code if that was the only way to address their needs. The move from a centralized design practice to a distributed FOSS strategy also helped to establish collaboration between designers. Local designers, from Ethiopia, India and Zambia, were all able to innovate from the source code of DHIS2 and establish a local solution that worked for their contexts. Though the local solutions were not accepted as a global solution right away, they were working in their own respective settings. Over time, the global team, in collaboration with the locals, had brought a generic DHIS2 based on the experiences and achievements of the locals. In this way, HISP was slowly building collective innovation capacity by utilizing and nurturing the expertise of global/local level designers. This helped HISP to handle the complex process of designing ‘generic’ health information systems for the contexts of developing countries.

In summary, this case illustrates how the DHIS2 was made to fit the needs of multiple countries through generification processes. The key aspect of the process was its nature of being open and collaborative, through strategies of platform independence, multi-language, FOSS, meta-design and configuration of designers at global and local levels. By providing a FOSS and meta system, it was possible for the global team to engage local teams and a must for the local teams to design for their needs. Of course, the local teams were never left alone in the design process – they were helped by a halfway completed meta-solution that was open for further design. The
same applied for the global designers. They were never left alone to shoulder the full task of generating a solution that matched the needs of multiple countries, each with strong institutions with specific and changing needs, because local designers greatly helped establishing a technology-context match in the final solution. We believe that this is a unique practical example to learn from and address challenges of technology-context mismatch when designing health systems in the context of developing countries.

**Theoretical contribution: open generification**

We theorize the findings from our case by extending Pollock et al’s (2007) concept of generification, which focuses on mechanisms of content smoothing and segmentation. These mechanisms address suppliers’ practices for managing user needs through homogenization either by curbing, sifting, and sometimes rejecting diversity or by answering the needs of only those considered surrogates that others would follow. In contrast to these mechanisms, our findings reveal a different form of generification for supporting diverse user needs through open and collaborative design practices. We suggest calling this *open generification*, which we illustrate in Figure 2.

![Figure 2: Open Generification as a continuous process of embedding and disembedding](image.png)

In the figure, we illustrate open generification as a continuous interplay between generic and specific software, based on the collaboration of global and local software designers, through the processes of *embedding and disembedding*. As described in the literature review, embedding is the process of adapting the software into a local
context, while disembedding is the process of taking it out of the context and (re)making it generic.

We identify two types of embedding processes. The first is appropriating or pinning down the ‘empty’ global software in local setting, i.e. filling out or configuring missing parts that are left intentionally open by the global team. The second type of embedding is far more open and potentially broader in scope. It is a process where the generic software is made to work for specific needs that are not anticipated by the global team. This involves local level innovations, which could be creating new, removing or modifying parts from global software. This is possible because the open and collaborative aspect of the generification process provides a design space for local developers and users to make the necessary innovation and satisfy their heterogeneous needs (Franke & von Hippel, 2003). We regard it as an innovation process, where local practices and technology are mutually adapted (Leonard-Barton, 1988; Bygstad et al., 2010).

The result of this innovation process is a local working solution, as described in the case section, but it also represents a software problem; there are now a number of differences between the global and local versions of the software. In our HISP case two disembedding processes solved this problem. First, the global team reviewed the changes, and decided which changes might be included into the global version, either by architectural restructuring or by adding new components. This implied that the next version of the global software would include the features wanted by the local site. The other process was more political; in the cases where the global team was unable or unwilling to integrate the changes into the global version, a discussion between the global and local team took place. Negotiating a solution was sometimes difficult, and highlighted the risks: If the global team was too strict, or the local team was too stubborn, they risked the branching-out of the software, which actually happened in the case of India. Usually, a solution was found to avoid this.

The open generification process is different from the generification approach described by Pollock et al. (2007) in being open and collaborative; our emphasis is not in managing the community of users attached to the software, but in managing the diverse needs of the community the software is expected to serve. The open and
collaborative aspects, we argue, bring attention to the heterogeneity of local needs and practices that need to be matched by the generic software. This brings at least two major implications that are less visible in the existing discussions of generification. The first is that open generification of software - in some contexts, such as global health systems – is a viable alternative to the single supplier approach. We find that catering for multiple needs is best achieved by collaboration of designers configured at different levels. Our analysis reveals that collaboration of designers at global and local levels is beneficial in order to maintain a common core across diverse contexts and establish technology-context match in local contexts.

The second implication is that not only the locally adapted software benefits from the approach; it also applies to the central core of the software. The innovation that takes place in local settings is an opportunity to improve the generic software. It allows for a bottom-up generification process that goes back from the local to the global and from users to suppliers. This requires that designers need to undertake the complex work of disembedding the solution from local realities through material restricting, architectural innovation, and negotiation between global and local level designers. As pointed in our case analysis, sometimes it might be difficult to disembed a solution from its local setting and make it part of the global core.

Conclusion

We started our study by asking: How can the generification approach be extended in order to be applicable in the context of health systems in developing countries? We investigated this question through a longitudinal case study of a large, international health information system program operating in more than 30 developing countries. Based on the analysis of the case, we suggest the concept of open generification.

Open generification denotes a process of continuous interplay between generic and specific software, based on the collaboration of global and local software designers, through the mechanisms of embedding and disembedding. The open generification concept is different from the extant generification approach in being open and collaborative; the emphasis is not in managing the community of users attached to the software, but in managing the diverse needs of the community the software is
expected to serve. We have documented that this approach was effective, even if challenging, in a context of health systems in developing countries, and future research could investigate the merits of this strategy in other settings.
References


