

Scaling ICT4D Sustainably

A Naturalistic Inquiry of District Health Information System (DHIS) 2

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To my parents

Ik houd zielsveel van jullie.

In memory of our colleague and friend,

Brown Msiska

Whose warm and gentle spirit was a bright light in the department.

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Acronyms

ANT	Actor Network Theory
API	Application Programming Interface
AR	Action Research
DHIS	District Health Information Software
DHIS1	District Health Information Software version 1
DHIS2	District Health Information Software version 2
HIS	Health Information System
HISP UiO	Health Information System Programme University of Oslo
HMIS	Health Management Information System
ICT	Information and Communication Technology
ICT4D	ICT for Development
II	Information Infrastructures
MoH	Ministry of Health
NoA	Network of Action
NORAD	Norwegian Agency for Development Cooperation
OPP	Obligatory Passage Point
OSS	Open Source Software
PEPFAR	President's Emergency Plan for AIDS Relief
RCAT	Roadmap Country Advisory Team
UDSM	University of Dhar es Salaam
UiO	University of Oslo
WHO	World Health Organization

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Abstract

The ICT4D literature is abundant of cases in which local ICT4D implementations fail as a result of short-term funding and a dependency on external expertise. This issue is often linked to an inability of such implementations to scale, whereas scale is often associated with their sustainability. While there are many strategies to help ICT4D solutions scale beyond pilot stages, successful scaling may come at the expense of local embeddedness and user involvement. Existing strategies do not sufficiently engage with the risk that global success may undermine local implementations and overly rely on the limited involvement of external researchers and experts for their effectiveness.

More sustainable scaling strategies are needed to ensure that local implementations can outlive the vacuum that arises when the attention of developers and funders is redirected after ICT4D projects are successfully scaled up. Accordingly, we need to better understand how scaling solutions affect their local implementation.

This research was guided by the following research question:

What strategies would enable global ICT4D solutions to scale in a locally sustainable way?

This study describes a naturalistic inquiry into the scaling processes of an ICT4D solution called 'DHIS2' which is short for 'District Health Information Software 2' and developed by the University of Oslo under the Health Information Systems Programme (HISP). This means that the research design and focus unfolded over time as a result of my role as an embedded researcher within the HISP project. Whereas ethnographic techniques were a central tool to access data, meaning of this data was negotiated in close collaboration with key informants where possible. I furthermore applied Actor Network Theory to guide my analytical thought process.

Findings from this study shed light on the challenges of sustaining local implementations once ICT4D solutions scale, as well as ways in which large scale ICT4D may continue to be developed organically and driven locally as they grow more complex over time.

Based on these findings, this study offers ICT4D implementers a strategy to design for sustainable dynamics of scale from the start, referred to as 'two-way bootstrapping'. Bootstrapping is an action-oriented customisation process through which a critical mass of users is attracted to a

solution as a platform for scaling. A 2-way bootstrapping strategy is based on the notion that sustainable scaling process consist of two dimensions of scale (size and scope), and accordingly describes the attraction of a critical mass of users across these two dimensions to create robust global solutions that remain locally diverse.

This strategy offers an alternative to existing strategies that offer one-dimensional perspectives of the sustainable impact of scaling processes of ICT4D solutions by concentrating on their expansion in size only or by foregrounding the role of flexible architecture in contextualising large-scale solutions. A two-way bootstrapping approach assumes that architecture is a conditional but not a driving factor in enabling large scale ICT4D solutions to scale sustainably. In addition, it suggests that potential threats of ICT4D projects - both short-natured and pilot-oriented funding as well as the use of external experts – may benefit the development of capacity needed to sustain ICT4D implementations locally *providing their role is understood in relation to different moments in the scaling process.*

In addition to extending current knowledge on scaling processes of large of large scale ICT4D, these findings have implications for our current understanding of what sustainability entails in ICT4D contexts and the factors that threaten it. Importantly, they encourage researchers to move away from dualistic approaches that refrain them from gaging beyond factors and divisions. Instead, they call for the adoption of holistic and dialectic approaches in understanding large scale ICT4D infrastructures. To this end, this study proposes an extension of the vocabulary available to researchers to discuss sustainability and scale as intertwined phenomena in all their complexity.

Keywords: ICT4D, Sustainability, Scaling, Information Infrastructures, Actor Network Theory

1 Introduction

1.1 The Challenge of Achieving Sustainability in ICT4D

The expectations for developmental effects from using ICT's are high (Avgerou, Hayes and La Rovere, 2016), and this has long been the very premise of the Information and Communication Technology for Development (ICT4D) domain. Digital technologies can potentially lower the cost of economic and social transactions for firms, individuals, and the public sector; promote innovation; boost efficiency and importantly, make that services reach more people. Perhaps more importantly, ICT4D projects can increase the 'freedom' (Sen, 1999) for a specific group of community members; for instance, they can increase social freedom by enabling greater access to information (Parkinson 2005). Despite these potentials, the increasing diffusion of ICT in developing countries does not necessarily result in the previously envisioned effects (World Bank, 2016). Apart from the fact large populations still do not have access to the internet, high failure rates of ICT initiatives remain a key concern (Ibid.). Sanner (2017) even refers to the failure to sustain technology innovations as symptomatic of ICT4D solutions.

The success of ICT4D projects, on the other hand, may be categorised by local ownership as a result of their maturity over time (Pade-Khene, Mallinson and Sewry, 2011). In this regard, researchers have referred to economic or financial sustainability as the long-term ability of ICT projects to generate enough income to meet their operational and maintenance costs (Proenza, 2001). Similarly, Breytenbach *et al.* (2012 p. 136) consider a scenario sustainable when 'a project has matured to a point where it has gained enough economic footing and social momentum to survive without large investments from non-local benefactors'. Intertwined with financial sustainability is technological sustainability, which makes technology can exist for a long period of time without major shifts in hardware or software that reduce its availability or durability (Misund and Hoiberg, 2003).

The capacity required to adapt to changing technologies and needs makes the persistence of technological solutions in low resources environments over time especially difficult (Kimaro and Nhampossa, 2005; Jacucci, Shaw and Braa, 2006). Several scholars have pointed out that the local capacity of users to further technological innovation as a requirement for their long-term embedding. Sanner (2017) proposes an operational strategy in enabling local innovation that is

based on ‘generativity’. Generativity has been referred to in the information systems literature to emphasize a capacity to create and innovate without any input from the originator of the system (Tilson, Lyytinen and Sørensen, 2010). According to Sanner (2017), generativity is an operational ICT4D aspiration due to the way it aligns with a ‘sustainability ethos’ and its sensitivity to the ‘self-reinventing’ characteristics of digital ICTs. In addition, Ali and Bailur (2007) argue local improvisation is required for the sustainable development of ICT4D. However, they also note that local improvisation may not be enabled by implementing agencies for ICT for development projects.

Despite a need to understand ICT4D intervention as flexible and long-term endeavors in a changing context (Walton & Heeks 2011), ICT4D projects are rarely equipped to anticipate for the longitudinal and organic nature of ICT4D processes. In addition, the development of local capacity and funds to maintain local ICT4D solutions has proven to be challenging in an environment that is characterised by short-term funded pilot projects (Sanner and Sæbø 2014). In fact, Unwin (2009) considers the challenge to continue achievements of externally situated ICT4D programs beyond the period of investment to be located at the heart of the fields’ sustainability problem.

1.2 The Complexity of Scaling ICT4D Solutions

In order to secure the required financial and knowledge resources as well as political commitment for their continuing cultivation and growth, Braa *et al.* (2004) argue ICT4D projects need to be scaled up. However, especially in the case of information systems, scaling may be required to make systems useful in the first place. As noted by Avgerou (2008 p.137), *‘even if successful in pilot implementation, many large-scale IS projects in developing countries face problems of scalability, that is, they may not be extended to form fully operational IS’*. Importantly, however, scaling processes are subject to an inherent tension in which the need to scale similar systems for the benefit of their sustainably and developmental impact comes at the cost of a need to for them to remain useful and appropriate in local contexts on another. This means that scaling ICT4D solutions can also put a strain on already scarce human resources capacity, both at the level of users (who need more complex skills to navigate through larger databases) and at the level of those required to provide technical support to those users (Sahay and Walsham 2006). Accordingly, Sahay and Walsham (2006) argue that the scaling challenge is inextricably linked with issues of

human resources capacity. Without addressing them, large-scale ICT4D are subject to the same shortcomings of fragmented small-scale ICT4D implementations in achieving sustainability.

Addressing this challenge requires careful examination of which aspects of systems can be scaled up and which require local customization (Rolland and Monteiro, 2002). As noted by Braa *et al.* (2007), this calls for strategies that enable flexibility (particularity) of global solutions. Such features of large-scale information systems have also been discussed by Hanseth (1996) as two kinds of flexibility: Use and change flexibility. Change flexibility (the ability to change) is enabled by modularization, whereas use flexibility makes it possible for users to change how they use a global solution without changing it (also discussed as generativity in section 1.1). In other words, scaling ICT4D requires local capacity. As mentioned, there is a severe risk that long-term local customisation becomes a problem for the (low resourced) user faced with an environment in which short-term pilot-based funding is the norm. In this scenario, global scale may lead to increasing lock-in effects (Hanseth & Monteiro, 2004). Without an understanding of how users with low capacity levels are affected, sustainability cannot be achieved.

1.3 Research Question and Rationale

In previous sections it has become clear that scaling ICT4D sustainably requires that scaling is not only approached as a matter of *size* (**‘whereas the value of a technology increases, more users will adopt it’**), but also of *scope* (through **‘processes and embedded practices by which heterogeneous networks around the technology are spread, enhanced, scoped, and enlarged’**) (Sahay and Sahay 2006 p. 188). Importantly, this definition suggests that sustainability is actualised in networks (a group or system of interconnected people and/or things). However, it does not reveal anything about the interplay between processes through which an ICT4D solution acquires a global user base, and processes through which local implementations can be maintained and evolve.

This study aims to understand how ICT4D projects may become sustainable both as a result of - and despite of scaling processes. In other words, it is interested in achieving optimal levels of scale (both in size and scope following definitions offered earlier) that enable local capacity building to enable long term usage, improvisation and innovation. The following research question was formulated:

What strategies would enable global ICT4D solutions to scale in a locally sustainable way?

To answer this question, this study has the following objectives:

- 1) To understand how global ICT4D solutions may acquire scale in size by expanding their user-base.
- 2) To understand how global solutions may acquire scale in scope through embedded practices that enable dynamic networks to emerge around implementations.
- 3) To understand how these two processes affect each other.

1.4 Positioning

There are two strands in the ICT4D literature that approach the sustainability dilemma in ICT4D differently, attempting to understand either a) the barriers and challenges around the transfer and diffusion of ICT4Ds or b) their socially embedded action (Avgerou, 2010). The first assumes ICTs are transferable across contexts and can make a desirable developmental impact when subject to suitable adaptation. The second assumes that the development and use of ICT artefacts in developing countries requires new techno-organizational arrangements that need to be constructed in the local context of a developing country. These different point of departure in analysing and understanding ICT4D implementation have led to different views on transfer and diffusions of ICT4D in which transformation is either perceived as progressive or disruptive (Avgerou, 2010 p. 9).

In exploring the tension between large scale ICT4D and their local sustainability, it is important to understand both the transfer and diffusion of technologies as well as their social embedded innovation as part of the same phenomena. This is in line with the assumption that both the transfer and diffusion of technology as well as its social embeddedness is needed to scale it sustainably in terms of size and in scope. As stated in the previous section, size is associated with the spread or diffusion of a technology, and scope with its embeddedness through the development of local networks of support. Accordingly, in the following matrix (figure 1) which illustrates these views, my study could be understood to be positioned in the centre.

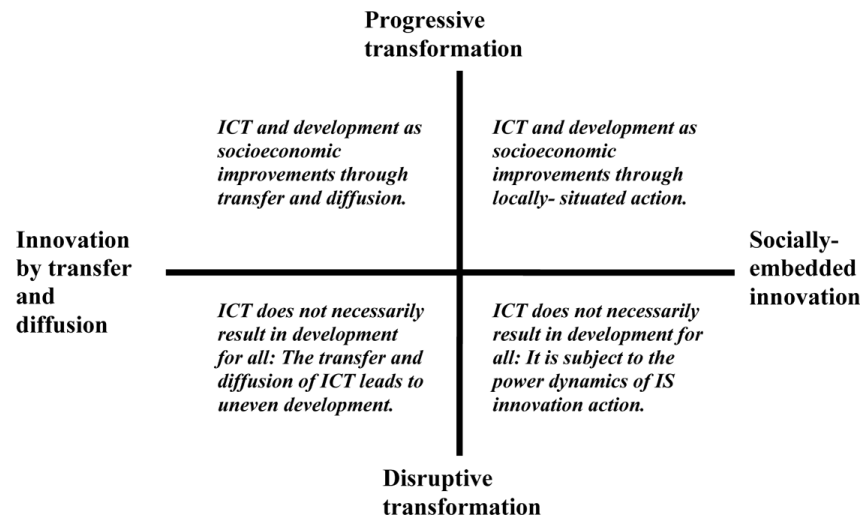


Figure 1. Perspectives on technology (Avgerou 2009 p.9)

This is in line with calls from Ramadani *et al.* (2018) that both research trajectories (horizontal axis in the figure) should not be perceived as mutually exclusive. However, a systematic review of IS literature by Ramani et al showed that covering a holistic middle ground requires researchers to develop theoretically underpinned approaches. Importantly, studies have yet to produce such a holistic approach (Ibid.) despite its importance in addressing sustainability issues. This is a significant barrier towards understanding how to scale ICT4D solutions sustainably.

In chapter 2 this study engages with related research to discuss the challenges of scaling ICT4D solutions sustainably. This stream was championed by Star and Bowker (1999) and is characterised by an emphasis on the critical role of human elements in infrastructures, work practices, organisational aspects and ways in which infrastructures can be exclusive for certain actors. Infrastructure studies approach technical architectures as evolutionary technologically-mediated networks that connect heterogeneous actors and need to be aligned with a changing and evolving user-base (Star and Ruhleder, 1996, Ciborra 1997, Hanseth and Lyytinen, 2010). This notion of information infrastructures engages with the processes through which IT scale in scope and size and a tension that occurs between the two that requires such infrastructures to be flexible. In section 1.6 I will discuss how the research position had important implications on the methodological and theoretical choices made in chapter 3 and 4 that shaped the design of the study.

1.5 Empirical Setting

Empirically, this study has attempted to develop insights in the scaling processes of an ICT4D solution called ‘DHIS2’ which is short for ‘District Health Information Software 2’, as well as the ability of local developers to make these solutions work over time under challenging circumstances. DHIS2 is a free and open source-based software information system that is highly configurable and customisable and has extensive interfaces allowing for integration with other systems. Its development started in 2006 under the Health Information System Programme (HISP) led by the University of Oslo. In 2012, the system was turned into a software platform in order to cope with the consequences of scale on usability.

Today, DHIS2 is used in developing countries all over the world as a tool for collection, validation, analysis, and presentation of aggregate and transactional data, tailored to integrated health information management activities in low resource settings. To enable new uses, customisation, as well as interoperability with other systems, developers at the University of Oslo, work closely together with Ministries of Health, non-government organisations (NGO’s), international agencies, universities and implementing agencies commonly referred to as HISP nodes. A new version of DHIS2 is released trice-yearly and users must update regularly if they want to benefit from the latest improvements and bug-fixes. More details on the empirical case will be provided in chapter 5.

1.6 Research Approach

Because of their complex and networked nature, the study of information infrastructures has been suggested to benefit from ethnographic methods (Star and Ruhleder 1996, Star, 1999, Karasti and Blomberg, 2018). Ethnography refers to a set of methods or a research strategy that mostly involves field work through some combination of observation, more or less formal conversations and the study of material artefacts to understand their meanings for situational actors (Yannow, Ybema and Van Hulst, 2012). Understanding the ethnographic methods required in doing so has been central to the work of Karasti and Blomberg (2018). In an extensive analysis, Karasti and Blomberg (2018) identify 5 dimensions across which researchers who wish to study ‘infrastructuring’ (a term which they use to reflect a broad interest in the ongoing process through which information infrastructures emerge) experience methodological challenges.

In studying information infrastructures, researchers are faced with face-to-face, collocated as well as online activities that are mobile or distributed across settings. As elaborated in chapter 5 and touched upon in section 1.5, there is not a single ‘DHIS2’; rather, it is a live and evolutionary effort of a transient and distributed network of developers and users from a variety of backgrounds and settings. Studying such efforts requires an emphasis on the emerging and open-ended processual qualities of information infrastructures and can be challenging and demanding (Karasti and Blomberg 2018). This involves open ended and long-term research designs, shifting objects of inquiry, and a need for high mobility and making strategic connections (Ibid.).

In chapter 4, I explain why I have found that a naturalistic inquiry approach provides II researchers with the right guidance on how to apply their ethnographic skills in such a way that will help them grapple with challenges in relation to constructing II fields as pointed out by Karasti and Blomberg (2018) and seen in the DHIS2 case. Following a naturalistic inquiry approach, I started my investigation as an immersed researcher driven by the question: ‘what is happening here?’. To address this question, I conducted three cases studies. These studies are discussed in paper 3, 4 and 5 which for this reason receive emphasis over paper 1 and 2 (as elaborated on in chapter 6). The cases are:

- I. The longitudinal and local implementation of DHIS2 in Sierra Leone, which had started off as a ‘success story’ but developed into a less successful scenario over time due to challenges to sustain previous efforts (paper 3).
- II. The longitudinal and local implementation of DHIS2 in Tanzania, which was not initially considered a success story but somewhat ‘silently’ developed into a strong example for the wider network of how local efforts can be sustained with the help of local developers (paper 4).
- III. The introduction of a Roadmap Country Advisory Team initiative, which was born out of challenges within the project to balance requirements from local (third-party) developers (representing ministries) and international NGO’s and funders of the project (paper 5).

These cases offer important insights into the development of large scale ICT4D infrastructures over time. The third case provided crucial insights into the challenges of balancing the effects of scaling on the sustainability of local projects. These insights are important to place insights from the first 2 cases in a wider context.

To make sense of my data, I applied an Actor Network Theory lens (ANT). ANT originated from the work of Michel Callon and Bruno Latour and has been applied in the ICT4D domain in recognition that both technical and human elements of infrastructures should be understood as intertwined based on interests (see Walsham 2017 for an overview of the use of ANT in ICT4D). As noted by Diaz-Andrade and Urquhart (2013) ANT gives particular insight into processes through which various users of ICT4D are engaged.

An Actor Network Theory perspective furthermore matches important ontological assumptions about scaling and infrastructures that underpin this work. As mentioned, infrastructures are approached as constructs that cannot be studied as whole networks or ecologies. ANT was highly influential in the development of the perspective that studying information infrastructures requires ‘crafting the field’ (Karasti and Blomberg 2018), as well as in efforts to describe the qualities and open-ended nature of Information Infrastructures (Hanseth and Lyytinen 2010). In addition, because scaling (and its sustainable operation) is understood in this study to be networked in nature (occurring in size and scope) it made sense to apply an analytical lens that perceives phenomena as networked.

In chapter 6 and 7 I draw on contributions made to ANT to unpack:

- a) Infrastructuring in ICT4D as a process of inscription whereby the material world is translated into formats that are durable and transportable and;
- b) Large scale ICT4D solutions as constructions of their methods and practices that involve a network of different actors, both humans and non-humans and their interactions and alliances.

Notably, this chapter provides detailed and illustrative examples to show the reader how I have made ANT ‘thinking’ my own and to make the synthesis of my findings and my analysis in chapter 7 more accessible.

1.7 Overview of the Papers

This thesis comprises 5 papers:

- | | |
|---------|---|
| Paper 1 | Fruijtier, E. and Pinar, M. (2016), ‘Collaborative Development of Global Information Systems: Toward Community Based Generification’. <i>The Electronic Journal for Information Systems in Developing Countries</i> , 73. |
|---------|---|

- Paper 2 Fruijtier, E. (2017) Action Research and Open Innovation: A Synergy? In: T.A. Mapotse (Ed.), *Cross-Disciplinary Approaches to Action Research and Action Learning*, IGI Global, 19 – 39.
- Paper 3 Fruijtier, E., Sæbø, J. The Role of Action Research in Making ICT4D Sustainable (unpublished).
- Paper 4 Fruijtier, E., and Senyoni, W. (2018) The Role of Local Bricoleurs in Sustaining Changing ICT4D Solutions, in: Kraus, K, Turpin, M., Naude, F. (Eds.), *Locally Relevant ICT Research: 10th International Development Informatics Association Conference, IDIA 2018, Tshwane, South Africa, August 23-24, 2018, Revised Selected Papers*, Springer Nature Switzerland AG.
- Paper 5 Fruijtier, E. (in review) Open Development: Game-changer or Sugar-coat? In review.

1.8 Contributions and Implications

This thesis contributes to our understandings of sustainability as something that is achieved in networks that surround ICT4D as they grow in scope and size. Specifically, these findings shed light on the inclusive and exclusive nature of such networks, in which sustainability for some may come at the expense of the sustainability for others and that these dynamics vary at different stages in the evolution of ICT4D. These findings align with the perspective from Star (1996) that metaphorically turning complex (platform) infrastructures from ‘houses’ in to ‘homes’ requires a working relationship (see section 2.2). In unpacking this working relationship, this study identifies a certain level of ‘discomfort’ that arises when power positions within actor networks change as projects scale. This discomfort plays an important role in realising sustainable scaling processes, in which moderate levels of discomfort have the ability to drive the sustainability of ICT4D with the risk that too much or even too little discomfort hampers it. These findings are discussed in more detail in chapter 6.

In addition, this research contributes to the overall study of large and complex ICT4D infrastructures by illustrating how a naturalistic inquiry, as well as an ANT lens, can offer researchers a suitable methodology to unpack large and complex ICT4D phenomena. This is

important if we are to study ICT4D infrastructures holistically and consider their growth to encompass both processes through which they are transferred as well as embedded. Importantly, this study enhances the vocabulary available to researchers in support of their attempts to develop a language that allows them to discuss sustainability and scale as intertwined phenomena in all their complexity.

This study also has several practical implications for how we understand sustainability in ICT4D projects that I discuss in chapter 8. First, it expands our understanding of sustainable scaling processes as a working relationship by providing insights on how this working relationship is achieved and implications it has in terms of who is able to draw benefits from large-scale ICT4D implementations over time. These implications are important to ensure large scale ICT4D solutions that are gaining footing in developing country environments continue to serve the needs of those who need it most. Second, this study proposes a way for ICT4D implementers to both design for sustainable dynamics of scale from the start as well as reflect upon the sustainability of existing designs retrospectively by ‘bootstrapping both ways’. Bootstrapping is currently known as an approach to enable information systems to reach a critical mass from where they may be scaled in size. The two-way bootstrapping approach developed in this study extends our current understanding of the role of bootstrapping and bootstrapping approaches in ICT4D as a process through which large-scale ICT4D can be scaled in both size and scope.

1.9 A Personal Journey

The process of undertaking this research in the form of a naturalistic inquiry has had important consequences for how the work is presented in the next chapters. Given both the methodological approach I have taken, coupled with the nature of the topic of focus, I believe it would be helpful to provide some insights in my personal journey to help the reader navigate through this thesis.

As briefly mentioned, a naturalistic inquiry approach meant I started with a broad interest in how various actors were engaged in the development of a large scale ICT4D solution and what this meant for its overall sustainability. This resulted in a multiplicity of different themes, research questions, approaches and conclusions that are mirrored in my papers. Especially in the beginning, the process of writing research papers functioned as a vehicle for me to apply different lenses to my work. A new paper offered more insights in a previous one by adding more depth, placing it into context or even by contrasting it at times.

While I appreciate this ‘jigsaw’ nature of the work can cause confusion (very much in accordance with my lived experience of it) I felt it was important to take the reader on this journey with me, rather than to present the work as if it was always part of a smooth and coherent trajectory where research question A led me to outcomes B C and D. Accordingly, my approach has been to first synthesize the various cases I have looked at in chapter 6 to explain how I see them as shedding light on different but crucial elements of the same phenomena, before making sense of the ‘whole’ in my analysis with the help of ANT in chapter 7. The papers discussed in chapter 6 thus shows an evolution of my understanding over a period of time, whereas chapter 6 should be read as a summary of my ‘meta-analysis’ which underpin my main contributions in chapter 8.

In retrospect, one could argue the work could have benefited from a monograph-type of presentation. However, this would have required me to mask the unique challenges I encountered in my efforts to study a highly complex information infrastructure, that are all too easy covered up in academic publications. I also saw this thesis as an opportunity to illustrate the role a naturalistic inquiry approach and an ANT lens can play in guiding researchers that are grappling with finding suitable methodologies to make sense of information infrastructures. Especially when placed in the context of a doctoral research journey, I believe the lessons this approach taught me about navigating complex topics are of equal importance to the theoretical contributions this enabled me to make as a result.

2 Related Research

In this study, large-scale ICT4D solutions are understood as information infrastructures (II): unbound, evolving, shared, heterogeneous networks that develop upon an open installed base (Hanseth and Lyytinen 2010) which implies the diverse information technology capabilities and their user, operations, and design community practices already in place. Motivated by an interest in their engineering design, information infrastructure studies tend to provide insights into what determines how or why large systems evolve the way they do, which is why this stream of literature is able to offer insights that are relevant to understanding the development of large-scale ICT4D.

The literature on information infrastructures sheds light on why growing II is a challenging endeavour in itself – regardless of the environment. Star and Ruhleder (1996, p. 112) capture this well by introducing the metaphor that *‘trying to develop a large-scale information infrastructure (...) is metaphorically like building a boat you’re on while designing the navigation system and being in a highly competitive boat race with a constantly shifting finish line’*. This chapter will discuss why growing II in a developing country context is particularly difficult. In doing so, I will draw from both Information Infrastructure and ICT4D literature. Where needed, I will occasionally include literature from the broader Information Systems domain. Specifically, this chapter addresses the complex issues related to scaling large information infrastructures in size and in scope; how these challenges play out within an ICT4D environment and may affect their sustainability; and strategies applied to address them.

2.1 Scaling Information Infrastructures

As elegantly formulated by Ciborra (1997 p. 78), information systems require care, hospitality and cultivation¹ (an ‘anthropology of machines’) to become infrastructured. And yet, Monteiro (1998 p. 229) voices a dilemma in which *‘an information infrastructure also has to scale, and hence change, as it expands (...) to meet new requirements stemming from its growth’*. In II literature,

¹ Care refers to enabling a level of understanding of a system or tool that involves *‘becoming so intimately familiar with it, so that it disappears from our alert attention, and becomes taken for granted, that is appropriated into the routines of our daily absorbed coping’* (Ciborra 1997 p 74). This also requires factoring in hospitality, in the form of a recognition for all that it takes to ‘host a stranger’ and for the way technology needs to become understood through the ‘organizingness’ of their everyday life. Finally, cultivation is a form of interference with and support for ‘material that is in itself dynamic and possesses its own logic of growth’ and compares its function to efforts related to ‘helping a wound to heal’.

the process of embedding is often discussed as a cultivation of the ‘installed base’. The notion of installed base refers to the way a new infrastructure is always introduced as an extension of an existing infrastructure (Hanseth 2001). For instance, a digital information infrastructure may be replacing parts of a paper-based information infrastructure. The installed base is understood to go through stabilizing and destabilizing phases as information system ‘builders’ engage with it or disregard it. Accordingly, Aanestad *et al.* (2017) suggest it is more important to understand ‘when’ rather than ‘what’ the installed base is. Unlike managerial association that notions of ‘building’ and installing’ provoke, II call for evolutionary, prototyping approaches to design and development that are open-ended and unplanned in nature (Hanseth and Aanestad, 2003).

Because Information infrastructure development is influenced by its history and unique events, they tend to become path dependent and ‘irreversible’ in their configuration. As part of their alignment, II require the integration of previously separate systems through a process of embedding political and institutional interests (Aanestad *et al.* 2017). In addition, especially when II concern platforms, platform builders profit from increased buy-in (or lock-in) by both users and third-party developers (Plantin *et al.*, 2018). Accordingly, irreversibility is also inherently political. Irreversibility is needed for alignment with local contexts, whereas in other ways it also battles with these processes.

As noted by Ciborra (1997 p. 76), technology ‘tends to drift when put to use’, suggesting that technical systems should be approached as organisms with a life of their own that has a tendency of moving toward perfection and systematization. This organism can be understood as a body of knowledge that is not neutral nor passive; it is a system oriented toward human needs that sinks into a basis or installed base and reshapes it at the same time as it challenges existing strategies (Ibid.). According to Star (1996) infrastructure must be understood to emerge in this process:

An infrastructure occurs when the tension between local and global is resolved. That is, an infrastructure occurs when local practices are afforded by a larger-scale technology, which can then be used in a natural, ready-to-hand fashion. It becomes transparent as local variations are folded into organizational changes, and becomes an unambiguous home—for somebody. This is not a physical location nor a permanent one, but a working relation— since no home is universal. (Star, 1996)

The principle of irreversibility implies that once users turn II into their home, whereas the working relationship continues, it may be hard to ‘move out’. Accordingly, irreversibility of II is both responsible for making II sustainable on the one hand, and potentially disruptive on the other.

Developers need to distinguish between those aspects of the II are irreversible (constant, embedded in to its core) and aspects of it that are flexible enough to adapt as more users seek to adopt a system in meeting their own unique use needs. Despite the way II tend to (and need to) become irreversible over time as they attract more users, such development processes cannot be controlled top-down and that their development paths might deviate from originally planned purposes (Ciborra and Hanseth, 2000). Although, it would be more accurate to state that this lack of control is in important ways a *result* of irreversibility. This is because there is a tension between the process of adaptation on the one hand and standardization on the other.

Information infrastructures are thus constant duals of two opposing forces of change and control that rely upon each other's existence (Tilson, Lyytinen and Sørensen, 2010). Because they shape and reshape work practices, there is a tension between local, customized, intimate and flexible use on the one hand and the need for standards and continuity on the other (Star and Ruhleder 1996). This implies stability is reinforced by allowing flexibility – while threatened by it at the same time. As noted by Tilson *et al.* (2010 p. 754), the same is true for flexibility, which both resists control as much as it depends on it:

Change is enabled and constrained by the very stability of these sociotechnical formations; only a stable installed base allows new connections to be created. After all, there has to be something to connect to, and the means of connecting must be predictable.

At the same time, control is required to stabilise both social as well as technical components of the installed base. Yet it is undermined by flexibility which may cause invested meanings, roles, and lines of responsibility to be '*wiped out in an instant*' (Tilson, Lyytinen and Sørensen, 2010 p. 754). On the other hand, too much control may diminish emergent designs, may create unwanted path dependencies, and hamper creative innovation (Racherla and Mandviwalla, 2013). Hanseth (1996) makes a similar distinction between use- and change flexibility of infrastructures. Use flexibility means that an infrastructure can be used in a variety of ways and in a range of areas without needing to be changed, whereas change flexibility means the infrastructure is easy to change. Because infrastructures are a sum of both, extensive use flexibility decreases the level of change that is required whereas limited use flexibility requires high levels of change to the infrastructure itself. Hanseth (2001) furthermore points out that top-down specification-driven approaches tend to give rise to more complex, and accordingly less flexible infrastructures, in contrast to more bottom-up and evolutionary processes. Especially at later stages in their evolution, systems become inevitably

more bounded and may create lock-in situations (Aanestad *et al.* 2017). This indicates that change-flexibility reduces over time, which may require that use-flexibility may need to increase again as II grow in size and scope.

2.2 Scaling Strategies

In the previous section, it has become clear that dimensions of scale (in size and scope) are not easily separated. Rather, they are in dynamic with each other, in which an increase in users overall adds value to a solution, whereas efforts to design for vast amounts of users tend to ignore unique characteristics required by individual users in order to embed a solution in heterogenous contexts of use. Information infrastructures are the result of efforts to scale a technological solution across dimensions of scale in terms of both size and scope. As such, they are an embodiment of this tension, without revealing anything about the sustainability of the outcome of this compromise at a given moment in time. As noted by Koutsikouri *et al.* (2018), effectively serving for emerging possibilities and changing purposes raises a crucial question of how infrastructures can be extended to accommodate future forms of use. Importantly, processes of scaling in scope are needed to combat negative effects of irreversibility such as lock-in situation and a lack of flexibility to change solutions beyond their initial implementation. In this section, I will delve deeper into strategies used to influence this dynamic.

In the early stages in the evolution of systems, the paths of information infrastructures tend to be relatively open, which makes it easier to embed systems in specific use contexts. In other words, in the early stages of an infrastructure, the emphasis is on catering for an initial user base in order to enable it to grow by enabling practices around the technology through which it can be embedded. This is evident in an approach known in information infrastructure literature as ‘bootstrapping’ (Hanseth and Aanestad, 2003). Bootstrapping involves a design process through which an initial base of users is developed for a certain technology, which can then be expanded upon by enrolling new users and developing new generations of technical solutions. Bootstrapping is based on the assumption that users have different interests, and that scaling a system (by reaching a critical mass of users) is achieved by persuading different user groups. This means that, unless there is already a critical mass of users in place as a result of other incentives, users willing to adopt a technology need to be identified in stages.

A bootstrapping approach will likely start off with highly motivated users who believe a technical solution will improve their practices, and preferably have a relatively high level of knowledge and skills to smoothen the adoption process. Less motivated users follow when the network grows, the technology improves, and practices improve as a result. For this, the innovation process must be available; simple, cheap, solutions must be flexible and future-oriented to avoid path-dependency through which adopters may be trapped in a too narrow spectrum of use. As such, through bootstrapping implementers aim to make a technology immediately useful to attract early users and deliberately neglect long-term issues such as architectural robustness if so required (Hanseth and Lyytinen, 2010; Grisot, Hanseth and Thorseng, 2014).

From an entrepreneurial perspective, bootstrapping furthermore offers a strategy to innovate creatively with limited resources available in a serendipitous fashion that reminds of *bricolage* (Ciborra 1991). Ciborra (Ibid.) introduces the concept of bricolage in his search for the development of 'true' information systems that avoid 'easy imitation' and misalignment that would furthermore lead to more competitive advantages. Bricolage has been advocated by Ciborra (1991) as a grassroots approach in which IS emerges from the grassroots of the organization through a process of tinkering and improvisation. This approach builds on the perspective that limitation is a driving force behind success (Rosenberg, 1982). Especially in volatile environments, Ciborra (1991 p. 288) perceived effective solutions needed to be embedded in everyday practices which form the 'Petri dish for tinkering'.

There is some literature indicating that bootstrapping and bricolage-like strategies may work well in an ICT4D context. For instance, Ali and Bailur (2007) take a rare stance in suggesting bricolage can play a role in the sustainable development of ICT4D. However, they also point out that such efforts may suffer from a lack of flexibility among implementing agencies who deliver ICT for development projects. In addition, Nguyen *et al.* (2017) illustrate how a bootstrapping approach may be applied in an ICT4D context. They furthermore add various nuances to the bootstrapping approach, which involve political support, cost of technology, and personal relationships.

Koutsikouri *et al.* (2018) consider the alignment of new partners with digital capabilities to spur innovation central to the growth of information infrastructures. To achieve this they identify 4 'growth tactics'; the adding of services that are managed by designers responsible for their local evolution; inventing processes that allow for complex coordination or 'organisational glue' for the

purpose of balancing flexibility and stability; the standardisation of classifications and uses of names for objects that identify relevant aspects of the infrastructure and providing interfaces for heterogeneous participation such as API's. The authors (Ibid. p. 1004) also note that there are few IS studies of practical attempts to achieve adaptive information infrastructures that pursue the previous tactics, and that *'even less attention has been devoted to the individual capacity of these tactics to specifically extend the functional scope of an infrastructure and enhance its fit with emerging service requirements in an changing environment'*. This is especially true for ICT4D environments.

Thus far, scaling strategies for ICT4D solutions have predominately focussed on how a local ICT4D solution can attract a critical user-base and achieve a level of embeddedness from where information infrastructures can scale. The following two strategies toward scaling emerged from a study of the same ICT4D solution (DHIS1, a desktop-based predecessor of the later cloud-based DHIS2) at slightly different points in time and within different contexts (despite some overlapping). However, from a sustainability perspective, I will discuss why these strategies share an important limitation. Despite placing emphasis on processes of embeddedness, they lack a concern for ensuring levels of embeddedness achieved are sustained once external expertise is withdrawn.

The first strategy is a 'Networks of Action approach' (Braa *et al.* 2004) which argues that sustainability in terms of continuous learning (in the form of a network) is required to sustain ICT4D solutions locally. It was based on developments around DHIS1 in South Africa, Mozambique and India and largely based on the period between 1999 and 2003 during which action researchers from UiO worked on the development and scale of DHIS1.

The term 'Action Research' is usually traced back to the work of the social psychologist Kurt Lewin who developed AR from a concern and urgency for finding methods to deal with critical social problems and aiding social justice through understanding and changing human actions (Lewin, 1946 p. 202-203). Involving a spiral process in which a hypothetical solution to a problem is formulated, tried out, monitored, reformulated and so on, the purpose of AR was to gain closer approximation to an ideal solution to the problem then approaches based on a genuine theoretical understanding of the processes involved (Hammersley, 2004).

As part of the Networks of Action approach, action researchers from UIO attempted to create a network of sites through putting in place both vertical processes of appropriation and horizontal processes of “replication” and sharing. This involved enabling local learning processes; bringing together a variety of actors around shared goals and interests and aligning interventions with environmental structures (existing institutions, competing projects, and efforts as well as everyday practices). This network mainly consisted of researchers who took roles of supervising, training, systems design, mobilising support and generating funding (Braa *et al.* 2004) in alignment with Ministries of Health in countries of implementation. Following this approach, scaling became a mechanism for sustainability, which was achieved as researchers travelled along with the solution they continued to re-create in different settings. Doing so, they gave rise to a networked environment, while rooting their efforts in local continuous action at the same time. The authors conclude that scaling (i.e., spreading) of the intervention is a prerequisite for sustaining ICT4D efforts in low resource environments, based on which local processes can be continued.

However, acknowledging that not all implementations may develop such local capacity, a case seems to be made for sustaining the overall activities of the network in creating sustainability *beyond* individual cases in coping with these tensions. In line with the theoretical lens in this study, we can detect the presence of an actor-network-theory logic here (elaborated on in chapter 3) in that once a network enrolls enough actors, its survival becomes less dependent on individual linkages. In cases mentioned in this study (Cuba, Ethiopia, and Mongolia) the networks created fell apart after initial efforts discussed by Braa *et al.* (2004) for a diversity of reasons (see for instance Saebo and Titlestad, 2004) while others (Tanzania and Mozambique) experienced significant setbacks.

Another strategy that was applied to scale DHIS1 is conceptualised as a ‘flexible standards’ approach (Braa *et al.* 2007). Again, the paper in which this approach is introduced covers DHIS1 implementation in South Africa (the same implementation as the one upon the networks of action approach was based) as well as implementations in Ethiopia starting 2003 (exact data collection periods are not specified in the paper). Braa *et al.* (2007), propose that flexible standards can act as ‘attractors’ in attracting enough elements of the installed base for a technology to become rooted. Although the authors do not provide a definition of what they mean by a standard, the text appears to consider large information infrastructures to standardise practices as a result of their path dependency or irreversibility.

This approach has similarities to the bootstrapping approach in that a critical mass of users is required to take a technology to scalable levels. As much as an installed base needs to be cultivated, it also needs to be locked in ‘flexibly’. The flexible standard approach suggests change flexibility can be achieved through a modularised architecture, whereas use flexibility can be achieved by allowing new combinations of existing features in addressing new needs. However, both of the aforementioned approaches fail to engage with issues of ownership and local capacity; and the question whom should enable such combinations and how once a local infrastructure is established. Rather, their main concern is with the development of the infrastructure as a whole, placing emphasis on processes of scale in size over scaling in scope. Although this strategy engages with the flexibility of ICT4D solutions, it does not elaborate on how the tension between scaling in size and scope should be addressed once the boundaries of what flexibility can be offered by the modularity of an ICT4D solution are met, nor how (and by whom) flexible solutions can be customised post-implementation.

Some efforts have been made to shed light on the cultivation aspect of scaling in terms of scope. For instance, Sanner *et al.* (2014) define a process they call ‘grafting’ through which organisational goal-oriented information system innovations merge with and extend existing socio-technical arrangements so that the parts continue to grow as part of the existing installed base. This concept was inspired by the practice of ‘grafting’ defined as creating hybrids by combining certain desirable varietal characteristics and speeding the propagation of such traits. Again, the empirical data that inspired this strategy comes from a DHIS implementation – only this time, the development of DHIS2, a cloud-based version of DHIS1 that was developed in 2006 and was scaled rapidly since across developing countries all over the world (as elaborated on in chapter 5). Data collection for this paper was conducted from 2011 and 2013 in Malawi.

Notably, there are some potential problems with the choice of the grafting metaphor (which could be perceived as a rather brutal process in which two entirely different organisms are merged together by force) and I will refrain from engaging in a debate about whether this does or does not accurately portray ICT4D processes of transfer and embeddedness. This debate aside, grafting has similarities to bootstrapping. An important difference is that grafting does not approach a cultivation of the installed base from a design-centred perspective and considers the process of grafting to be more organic in nature. It acknowledges that once an installed base is successfully cultivated it requires to be nurtured ‘in order for the graft to hold’ (whereas a bootstrapping

approach aims to scale a solution in size). A grafting approach draws our attention to the way scaling in scope should be an objective rather than a means to an end. When the attention is redirected to scaling in size because of successful outcomes of scaling in scope, this could be considered a failure of this objective.

However, the empirical case that underpins this work relies heavily on the involvement and expertise of external experts and the grafting approach fails to engage with who should nurture ‘grafts’ and how local ownership and capacity can be developed and secured in the face of funding gaps. One could argue that, when grafting is the result of external experts, a redirection of attention from processes of scope toward processes of scale becomes inevitable. In addition, black boxing this aspect of the approach risks that this strategy lacks practical implementation, remaining abstract and metaphorical. The main critique being an overreliance on the II graft to continue to ‘grow’ organically as part of the installed base, without questioning the resources of the installed base to nurture the II long-term. In this regard, the authors acknowledge (Ibid. p.238) that ‘*the availability of local capacity to add local enhancements to implemented solutions will be paramount*’ and that ‘*a tremendous amount of domain and context-specific knowledge and much sensitive and well-targeted practical work is needed*’.

2.3 A Trend Toward Platformisation

Thus far, this chapter has focused on the tensions that affect users of information systems as they scale and strategies implementers of II can deploy in attempts to ease growing pains where possible. The limitations of these strategies have also become clear. Importantly, the previous section also identified a gap in the literature where few growth strategies have explored how infrastructures can grow once they reach significant levels of scale. In this section, I will look at the platformisation of II for various reasons. For one, because there is an increasing interest in the ICT4D literature in platform-architectures that foregrounds the benefits of platforms for more sustainable designs through more direct engagement of a vast and diverse user community. I will also discuss how these discussions currently fail to acknowledge that platforms are subject to the same tensions that are inherent to II and discuss why these tensions are transcended rather than dissolved through flexible architectures.

In recent years, the ICT4D literature has developed a strong bias toward the potentials of platform-based ICT4D to facilitate more scalable and sustainable ways of development (Heeks, 2008;

Thompson, 2008; Smith, Elder and Emdon, 2011; Roland *et al.*, 2017). The logic behind this interest is that through platforms, devices, applications, and data may become interconnected and participation, collaboration, and co-creation is facilitated. For instance, Roland *et al.* (2017) highlight how an emergent platform architecture and its surrounding ecosystem co-constitute a platform for participation in design. These studies pave the way for networked forms of development that are greater in reach and importantly, more sustainable (Heeks, 2008, 2010; Reilly and Smith, 2013). To understand both the potentials and challenges of adopting platform strategies in developing contexts and ICT4D, I will first elaborate on what platforms are and how we should understand platform dynamics.

According to Hanseth & Lyytinen (2010), platforms should be considered specific types of information infrastructures because a digital platform is controlled by one single actor while control of a digital infrastructure is distributed across many actors (Ibid. 2010). However, others perceive the boundaries between platforms and large information infrastructure to be of a more fluid nature (Eck, Uebernickel and Brenner, 2015). This is because to some extent, platforms are also designed to externalise control. For instance, Plantin *et al.*, (2018 p. 8) note that *'unlike system builders, platform builders do not seek to internalize their environments through vertical integration. Instead, their platforms are designed to be extended and elaborated from outside, by other actors, provided that those actors follow certain rules'*. In this thesis, a platform will be considered of a specific type of information infrastructure because platforms act as environments for collaboration that connect platform owners, third-party developers and other actors in the platform ecosystem (Tiwana *et al.* 2010).

This is in line with the way most platform definitions focus on the reuse or sharing of common elements across complex products or systems of production (Baldwin and Woodard, 2008). The definition provided by Tiwana *et al.* (2010, p. 676) in which platforms have core functionality and shared modules that interoperate through interfaces is an example. They enable and facilitate the translation of new ideas and solutions into software applications and services (Ghazawneh, 2012). As such, they enable that a 'packaged' software solution (designed for a large user base) does not imply a single 'one size fits all' solution, but a set with various options which users can choose from and extent depending on their heterogeneous needs. This is possible because platforms can be extended by external developers with applications that increase the functionality of the platform, attract new consumers and help develop the platform's ecosystem (Tiwana *et al.* 2010).

This interconnectivity is mediated through interfaces. Platform interfaces between components may be fixed in architectural decisions, which may create specific thin crossings that constrain dependencies between various components while other forms of dependency are ruled out (Baldwin and Woodard, 2008). Platforms may, for instance, support capture, management, and analysis of information that enable organisations to build their own system on top of it using applications that may come with the platform and can be extended.

Platforms provide the APIs that define the base functionality a developer will use to build applications. They are used to identify the set of services that will be made available to applications via the platform. With *open APIs*, also referred to as web API's, vendors find a way to provide their proprietary data to external developers regardless of whether the source code of the platforms is open. Open API's are named 'open', as they are for public use in opposition to 'private' use that is limited by internal intent. At implementation level, an open *source code* makes it easier for communications infrastructure to interoperate with platforms, whereas with closed source codes enable vendors to regulate interoperability with other systems. Open source specifically entails conveying the right to develop new software with the source code of original software (also referred to as 'forking') and use free of charge. From a historical perspective, the popularity of open source software development and development of the Web 2.0 resulted in a culture of collaboration and sharing that inspired this widespread use of open API's (Floyd *et al.*, 2007).

Today, open API's are so central to many platforms that the term 'open' is no longer mentioned (Qiu, 2017). Qiu (Ibid.) furthermore notes that, because open APIs facilitate collaboration between different software platforms, many programmers treat them as alternatives to open source. However, open APIs do not imply that source codes at the communications infrastructure interface are open. Researchers have pointed out a risk of using them as interchangeable in which the 'openness' of API's outshines restrictions imposed by closed source codes (Ibid.). Importantly, Qiu (2017) distinguishes between 'data' enabled by platforms that have open APIs and 'functionality' enabled by platforms that have both Open APIs and open source codes of the underlying software, arguing the openness of open API should draw from both of these two levels. The effects envisioned by advocates of platforms in the ICT4D field (increased participation, collaboration, and co-creation that might transform how development is delivered) are associated in the literature with a self-reinforcing feedback loop that may become into effect once platforms

reach a certain scale. Although they nevertheless magnify initiators early advantages (Gawer, 2014), they are also considered to create mutually reinforcing relationships between the platform owner, the user and third-party developers. The platform builder profits from an increased buy-in (or lock-in) by both the side of the user who is able to benefit from its standardised services, and the interdependent service provider (in ICT4D these are developers) who can benefit from the platforms code base and user base in responding to new user needs (Plantin *et al.*, 2018). In other words, platforms thrive on the irreversibility of infrastructures but have a potential to nevertheless offer flexibility to a large and diverse user base.

However, Jha *et al.* (2016) also note that research in this area is limited and that their case raises many questions that require further research on a broader set of ICT platform-enabled networks. They state (Ibid. 442): *'one key issue is the development and maintenance of a complex ICT-enabled ecosystem'*. However, literature on what such networked development should entail is scarce. An important question has been almost completely neglected in ICT4D literature as well as literature in information infrastructures in general is: who benefits most from these potentials?

2.4 Challenges

While driving the platforms development and its services, the aforementioned self-reinforcing dynamics also have their downsides that need further investigation. As discussed, negotiating control and flexibility can be a political process that involves constraints, constant revisions forced by platform updates, and lock-in to the platform's conception of users, functionality, and design values. According to Toyama (2011 p. 3) this may contribute rather than solve issues of inequality, noting: *'the greater one's capacity, the more technology delivers; conversely, the lesser one's capacity, the less value technology has. In effect, technology helps the rich get proportionately richer, thus widening, not narrowing, the gaps between rich and poor.'* In addition, as noted by Gillespie (2010) the term "platform" wrongly downplays the agency of platform owners. For instance, the World Bank (2016) points to a concern that limited contestation across digital platforms could lead to harmful concentration in many sectors.

Extending software platform services requires advanced technical expertise. As discussed in previous sections, technical expertise may be scarce in developing country environments and difficult to retain. In addition, Wade (2002) note how the self-reinforcing effects of platforms can lead to lock-in situations or incompatibility issues with existing systems in developing countries

regardless of whether platforms are based on open source models. In addition, Avgerou (2008) point toward a risk that platforms may disproportionately benefit North-based companies and may not contribute to local capacity. As noted by Kleine and Unwin (2009 p. 1060) ICT(4D)s '*can be used to reinforce the position of those in power (...) but they can also be used to subvert that power*' and that, if poverty is really to be addressed by development initiatives, these initiatives should focus explicitly on addressing the needs and choices of the poor.

To better understand the potentials of platforms in this context, it is important to take another look at how platforms are designed. Platforms are designed for generativity. According to the Oxford dictionary, generativity means 'capable of production or reproduction'. In the words of Tilson *et al.* (2010 p. 753) '*Generativity can be viewed as the fruit of an urge to harness the possibilities enabled by the flexibility of digitizing.*' Zittrain (2008 p. 90) sheds light on the self-reinforcing dynamics of active infrastructures in which the generative capacity of a system increases the moment more actors contribute in using, operating, and designing. Following generativity, information infrastructures may give rise to ecosystems because of the way they are extended with innovations and services. The further they develop, the more they morph into complex ecologies whose components must continually adapt to each other's ongoing change (Plantin *et al.*, 2018).

Although platforms are designed for generativity, too much variation on software platforms can hinder their functionality and their ability to attract users (Boudreau, 2011). And while they may offer a set of options rather than a generic package, components that are sunk into the set nevertheless do so based on their ability to acquire generic features. This means that to avoid too much variety, platform owners can seek to control generativity (Iansiti and Lakhani 2009). This, however, comes with the risk that platform contributors are alienated (Boudreau, 2011). In addition, the aim to achieve lock-in can also discourage interoperability with competitors, forcing independent developers to either commit to a single platform or to develop (and maintain) multiple versions of a product (Plantin 2018). As such, the trade-off between stimulating generativity and control is delicate (Boudreau 2012; Tiwana *et al.* 2010).

The previous trade-off affects participation at multiple levels (Eisenmann *et al.* 2008 p. 22):

- a) demand-side users (end-users)
- b) supply-side users (application developers)

- c) platform providers
- d) platform sponsors

Little is known about the influence various actors of inter-organisational information system projects have on each other and decision-making processes over time. This can be related to a lack of studies in this area (Levina, 2005) but also to the fact that in, given the complexity of such projects, it is difficult to say who ‘has’ power and who ‘lacks’ power at certain points in time (Hekkala and Urquhart, 2013). In this context, Hekkala and Urquhaer (2013) find that the complexity of inter-organisational information system projects can result in a lack of informal relationships which make it harder to ‘get things done’ and threaten their sustainability.

Participation of actors at various levels may vary depending on the level of maturity of a platform and there is not a single participation pattern that is correlated with the success of a platform to grow in scale or size (Eisenmann *et al.* 2008). While there are models to characterize the optimal levels of openness in commercially driven platform ecosystems that aim to harness external innovation as a complement to internal innovation (Chesbrough, 2003) (see for instance Eisenmann *et al.* 2008), no such models yet exist to understand optimal levels of openness in ICT4D platforms that aim to make a sustainable impact in communities.

In addition, it remains debatable how much openness open sourcing a platforms code adds in practice – especially in developing country contexts. Importantly, developing countries do not have the same history with ICT development before it was introduced through donor-supported projects in the last two decades (Van Reijswoud and De Jager, 2008). As a result, these countries have limited knowledge infrastructure to support the use of ICT. ICT literacy was not integrated in the educational system, decision-makers were unaware of ICT potentials and there was no trained business support. *‘In other words, the powerful technology landed in a knowledge and capacity vacuum. Expensive foreign experts were more than happy to fill this vacuum.’* (Ibid. p 24). Though this situation is gradually changing, this means we have to adjust the perception that platformisation leads to networked collaborations that benefit developing countries. As noted by Negash *et al.* (2007), this may be true for trends in the global North, but the application of open models is different in developing countries that have limited access to such global networks. OSS developers in developing countries are more likely to be hindered by a lack of financial compensation to participate in OSS development. However, trends toward platformisation re-

introduce a risk that a new form of cathedral is created in which open platforms as product packages represent the needs of those who 1) can participate in the network 2) are able to contribute to it and 3) are able to make a living out of it.

2.5 Summary

This chapter has reviewed the complex processes through which information infrastructures are scaled. Coping with tensions between scaling in scope and size were identified as a key challenge in creating solutions that can be sustained locally. We have seen that while local embeddedness is considered key in any strategy for scaling an infrastructure in size, there is a lack of strategies that deal with their ongoing nurturing. A dominant concern in the literature toward scaling in size risks that researchers and/or practitioners insufficiently attend to processes through which ICT4D solutions can be scaled in scope with the consequence that solutions fail to address local needs. This includes scaling strategies that propose to scale processes in terms of scope with an increased modularity of the solution – such as in the form of platforms. Despite potentials of modular solutions such as platforms to increase the flexibility of a solution to ensure it can continue to evolve along with changing contextual needs, there is a blind spot in the literature when it comes to understanding who benefits from flexible solutions; an over-enthusiasm for potentials of platforms to spur local innovation and too little concern for those actors that lack resources and capacity to participate in such processes. In this regard, it is furthermore important to pay attention to practical scenarios in which the role of funders and external experts is accounted for and potentially reduced or even diminished.

3. Analytical lens: Actor-Network Theory

In this chapter I will first explain what Actor Network Theory is and the value of understanding and unpacking inherently complex phenomena as actor networks. The remainder of the chapter is structured around 5 elements of ANT that, according to Karasti and Blomberg (2018), are crucial dimensions in any efforts to study them. For each element I will then explore key contributions to ANT that may be used to unpack them, which I will do in chapters 5 and 6.

3.1 Introduction

Information infrastructures challenge the researcher analytically. Star (1995) encourages ecological thinking to transcend dichotomies (social vs technical etc) in how infrastructures are perceived and analysed. The term ecology was carried over from Bateson's conceptualisation of third-loop learning (1972, 1987), which encourages organisations to develop 'ecologies of mind'. This refers to a form of collective learning which, based on accessing multiple-view points, enables one to question a thus far taken for granted 'reality'. For instance, it enables organisations to question the assumptions that are embedded in their management and governance strategies. This is in line with Bateson's perspective that the lines between man, computer, and environment are merely artificial, in that it is the totality of the tree that engage collectively in trial and error (Bateson, 1973).

It was this type of thinking that resulted in the uptake of an Actor Network perspective in IS studies (Ciborra 1997), which elaborates on this relationship between human and non-human actors. Actor Network Theory originates from the work of Michel Callon (1990) and Bruno Latour (Latour, 1992). Actor Network Theory (ANT) attempts to understand how phenomena come to be in practice as part of networks of actors in which some actors successfully (or unsuccessfully) can translate the interests of others. As noted by Latour (2003 p. 35):

ANT started with research into the history and sociology of science, tried first to provide a 'social' explanation of scientific facts, failed to do so, and then, from this failure, it drew the conclusion that it was the project of a social explanation of everything that was itself wanting.

According to an ANT understanding, phenomena are not 'out there' but entangled with the lived world and inherently socio-technical in nature. An ANT perspective thus urges us to investigate phenomena as constructs of their material and social context. I.e.: a disease does not 'exist' in the

absence of a network of medical researchers, a laboratory, microscopes etc because the disease phenomena are part of its network. This led Latour (1996) to claim for instance that Ramses did not die of ‘tuberculosis’, based on the perspective that scientific objects gain their qualities through their network, and the organism causing what we diagnose to be tuberculosis today had not yet been discovered.

Bateson, Callon, and Latour all share the idea that as a result, power is ‘flat’ (there is no position within a system or network from which to capture the whole system, there are merely ways to mobilise elements of the system) and that nothing is reducible to anything else. Following an ANT perspective, mobilisations or translations can be observed but will always remain incomplete and produced as part of the system. It is following this type of thought that infrastructures are assigned heterogeneous, complex, random and open qualities. As Monteiro (2000 p. 1) puts it ‘ANT (...) offers an illuminating vocabulary to describe information infrastructure’. Similarly, Cordella (2010 p.15) makes a case for using ANT to answer the question ‘What is an information infrastructure?’.

Later contributions to ANT (‘ANT and after’) by Moll and Law delve deeper into the way phenomena change shape according to the way they ‘travel’ (De Laet & Mol 2000), which is relevant when we consider information infrastructures to be socio-technical webs in which technology is spread across and entangled with a variety of use environments. For instance, de Laet and Mol (2000, p. 252) make the following observations about a Zimbabwe bush pump:

The Pump is a mechanical object, it is a hydraulic system, but it is also a device installed by the community, a health promoter and a nation-building apparatus. It has each of these identities—and each comes with its own different boundaries.

Law and Singleton (2005) furthermore draw further attention to the way phenomena in ANT are subject to multiple perspectives (Law and Singleton 2005) by considering the way a doctor may perceive a liver disease as putting the patient at risk of dying whereas the alcoholic patient who does not dream of a long life may perceive it to be a remedy. Yet the network of the doctor and his tools are designed to deconstruct the liver disease as a scientific object. In this case, it is based on the misalignment of perspectives and interests that become visible.

3.2 Using ANT to Study Information Infrastructures

3.2.1 Studying Relations

The term 'infrastructure' itself is a reference to the relational qualities of infrastructures (Karasti and Blomberg 2018). This dimension is inspired by the work of Star and Ruhleder (1996 p. 113) who propose that *'analytically, infrastructure appears only as a relational property, not as a thing stripped of use.'* Rather, they are something that is sunk into other structures and arrangements, which has been captured as an installed-base (Star and Ruhleder 1996; Hanseth 2001) which is shaped by and shapes the infrastructure-in the making. This relational dimension is present in the many definition of infrastructures which all attempt to capture their modular, multi-faceted, layered, open-ended, evolving nature and the number of studies that aim to research how they combine a diversity of agendas, social norms, and practices as a result (see for instance Edwards *et al.* 2013; Monteiro *et al.* 2013, Hanseth 2001).

This relation aspect of infrastructures suits an actor network theory approach which, as noted by Cressman (2009 p. 1) is *'notoriously difficult to summarize, define or explain (...) [not in the least because of] ANT's unrelenting attack on the categories and concepts that have been part of Western thought for centuries.* Cressman further illustrates his point with the following excerpt provided by Law (1999, p.3), which furthermore perfectly reflects the tensions inherent to information infrastructures as discussed in chapter 2:

Truth and falsehood. Large and small. Agency and structure. Human and nonhuman. Before and after. Knowledge and power. Context and content. Materiality and sociality. Activity and passivity...all of these divides have been rubbished in work undertaken in the name of actor network theory.

Given these tensions have been acknowledged and elaborated upon extensively in the previous chapter, the intention is not to 'rubbish' them by adopting an ANT lens. Rather, the intention is to move from infrastructural characterisations which make them 'relational' to an 'infrastructure' perspective which is 'processual' (Karasti and Blomberg 2018) with the help of ANT in investigating what are seemingly extremities. As such, ANT helps reveal that things may not be what they seem.

In this regard, Law and Singleton (2005 p. 337) furthermore argue that:

If (we insist on the ‘if’) objects may be treated as immutable configurations of relations, then these are at best only the tip of the iceberg. By definition, all the (indispensable) invisible work lies below the waterline. Or, to put the argument slightly differently, might it not be the case that, if we want to understand objects, to characterize and study them, then we need to attend as much to the mutability of what lies invisibly below the waterline as to any immutability that rises above the surface?

A book well cited by anthropologists written by Anne Fadiman titled ‘The spirit catches you and you fall down’ could be an example. This book tells the story of a young girl, Lia Lee, who was diagnosed with severe epilepsy, and the culture conflict that hinders her treatment. The family believed that Lia Lee's state showed a sense of spiritual giftedness, and they did not want to take that away. Here, the phenomena of ‘epilepsy’ constructed through the scientific method, conflicts with the phenomena of ‘spirit’ constructed through culture. The network surrounding this object consists of various actors: the patient, Lia Lee, the family, the epileptic episodes, the doctors, and spirit as actors, their interactions and in this case their misalignments. Any dualism that may be observed (for instance the power and knowledge of the doctor or of spiritual leaders, truth and falsehood, etc) is the result of this network, and accordingly ANT urges us to investigate them as such.

Translation

A key concept that explains how relationships are understood and formed from an ANT-perspective is ‘translation’. Translation is an aspect within ANT that helps unravel the networked nature of power central to ANT. It was developed by sociologist Michel Callon (1984) in an influential contribution to actor–network theory. Based on a study of scallops in St. Briec Bay, Callon (Ibid.) describes the process of domesticating scallops by introducing separate actors and their goals along four moments of translation:

1. *Problematization*, whereby the initiating actors try to make themselves indispensable to other actors by defining the nature of the problem those actors face in achieving their goals and by identifying a way forward;
2. *Interessement*, whereby the initiating actors lock the others into place by interposing themselves, weakening the links of other actors to alternative interpretations and strengthening their focus on the problematised
3. *Enrolment*, whereby the initiating actors put interessement into practice by actions that define the roles that are to be played and the way in which others will relate to one another within the network;

4. *Mobilisation*, whereby the initiating actors borrow the force of their passive agent allies and turn themselves into their representatives or spokesmen.

Several aspects of translation can result in what is conceptualised as obligatory passage points (OPPs). OPPs are associated with the way actors converge on a certain topic, purpose or question defined by the initiating actors through translation. The OPP thereby becomes a necessary element for the formation of a network and the action that follows, through which all interactions between the actors in the network are mediated. In Callon's well-cited work called the 'sociology of translation' (1984), he discusses the OPP as primarily created by a group of researchers who introduce a solution to a group of fishermen and are able to interest and enrol the fishermen into adopting this solution, thereby creating an actor network at which the researchers place themselves at the centre, more or less pulling the ropes because they were able to identify a shared interest and inscribe this into a technical solution. OPPs may dissolve when those in power are unable to represent the interests of the alliance. For instance, what made the OPP dissolve in Callon's case (1984), was the way the scallops have trouble anchoring and the fishermen do not respect the decisions of their representatives.

That researchers can be an obligatory passage point is also seen in the example of the scientist Pasteur (Latour 1988), who is able to translate the interests of farmers by offering a solution to the anthrax disease. With the use of the controlled environment of his laboratory Pasteur can make himself as a scientist 'big' and anthrax 'small', and later, through his vaccines, he can make the farmers (changing their farms in small laboratories) big and anthrax small. The translation is as follows: If the farmers want to stop the anthrax disease, they have to go through Pasteur and his lab, and later on Pasteur and his vaccines (Ibid.). As a result, science itself can be understood as a translation through which the powers of several actors are changed.

Latour stretches perceptions of the obligatory passage point further by proposing that even something like a hydraulic door can be an OPP based on the fact that it demands energy from the one pushing the door open, which it uses to make it close (Latour 1992 p. 148). The one pushing the door has no choice but to allow this if he or she wishes to enter. With this example, he furthermore illustrates that OPP constructions can also be discriminating against something or someone; for instance, the old or the small persons that cannot spare this type of energy (Ibid. 1992 p. 158). OPP constructions, like technical solutions such as these, can also *inscribe* certain

behaviour. The annoying pinch of a seatbelt alarm can demand morality from the person sitting in the driver seat (by offering them the alternative of madness) (Ibid. p. 159). Heeks and Seo-Zindy, (2013 p. 6) also recognises two ways of perceiving OPPs, by describing it both as ‘*a single way for an actor to think about how to progress toward their goals*’ as well as ‘*a single channel through which exchange between actors takes place.*’.

After a successful translation process, we can picture OPP positions as illustrated in figure 2). In this figure, actor 1 has an OPP position in relation to actors 2: for instance, actors 2 are forced to go to actor 1 to participate in this network.

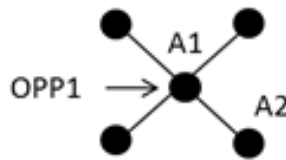


Figure 2. OPP construction

3.2.2 Studying Invisibility

Karasti and Blomberg (2018 p. 5) note that infrastructures are the ‘substrate’ that allow other things (the ‘substance’) to happen. This quality has been discussed by Star and Ruhleder (1996 p. 113) who note that, when infrastructures work well, they become transparent. Whereas the visible aspects of infrastructures tend to result from their breakdown, Karasti and Blomberg (2018) nevertheless point out that the ‘noticeable’ are often easier to deal with than the ‘unseen.’

In ANT, any technical object that operates as it should become ‘black boxed’ in that the complex sociotechnical relationships that constitute it are rendered invisible. The idea that phenomena are black boxed is not unique to ANT, however, the perspective that everything is both an actor and a network is especially well-addressed in this theory. This is referred to as punctualisation which Callon (1991 p. 153) describes as ‘the process of punctualisation thus converts an entire network into a single point or ‘node’ in another network’. This is precisely what is done when defining ‘infrastructures’ as evolving ecosystems and when studying ‘infrastructuring’ as a networked process. By opening the black box of technologies (systems, platforms) they become processes and the invisible is made visible. This also means that all black boxes (and therefore all information infrastructures) are ‘leaky’ (Callon & Latour 1981) in the sense that they are subject to competing

ideas and initiatives that will attempt to open black boxes that have been punctualised within larger actor networks (Cressman 2009). As such, punctualisation comes with a risk of facing resistance and the degeneration of a network (Ibid.). This aspect of ANT also draws attention to the fragile boundaries of infrastructures discussed in the previous section; and the difficulties of drawing and moving invisible boundaries when designing them but also when studying them.

This traditional ANT-perception of objects is furthermore visible in the way action is inscribed into the object, which shows the absent presence of assumptions about practices: the shape object attempts to influence how it is used similarly to the previously discussed example of hotel keys. The heavy key holders were meant to stimulate hotel guests to hand in their keys at the desk before leaving the hotel. However, the creation of such persuasive networks involves more than the persuasive design of objects; it furthermore requires weaker and stronger relations established around the interests of one or more actors.

In elaborating on this aspect, I will draw on a memory I had at the airport in the Netherlands shortly after I first learned about perceiving objects in ANT as discussed and expanded on by Law and Singeleton (2005). I was waiting in line to board a plane and I paused next to an advertisement which I observed longer than I normally would (see image 1). With the paper still fresh in my head, I spared a few thoughts about its 'object' features. This ad was part of a series of advertisements which tried to capture all the 'go to' places of a particular travel destination; in this case Istanbul. What jumped out most within everything that was going on within this relatively small ad (which had the size of a place mat) was the word 'rooftop bars' with two large cocktail shakers. Below the picture it said, (like all pictures): 'everything you need in just one photo' with the symbol of a phone underneath it in 'camera position'.

Clearly, this advertisement was aimed at making me do something (take a picture of it), which made me realize how much the concept of advertising changed with the introduction of technology. From something which in the first place had to be clear to read and convey a persuasive message in seconds, to an overdose of information crammed into a small place which you are not actually meant to look at until later as long as you take a picture of it. This also made me realize that absent but present in this advertisement was an assumption about me: that I would have a phone with me, but also that the first thing I would want to see in Istanbul would be its rooftop bars. An absent presence in this ad was the designer, who for some reason pictured me this way (has assumptions about what I want and what I will do).

This example illustrates how one object can be subject to multiple perspectives (and therefore would make it a fire object according to Law and Singleton 2005).

Following de Laet and Mol's ideas (2000), the shape of advertisements has changed over time and adapted to the presence of mobile phones (and in other instances to the introduction of led screen technology) (which makes it can be perceived as a 'fluid' object). Still, at the same time, there is a stable core: we can recognize different versions of the same object as 'advertising', which consists of some form of display of information for the purpose of tapping into consumer needs (Latour 1988).



Image 1. Source: Author. Photo taken December 2015

3.2.3 Studying Connectedness

Connectedness implies that because infrastructures are relational, they are constellations of elements other than the infrastructure itself. This dimension also implies scaling, in that infrastructures become dispersed and distributed across time (short-long term) and space (local-global). By connecting, they furthermore ignite standardisation processes that affect both the 'connecting' (substrate) as well as the connected (substance).

Important aspects of Latour's work elaborate on how, through the process of translation, the scientist can be made 'big' or 'small' (Latour, 1983). Latour explains this by taking a close look

at the influential work of ‘Pasteur’ in linking microbes and disease. Latour’s argues that to the outside world (at large scale) farm animals, veterinarians, and farmers are ‘weak’ compared to the microbes causing Anthrax, in that they easily fall ill. However, when the Anthrax microbe is ‘farmed’ inside a controlled lab environment (in which scale is reduced), the scientist becomes ‘stronger’ than the microbe, the veterinarians and the farmers who then have to come to the scientist for a solution. Nevertheless, in Latour's words, (Ibid. p. 150) ‘as for all translations it is possible and necessary to distort the meanings but not to betray them entirely.’ For this, it was necessary to move from the laboratory to the field, from the microscale to the macroscale, by enabling the extending of a laboratory product to every farm in France in the form of a vaccine and a limited set of laboratory practices required for maintaining and applying the vaccine correctly. Latour describes this translation as 'solve your problems through Pasteur's [scientists] lab' and later on through his vaccines implied that not only the scientist’s problem but those of the other actors could be solved. The translation, therefore, can be understood in part as a contract in which various interests are negotiated. Latour (Ibid. p 149) notes:

As the reader is aware, I am multiplying the words 'inside' and 'outside', 'micro' and 'macro', 'small scale' and 'large scale', so as to make clear the destabilizing role of the laboratory. It is through laboratory practices that the complex relations between microbes and cattle, the farmers and their cattle, the veterinarians and the farmers, the veterinarians, and the biological sciences, are going to be transformed.

When we consider connectedness in infrastructures to be constellations of elements other than the infrastructure itself, there is another concept in ANT that places a perspective on the interconnectedness of infrastructural elements across space and time called ‘circulating references’. To explain this concept, I will use a metaphor which is brought to the imagination by Latour (1999, p. 43) in the following excerpt, as Latour enables us to follow a botanic who comes back from the field with a bag full of samples and enters their workspace.

We are in a botanical institute, quite far from the forest (..) a cabinet with three ranks of shelves constitutes a workspace crisscrossed in columns and rows, x- and y-axes. Each compartment is used as much for classification [of leaves] as for tagging and preservation. This piece of furniture is a theory, only slightly heavier than a tag [on a tree] but much more capable of organizing this office.

Latour (Ibid., p. 36) continues about the office: ‘*space becomes a table chart, the table chart becomes a cabinet, the cabinet becomes a concept, and the concept becomes an institution*’. Latour also describes a table in this office (Ibid.):

In this little room where the botanist shelters her collection is a table (...) on which the specimens [from plants] brought back from the district locations at different times are now displayed. [this table] is where we see why the botanist gains so much more from her collection than she loses by distancing herself from the forest.

Latour's concept of circulating references explains what is gained and lost by the botanist by taking the leaves out of the context of the forest.

References are thus needed in '*aligning each stage with the one that precedes and follows it, so that, beginning with the last stage, we can return to the first*' (Latour, 1999, p. 64). At more abstract stages, we create models and diagrams which serve as inscriptions of the aforementioned stages, that enable us to 'oversee and control a situation in which we are submerged' (Ibid., p. 65). Such diagrams are inventions that serve to help discover and are assemblages of all the previous transformations without which it would have no meaning. It 'takes the place of the original situation' which we can re-trace, yet it doesn't replace anything. It summarises without substituting completely for what has been gathered. '*It is a strange transversal object, an alignment operator, truthful only on condition that it allows for passage between what precedes and what follows it*' (Ibid. p. 67).

This is a reversible chain of transformations which Latour describes as follows (Ibid. p. 69):

An essential property of this chain is that it must remain reversible, and that succession stages must be traceable – allowing for travel in both directions. If the chain is interrupted at any point, it ceases to transport truth (to produce, construct, trace and conduct it). The word 'reference' designates the quality of the chain in its entirety (...) truth value circulates here like electricity through a wire, so long as the circuit is not interrupted.

The following figure illustrates how this process is a dialectic between gain and loss which occurs at each information processing step. '*In the end, we do not only hold all of the Boa Vista [forest] to where we can return [through amplification] but also the explanation of its dynamic [through reduction]*'. To move in either direction, there must be successive stages (an unbroken link). This was illustrated in figure 3.

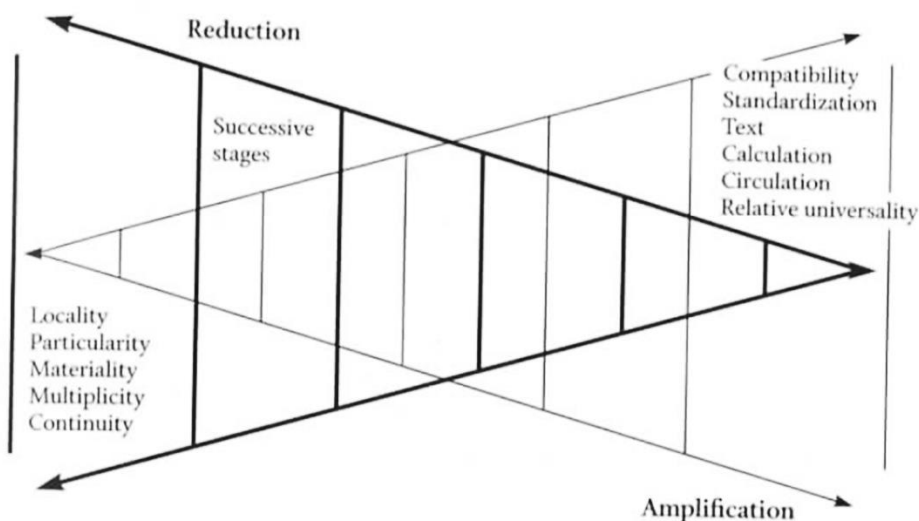


Figure 3. Circulating references (Latour 1999, p. 71)

Tracing something as abstract as a graph back to the trees in Boa forest seems to require merely tracing the steps of the botanist. However, as Latour mentions, as soon as ‘truth’ of a reference is interrupted, it no longer functions as a reference. This makes the application of this concept difficult in relation to information infrastructures because it introduces a contradiction. When perceiving II as networked, we can understand how a ‘global’ II is inscribed with the interests of actors in a position to problematise and mobilise the interests of others. However, this inscription process and the interest of various actors are black boxed when we perceive global II to be a distant reference of local requirements gathered. What is gained is not merely ‘a’ universality, it is always ‘someone’s’ universality.

ANT leaves us with the option to choose an explanation for why aspects are lost during this process. Is it because references need to be transformed as part of standardisation processes (an assumption present in literature on flexible standards (discussed in section 2.3) and generification (discussed in section 5.1)? Or is there no such thing as a generic ‘standard’ product, as all generic products and standards are outcomes of a translation process that is inclusive to some and exclusive to others? As discussed in previous sections, this research identified a risk that as local requirements become part of global systems, translation processes can be exclusive to those who lack the resources to either make up for what is lost locally through adaptation or push their ‘truths’ in the form of requirements. For instance, what if the botanic only gathered leaves on the periphery of the forest because the edges were more accessible? Would the selection of leaves on the table

still be a fair representation of the entire forest? What if the botanist was drawn to collect leaves only from the highest trees? In Latour's development of the concept of circulating references, the motives of the botanist are invisible. Nevertheless, unlike the concept of OPPs, the notion of circulating references in ANT urges reflection on what is inevitably lost as well as gained during processes of abstraction when interests are taking out of the equation. Doing so, it offers a refreshing perspective of translation processes.

3.2.4 Studying Emergence and Accreditation

According to Karisti and Blomberg (2018 p. 5), the prolonged processes through which infrastructures are continuously recreated are characterised by ongoing iterations, 'backing and forthing', expanding and retreating, and 'so much in the making' that they never exist in an absolute sense. In previous sections, it has become clear that, following an ANT perspective, we can understand objects as 'things manipulated in practices' (Mol 2002, p. 4). ANT opens up an analytical space in which we may examine objects as manipulated, enacted, emergent and as disappearing from one practice to the other. While according to this perspective no object is singular and yet 'more than one, less than many' (Mol 2002, p. 4-5), the object 'phenomena' hangs together as a result of relations that exist between the different enactments.

For instance, a disease is enacted through shared procedures or vocabulary, translations of instruments from one setting to the next, pieces of paper, x-rays, people moving between settings etc. that prevent the multiple objects from falling apart (Mol 2002, p. 5). Hospitals are accredited to treat diseases because they hold access and expertise to such procedures and equipment. However, when we recall the example in section 3.2.1 about the child whose epilepsy was perceived by the family as a spiritual event, the doctor and his equipment is no longer credible to detect and treat the child. One could imagine the family might turn to a priest instead. Here we can see how identifying the network that surrounds the object has a role in determining what kind of object this is and how we should understand its nature. This can also change over time, as evident in the way the spirit and the body were not treated as separate in Europe in the time before Descartes upon which Western medicine was founded.

Further clarity on the notion of programs is found in the work of Akrich (1992). Akrich (Ibid.) discusses how perceptions about objects make their way into the object itself in the form of ‘scripts’. Akrich’s mentioning of the techno-scientific script comes at around the same time as Latour’s discussions about programs of actions, and these two concepts have much more in common than the time they first popped up in writings. Both concern the intended use of an object as something that is ‘programmed’ inside the object, or as Akrich calls it: scripted.

There is a beautiful movie called ‘Another earth’, in which the story is told of a man who finds himself all alone hovering in a spacecraft far away from earth, and there is a defect to the spacecraft causing a pinching noise that won’t stop. What can he do? It will drive him mad! So, he decides to fall in love with it. When we relate this story back to the story from Latour, we could perhaps argue that, had his driver chosen to fall in love with the annoying seatbelt alarm, he would not even have needed to be deaf in order to disobey the program inscribed into it. Perhaps these examples seem to be farfetched; however, these they draw attention to the power of meaning. Later in the aforementioned movie there is a scene which makes reference to this story, in which the same man creates the most beautiful sounds with a saw. The saw has become an instrument to make music for the soul. Is the object still a saw, or is it a musical instrument that turns into a saw again when we take it to the woods? With that our perception of the object changes (‘this is a musical instrument’), our use of the object changes (making music) and therefore the ‘program’ of the object changes. Accordingly, ANT teaches us that the program of the object changes depending on where its users take it. One can never suspect a saw to be merely a saw.

3.2.5 Studying Intentionality and Intervention

Given the dynamic, heterogeneous and emerging nature of infrastructures, Ciborra and Hanseth (2000) suggested that their designers should not attempt to deliberately and coherently engineer and control them. Rather, changes to infrastructures should follow rather unplanned and unpredictable processes, also discussed by Ciborra and Hanseth (Ibid.) as a shift from ‘control’ to ‘drift’. Karisti and Blomberg (2018) note this perspective has been widely accepted and integrated in the language of those discussing the designing and developing of infrastructures with a family of ‘ing’ terms (i.e. ‘growing’, ‘fostering’, ‘cultivating’ as well as adapting, tailoring, tweaking and tinkering to name a few). Using ANT terminology, Karisti and Blomberg (Ibid. p.8) perceive the previous family of ‘ing’ terms to highlights ‘the many ways in which humans and non-humans engage in various translation activities that are inherent to systems building’.

Previous examples of the hydraulic door, seatbelt alarms and hotel keys illustrate how objects (including digital infrastructures) are what Latour (1992 p. 159) calls ‘anthromorphic’ as a result of 1) being made by humans; 2) substituting for the actions of humans or permanently occupying their position and 3) shaping human actions by prescribing back (for instance, what sort of people should pass through a door). From this understanding, we can see why ANT acknowledges both human and non-human actors, that are tied to each other in a network through the exchange of certain properties. Humans may also rebel against this type of prescriptions, and a deaf person may not feel the same urge to submit to a seatbelt alarm. The other way around, he makes a case for the way even a hydraulic door can be on strike. In these cases, there is a gap between the prescribed use (inscribed into the object) and what Latour refers to as ‘the user-in-flesh’, which can be big or small.

To further illustrate this, I will recall a memory which was triggered when I read the well-known example Latour uses to illustrate programs and anti-programs, when describing interventions of hotel management to make hotel guests return their keys. The most successful intervention turned out to attach a heavy key holder to the keys of hotel guests. This memory was of a moment I had in a rather shabby hotel in Dublin, that had the largest key holders I have ever seen in my life; wooden sticks the size of my underarm you could easily defend yourself with should it be necessary. Doubtful (yet not unthinkable) the interest inscribed into the key holder was a concern for my safety, we can assume they also meant to prevent guests from taking the keys with them. Which did not stop me from taking an extra big bag with me so the key would fit in it, as the poor way the hotel was run made that I did not trust the staff and that I easily foresaw them assigning my room to someone else while I was out.

In the words of Latour, I became living proof that (p 174) *‘no artefact is idiot-proof because any artefact is only a portion of a program of action and of the fight necessary to win against many antiprograms.’* Thus, use can also be ‘re-inscribed’, illustrating how *‘every wheel and crank of an artefact is the possible answer to an objection’* whereby *‘a program of action is in practice the answer to an antiprogram’* (1992 p 168).

In the previous descriptions, programs of action inscribed in artifacts need to ‘win’ from the antiprograms. However, such programs can also hinder desired use cases – as well as enable completely different ones. Had it turned out the key holders from my hotel experience in Dublin would contribute to a wave of violence on O’Connell street, an antiprogram would be needed for this program of action.

In an example case provided by Callon (1986), researchers came up with a solution to make scallops anchor better in a bay in France for the purpose of establishing a healthy population; however, as a result, the fishermen fished more because the scallops grew in numbers which threatened population growth. The short-term interest absently present in fishing (selling, getting paid, eating) weakened the interest the interest to more long-term aim of the researchers to grow a healthy population of scallops. Similarly, in the case of Latour with the hotel keys, the inconvenience of the heavy key weakened the benefit of taking it with you, just like a shabby poorly run hotel might encourage you to nevertheless find a bigger bag.

When we look at hotel keys nowadays, many have been replaced by electronic cards that can be activated and de-activated by hotel staff. Again, the key (as a solid 'concept') turned out to be a fluid object (de Laet and Mol, 2000). This fluidity furthermore demonstrated the way the absent present interest of the owner inscribed into the object has changed: the option of activating and de-activating keys electronically, the purpose is no longer to keep customers from taking the key with them and as a result the key could be transformed into from something that was too heavy to fit into your bag, to something you can actually carry in your wallet. What Law and Singleton (2005) and de Laet and Mol (2000) thus have achieved is to make the invisible, visible. They allowed us to uncover the fluidity of objects and absent presences in translation processes.

These examples illustrate that the extent to which networks can be made visible remains to be questioned and is interconnected with intentionality. Of the actors involved, but also of the researcher studying networks. My personal example from an experience in a hotel in Dublin illustrates how an absent presence is only uncovered when one is able to expose the way the hotel staff was absently present in my action. Had I not had carried a big handbag; my action would not have been possible, and this presence would not have been detectable. For, in that case, the people watching me go out would also be present; and the way I would have to visibly drag around a wooden stick with me for the day (with no intention of attending a baseball match). As Law and Singleton (2003) state, not everything can be brought into presence. This brings me to discuss some limitations of using ANT.

3.3 Critiques of ANT

Although referred to as a theory, ANT is better understood as an analytical lens to that may be used to examine narrative knowledge from the perspective of the researcher. As Whittle and Spicer

point out (2008 p 616) we live in a world of ‘translators’ but not in a world that is ‘translated’, which would also suggest every ANT application is, in fact, a translation. However, although ANT seeks to elucidate understandings that actors have of their own lived reality in the form of narrative representations (Latour 2005), ‘most analyses produced by ANT fail to match the kinds of descriptions and explanations that members would provide themselves’ (Whittle and Spicer 2008 p 617).

An ANT ‘translation’ thus inevitably advocates particular viewpoints, as it 1) lacks to acknowledge a situation (or tool) can be interpreted in different ways (Lynch, Bijker and Law, 1993) and 2) the power to translate is not equally distributed. ANT translators tend to produce explanations of the world (‘truths’) that resonate with ‘victors’ (Whittle and Spicer, 2008). Indeed, many ANT translations do not recognise the possibility of multiple versions of the process of translation as a result. This, however, contrasts the notion inherent to ANT that everything could always be otherwise. Secondly, the idea that there is a ‘true’ translation, contrasts with the assumption present in ANT that reality is constructed and re-constructed, and that therefore does not exist ‘out there’. Like all actor networks, ANT translations are also a matter of whose interests are inscribed into the network in such a way that other actors have to comply. Accordingly, ANT can be in fact used in multiple ‘directions’, meaning it can both challenge as well as concur to existing structures of domination.

Because of this, ANT does not aim to answer questions such as ‘who decides’ and ‘why do certain actors dominate?’. Rather, ANT speaks the language of connections and goes as far as to say: this actor is still in, this actor is out, and the strength of connections between actors depends among others on the extent to which interests of both human and nonhuman actors are aligned. In this sense, it is non-judgemental: it is explanatory and descriptive, in line with a methodological approach.

In fact, in many cases, critiques that seem to challenge ANT often instead address the ability and limitations of the researcher itself in the role of the ANT translator. For instance, Whittle and Spicer (2008 p. 618) point out a danger in) that the use of Callon’s (1984) four moments of translation in organisational studies (that is also present in IS studies) is ‘*reduced to a series of deductive tests that confirm or refute the four-stage model of translation, as opposed to being a process of inductive theory generation theory that is grounded in- and emergent from the empirical*

data'. Alternatively, they suggest viewing what they refer to as the 4-stage model as an analytical experiential and informative concept that can be employed by the researcher to make sense of complex observations without losing attention for the empirical complexity of individual cases. Their proposal to rather perceive translation to be ongoing, iterative and disorderly rather than a linear process does in fact not contrast uses of ANT. Mol (1999) and Alcadipani and Hassard (2010) encourage the idea that ANT has many usages and interpretations in the hands of a diversity of researchers, and that ANT can be used to develop a critical analysis. For instance, ANT could also be used to assess whether in the construction of a particular actor network 'real options' (in terms of alternatives) were available (Moll 1999). In addition, it may or may not be used to understand the evolutionary nature of actor networks.

3.4 Summary

This chapter has explained how Actor Network Theory can help us understand how information infrastructures can be understood as networked and translated, in line with notions that these infrastructures cannot be studied as whole networks or ecologies, and that in order to make them visible, they need to be constructed (Blomberg and Karasti 2018). Specifically, this chapter has explored how an ANT lens can offer insights in dimensions of information infrastructures that make them especially challenging to study. For each dimension (outlined by Blomberg and Karasti 2018) appropriate ANT concepts and approaches were identified as follows:

- Relations in II may benefit from an understanding of actor-networks as *translations with obligatory passage points*;
- Invisibility in II can benefit from an understanding of how aspects of actor-networks are *black-boxed* and *inscribed*;
- Connectedness in II can benefit from an understanding of how relationships between 'inside' and 'outside', 'micro' and 'macro', 'small scale' and 'large scale' can be transformed in actor-networks, in which the concept of '*circulating references*' might be used to reveal what is gained and lost during transformations;
- Emergence and Accreditation in II can benefit from an understanding of *object dimensions* (in which objects may be singular and multiple across time) and how perceptions about objects may their way into their functionality through '*scripts*';

- Intentionality and Intervention in II can benefit from an understanding of how both *human and non-human actors* can ‘act’ and relate to each other through *programs* and *anti-programs*.

Understanding phenomena as networked and translated also has implications for the researcher in outlining their study design and crafting each step with an awareness of his or her own set of tools and assumptions. In the next chapter, I will discuss how a naturalistic inquiry approach guided me in selecting my own set of tools as well as adopting a reflective process with an awareness that I too was a translator at work.

4. Methodology

In this chapter, I will discuss how a naturalistic inquiry enabled me to craft a DHIS2 ‘field’ in order to expose, understand and analyse the dynamics within that field. In 4.1, I will first discuss what I mean by constructing this field and unpack it as an ethnographic undertaking based on the work of Blomberg and Karasti (2018) in this area. However, given the complexity of this undertaking, I consider a heavy reliance on the researcher’s individual judgement, experience and ethnographic skills a limitation of this work. Therefore, in section 4.2, I suggest that a naturalistic inquiry approach provides II researchers with guidance on how to apply their ethnographic skills in such a way that will help them grapple with challenges in relation to constructing II fields, such as open ended and long-term research designs, shifting objects of inquiry, and a need for high mobility and making strategic connections. In the remaining sections, I explain how I shaped my own naturalistic inquiry in constructing the DHIS2 field laid bare in this study. While these sections primarily aim to make my research methods and their flaws transparent, they also serve as an example for other researchers of ways in which constructing II fields can benefit from naturalistic inquiries.

4.1 Constructing the Field

Blomberg and Karasti (2018) perceive information infrastructure ‘fields’ as constructed and therefore dismiss the field as ‘out there’ awaiting to be discovered (Smith, Flowers and Larkin, 2009). Rather, the role of ethnographers is an active one in which they simultaneously shape the field he or she attempts to understand.

At the same time, constructing the field wrongly gives the impression that the study’s focus should be predicted or controlled; rather, it should be emergent from ongoing engagement (Winthereik *et al.* 2002). This perspective can be linked back to the ontological assumption that access to infrastructures (be it as ecologies of thought or actor networks) require an emphasis on use and consequences instead of antecedents as well as political, non-reductionist and non-positivist accounts of multiple moral orders (Star, 1995 p. 21). Perceiving the field also involves understanding it as *‘a confluence of different times and temporalities, [that] emerges rather as a dynamic force of becoming that shifts in intensity and clarity, depending on the ethnographer’s immediate position and immersion’* (Dalsgaard and Nielsen 2013 p. 6). This especially applies to

information infrastructures, in which settings researchers are faced with may include face-to-face, collocated as well as online activities that are mobile or distributed across settings.

When studying infrastructuring, the object of inquiry is not stable or singular and therefore requires the researcher to put in place strategies that allow him or her to follow connections; allow for emergence of the research design or ‘pursue the phenomenon’ (Karasti and Blomberg 2018) and look for parallels and contrasts across seemingly incommensurate sites (Marcus 1998). The interest is in a fractal, empirical landscape rather than an empirical site that is not fixed, and researchers may adopt a range of methods to study it, including observations, interviews and document analysis (Ibid.) and other materials traces people produce about their communities in order to act within them. Such a triangulation of methods is also important to examine the information infrastructure phenomenon from multiple perspectives to reveal aspects of it that may be less visible and remain hidden using certain methods. Researchers can also experiment with different ways of framing the object of study (Winthereik *et al.* 2002). Another way of studying the visibility of infrastructure is by studying their breakdowns (Bowker and Star, 1999). These methods are aimed at revealing what underpins routinized activities and allow for ethnographic accounts of networked phenomena without having to visit every node (Geiger and Ribes, 2011).

Given the large-scale nature of infrastructures, researchers need to manage scale. One strategy to do so is a ‘multiplication of sites’ approach of several single-sited units. As part of such an approach, sites may be selected strategically based on theory or a provisional understanding of ‘moments, locales, nexuses in which artefacts and attendant practices and knowledge [are] created, exchanged, traded and validated’ (Pollock and Williams 2010 p. 544). Study designs are nevertheless likely to be undecided about relevant locations and need to ‘make it part of their goals to find out where interesting things might be going on’ (Hine, 2007 p. 661 in Karasti and Blomberg 2018). As such, multi-sited ethnography recognises that there are various transient and changing places, spaces, situations, and encounters that can form the focus of a study (Karasti and Blomberg 2018). One can also say it examines a ‘circulation’ of meanings, objects, and identities which may take unexpected trajectories (Marcus 1995 p. 96).

This implies that researchers also need to reflect critically on both the spatial as well as non-spatially oriented notions of the field and unpack the multi-temporality of the relationship between the field worker and the field (Karasti and Blomberg 2017). This may require a commitment to

mobile methods where researchers are participant observers, move with subjects of inquiry and follow selected objects and connections (Büscher, Urry and Witchger, 2010). A useful concept coined by Karasti and Blomberg (2018) in this regard is the establishing of ‘co-presence’ over co-location, which foregrounds the relationship between the field worker and the participants regardless of time and space. This relationship is important because the unstable and incoherent nature of the object of study makes that researchers need to engage participants in constructing practical ontologies, be flexible and attentive and include informants throughout the process (Karasti and Blomberg 2018). Specifically, by seeking ‘infrastructural allies’ (Beaulieu, 2010) - who are involved in infrastructural activities as part of their job descriptions.

Working out these issues methodologically depends to some extent on whether the researchers deem it important to pursue a particular set of connections outward or drill down more in depth in a particular place or event (Hine 2009 p. 17) and -where he or she perceives a study should travel analytically (Ibid. p. 2) at different levels of the infrastructure. This also makes that boundaries of an investigation are outcomes of it rather than set at the onset. The previous inquiry makes that researchers need open-ended, long-term research designs to study processes of infrastructuring over temporally bounded, short-term designed projects (Karasti and Blomberg 2017).

The complexity of the skills and considerations this requires make that II researchers need a strong methodological grounding. Initially, the knowledge that researchers of II need to ‘construct the field’ raises more questions. How do researchers apply open-ended, long-term research designs? How do researchers find infrastructural allies? How do researchers commit to mobile methods where researchers are participant observers, move with subjects of inquiry and follow selected objects and connections? How can researchers experiment with different ways of framing the object of study? The remainder of this chapter is part of my efforts to meet this objective (my choice to apply ANT as an analytical lens in chapter 3 is another).

4.2 Naturalistic Inquiry

Naturalistic researchers often begin by asking the question ‘what is happening here?’ rather than start with a very specific question guided by a separate area of expertise to produce a comprehensive, meaningful picture or basis for action (Lincoln and Guba, 1985 p. 10). This suits particularly well with the researchers are required to ‘pursue’ the emergent phenomena of infrastructuring through open and flexible research designs. In a naturalistic inquiry, the research

design emerges from the research itself (Lincoln and Guba 1985 p. 6). Another aspect that makes naturalistic inquiry particularly compatible with the ethnographic study of infrastructures, is that naturalistic researchers understand realities to be constructed and that words to provide limited access to them. Consequently, a naturalistic inquiry is commonly understood to be based on the following strategies (Ibid. 1985):

- a) Prolonged engagement
- b) Persistent observation
- c) Triangulation
- d) Referential adequacy materials
- e) Peer debriefing
- f) Member checks

These strategies for naturalistic inquiry match with the more common usage of ‘ethnography’, however, applies them with an awareness that ‘to get to the relevant matters of human activity, the researcher must be involved in that activity’ (Lincoln and Guba 1985 p.15). As such, this approach is highly compatible with notions that those researching infrastructuring phenomena benefit from establishing co-presence and require a triangulation of methods to gain access to the more hidden aspects of infrastucturing. In the following sections, I will elaborate on what naturalistic inquiry entails and how the previous strategies are applied.

4.2.1 Blurry Boundaries

Naturalistic inquiries involve the study of a single phenomenon, which may concern a self-identified group or community. In my case, my unit of analysis is the HISP network surrounding DHIS2 and several communities or groups within this network. While self-identified group members tend to be conscious of boundaries that set them apart from others, in the DHIS2 case this boundary was somewhat blurred. There is a group of core developers that is changing, a group of researchers that is also changing, groups of local developers that are changing and groups of funders that are changing. The answer to the question ‘where does this community end?’ is different from moment to moment, and the periphery of the community cannot be mapped. In addition, while it was clear from the beginning, I would be able to have some level of access to

core development, researchers and local developers, the level of access was unclear. However, as mentioned in previous sections, boundaries in infrastructuring studies need to remain open and are likely to emerge as the research design unfolds.

In addition, in selecting a case for study, naturalistic researchers value cases based on the way they are interesting in their own right. My interest in the HISP case emerged from the way it had proven to be a unique approach toward creating sustainable ICT4D implementations in the past and a unique example of a large-scale information infrastructure in an ICT4D context. In addition, the boundlessness of the case that was selected is part of what makes it an interesting topic to study. In line with a naturalistic inquiry (and an ANT ontology) my aim has not been to find a representative case from which to generalize findings to other, similar individuals or groups – networked ICT4D is unique the same way not one community is the same. However, the idea behind this design is that the development of interpretations and local theories that afford deep insights into networked development this particular case will be of use in developing an understanding of how networked ICT4D may benefit the sustainability of development solutions.

4.2.2 Unfolding Research Design

This research is a longitudinal study which covers a period of 3,5 years of naturalistic engagement in various parts of the HISP network. The first stage of my research focused on exposing myself to the field. This process started almost immediately, as a result of me being a PhD. student on the project in the same department where the core team of the project was located. In addition, especially in the beginning of the research, I tried to make myself useful within the project as a way of familiarising myself with my research settings and identify informants. One could say I applied a ‘drag-net’ approach with the intention to learn as much about the HISP network, its actors, and its inner workings as fast as possible. Still, this stage took considerable time, which in part had to do with the way funding available to me was limited to conducting approximately one field trip a year.

On the other hand, being located in the University of Oslo provided me with opportunities to compensate for these limitations. For instance, I worked together with the community coordinator on the development of the online academy and onsite-DHIS2 academy related processes. I was also part of the brainstorming concerning community activities; and plans to furthermore mobilise community members. During this stage, I also participated in meetings in relation to the project

with stakeholders or with the core team and was involved in teaching and supervising MSc students from the project. This enabled me to delve into the history of the network, its infrastructure, present challenges and tensions and gain insights into the culture and work-ethic. In doing so, I adopted a range of methods to collect data that included observations, interviews, document analysis, and triangulation.

My first two publications (Fruijtier and Pinard 2017, Fruijtier, 2017) emerged from this phase and enabled me a provisional understanding of the phenomena I was trying to pursue – from which I could select my sites more strategically. This aligns with a ‘multiplication of sites’ approach recommended by Karasti and Blomberg (2018) and enabled me to determine which aspects of the networked phenomena would be especially interesting in getting a fuller grasp of these processes at large. This led me to select 4 cases – three of which made it into this thesis for reasons I will discuss in more detail in section 4.3. An overview of data gathered during the exploratory phase of the research is provided in table 1.

Table 1. Overview exploratory phase

Field site	Data collection	Gatekeepers	Outputs generated
Expert Academy 2015	Participatory observations of presentations and discussions, interviews with participants and UIP developers	Community coordinator	Informal interviews, Field notes, community exercise
Trainings, meetings, presentations at HISP UIO 2015- 2017	Participatory observations	Various HISP UIO members	4 formal Interviews, Participant observations
Academy Zambia 2015	Participatory observations and interviews	Community coordinator	8 Interviews and field notes, video
Field visit NGO Zambia 2015	Observations, informal interviews	Various HISP UIO members	Field notes, photos
Online Academy 2015-2016	Participatory observations of the process, the platform, and materials	Online academy / Community coordinator	Field notes
Academy Vietnam 2016	2 weeks were spent at a regional DHIS2 academy, organised by HISP UIO and a southern HISP node	HISP UIO researcher, HISP Vietnam staff	10 interviews
Field visit HISP node Vietnam 2016	Observations, formal interviews	Director HISP Vietnam	7 interviews, field notes, photos
Expert Academy 2016	Participatory observations of presentations and discussions, interviews with participants and HISP UIO developers	Community coordinator	Informal interviews, field notes
Expert Academy 2017	Participatory observations of presentations and discussions, interviews with participants and HISP UIO developers	Community coordinator	Informal Interviews, field notes
Total number of interviews exploratory phase:			29

While exploratory data collection continued, I gradually entered a new phase in which my broad interest in the network (and strategies to access happenings across the network) narrowed to specific processes that I wanted to study more closely. I had established a broad idea of the roles of various actors (action researchers, local developers, global developers, consultants, funders, local ministries):

- It had become clear to me the role of (action) researchers was important in the processes I was interested in and changed over time; however, I did not know exactly how.
- It had become clear that how the core team managed flexibility of the core changed over time and that this had become problematic for some local developers (and the representation of ministries) as funders had become more involved. However, the extent of this was unclear.
- I knew some local ministries depended quite heavily on either local or global developers, however, I did not know how these relationships unfolded and what this implied in terms of capacity.
- I knew that within the network the emphasis of creating flexible applications on top of the platform has increased, however, my data of whether local developers managed and how was fragmented based on the explorative nature of my methods thus far.

I needed to understand how all these roles as connected in creating sustainable, locally adaptable solutions. I also realised I needed to emerge myself more intensely in certain parts of the network; from visiting local academies and training events in Oslo and abroad and talking to developers about what they did, I needed to spend time with developers outside of these ‘unusual’ high-intensity settings and see them in their somewhat more natural working environments. As a result of my previous engagements and contact with key informants or ‘infrastructural allies’ (Beaulieu 2010), I was able to identify and utilise 4 opportunities to generate more insights. Table 2 provides an overview of how observations and questions that emerged from the exploratory phase were explored in more depth in the form of case-studies. In the following sections I will elaborate on these relationships in more detail.

Table 2. An overview of the research approach

Exploratory phase		Case-study approach	
What did I observe?	Questions this raised:	Cases selected	Rationale:
The role of (action) researchers was important in the processes I was interested in and changed over time	What was the role of action research and how did it change over time?	A retrospective study on DHIS2 in Sierra Leone	<ul style="list-style-type: none"> • Influential case in scaling of DHIS2 • Longitudinal action research endeavour and insights in what happened after action researchers left • Example implementation that did not give rise to a local team of developers
		A retrospective study on DHIS2 in Tanzania	<ul style="list-style-type: none"> • Longitudinal implementation of DHIS2 that was started as a result of action research involvement
How the core team managed flexibility of the core changed over time and this became problematic for some local developers (and the representation of ministries) as funders had become more involved.	What influence do local developers have on core development processes and what is the influence of funders?	Participation in the Roadmap Advisory Team Pilot	<ul style="list-style-type: none"> • Collaborations of a select group of local developers • Communication of the core developer team • Process through which features are selected, prioritised and implemented
Local ministries are reliant on either local or global developers for the implementation and development of local DHIS(2) instances.	How do these relationships unfold and what does this imply in terms of capacity?	Shadowing HISP implementers on a field trip to Asia	<ul style="list-style-type: none"> • Everyday practices of local developers in implementing a local instance, training users and identifying and negotiating user needs as part of a funded project
		A retrospective study on DHIS2 in Sierra Leone	<ul style="list-style-type: none"> • Sporadic support available to local users affecting an implementation over time in the absence of local capacity and a challenging funding climate
		A retrospective study on DHIS2 in Tanzania	<ul style="list-style-type: none"> • Challenges of local developers in supporting local users over time in a challenging funding climate
The emphasis of creating flexible applications on top of the platform (in response to reduced flexibility of the core) had increased	(How) are local developers able to create flexible applications on top of the platform?	A retrospective study on DHIS2 in Tanzania	<ul style="list-style-type: none"> • One of the few local developer teams involved in creating applications that are generic enough to feed them in to the DHIS2 Appstore for others to use.

1. Shadowing HISP implementers on a field trip to Asia

The exploratory stage of my research had among others flagged issues with decision-making processes. At the same time, opportunities of technical mediators in representing users as part of these community structures were identified. This sparked an interest in understanding this representation more deeply. Hence, I initially entered the field with a rather open question; ‘what does user-representation look like?’ and a keen eye for possible restrictions as well as opportunities in the user-representative relationship. Aiming to understand the representation of users by designers, detailed observation and careful analysis of everyday work practices of designers and users as they interact was particularly important. For this, I identified an opportunity to shadow (Czarniawska, 2014; Weick, 2003) a HISP UIO researcher, consultant and 2 members of a regional HISP node for 5 weeks during a DHIS2 training and a field trip visit.

During this period, 2 weeks were spent at a regional DHIS2 academy, organised by HISP UIO and a southern HISP node, that hosted among others 15 participants from the organisations. 3 weeks were spent in the field with the Ministry of DC and one member from the Ministry of HMIS. Of these, I spent 2 weeks with 3 developers /implementers (1 HISP UIO, 2 HISP Vietnam); 1 week with two developers, of which one was part of the first group (1 HISP, 1 HISP Vietnam). 2 days were spent at a training with a local NGO. This field trip produced 2 notebooks of field notes, a diary and a series of pictures.

One problem with this case from a data collection point of view was that – while I obtained rich insights in the work practices and challenges of implementers and their different practices and relationships with ministry clients, I only had access to a ‘snapshot’ of the nationwide implementation process. These limitations are discussed in more detail in section 4.3.1. As such, I still needed to understand the sustainability of their efforts over time.

2. Conducting a retrospective study on DHIS2 in Sierra Leone

The Sierra Leone implementation of DHIS2 involved an early nationwide implementation of DHIS2 and had an important influence on the development of the network as well as the platform itself. Studying this case gave me insights in the role of action researchers; how these early implementations helped develop the network as a whole, and the challenges of maintaining local implementations when action researchers (or other DHIS2 experts) leave. While I did not have the opportunity to travel to Sierra Leone myself, I collaborated with a fellow researcher from HISP

UiO who had been involved in the early implementation of DHIS2 in Sierra Leone and was interested in piecing together what had happened and how these efforts could be understood retrospectively.

The primary data for this case was collected by my co-author in paper 3 between 2007 and 2011, during a total of 13 weeks spend in Sierra Leone across 6 separate visits. The data collection methods applied were varied, but mostly of a qualitative nature and focusing on understanding and improving health information systems in Sierra Leone (as reported in more detail in Sæbø 2013). This involved collaborations with a team consisting of three Sierra Leone nationals at the MoH as well as other action researchers and practitioners in the field of health informatics, which engaged in a participatory development process with health programs, district staff, and numerous NGOs to completely revamp the Sierra Leone health management information system. Activities covered amongst others a 6-week intensive training for 26 people and field visits to district offices, health clinics, and different departments at the Ministry of Health and Sanitation (MoH). A multiplicity of methods was applied, including informal and semi-structured interviews, observations, group discussion, and document (especially health data collection forms) analysis, as typical of AR projects.

Analysis resulted from collaborative sessions in which both authors attempted to piece together developments of the client system in Sierra Leone and its interaction with elements of the networked infrastructure surrounding DHIS2 after the researchers had left. My co-author has visited Sierra Leone at four later occasions (2014 and 2016-2018) for one week during our collaboration, related to the earlier work but not directly linked to it (crucial in this regard is the typical situation of a different funder/budget). In addition to secondary data, informal interviews were held with 5 informants (2 HISP node members, 1 HISP UIO consultant, 2 members of an NGO) and the DHIS2 user list (used for communication between HISP consultants and DHIS2 users) was analysed to identify activity specific to the Sierra Leone case.

Nevertheless, this case was limited by challenges we experienced in piecing together information of the period between 2011 and 2016, given organisational memory had been lost locally, projects had ended, and actors involved had moved on to other organisations. This was a significant insight in itself, because it illustrated how pilot-based involvement of NGO's complicated the development of organisational memory. This is discussed in more detail in paper 3.

3. Participate in the Roadmap Advisory Team Pilot

This case covers the pilot phase of the RCAT initiative from May 2017 until October 2017. During this period, I held several interviews with representatives from all members involved in the RCAT initiative (a representative of each HISP node that had at that point entered or was in the process of entering an MoU with UiO). I also had minimal one briefing meeting with the RCAT secretary; I tracked digital communication, discussions and activities undertaken by RCAT members; activities undertaken in relation to RCAT requirements on Jira (a software development tool used to coordinate the DHIS2 design process). I furthermore participated in 2 events attended by RCAT members since the introduction of the RCAT and attended 2 RCAT meetings and 1 skype-call between the RCAT secretary and the lead developer of DHIS2. This case produced 11 informal interviews, a collection of field notes, research diary segments, and an extensive Excel document which traced requirements suggested by different members during different stages of the process and their follow up.

The roadmap advisory team initiative by management at UiO proved a very visible, contained opportunity to study how the core team and management responded to challenges which had been bubbling in the network. These challenges concerned access to the innovation process by local developers, through which DHIS2 could be improved. The RCAT initiative meant to give local developers a venue to channel use requirements in addition to pre-existing venues and mechanisms to do so. The need for this initiative alone illustrated that the option of building ‘on top of’ the platform was not enough for local developers to make DHIS2 instances work locally. By studying the first pilot cycle of the RCAT requirement process, I gained insights into the nature of the previous challenges. The interview process, observations as well as interpretation of the data benefitted from previous experiences when I studied the work practices of local developers in Asia. My role in this initiative was mainly that of an observer, and occasionally as a soundboard for the RCAT secretary who was both an informant as well as a gatekeeper during the research. This was done with the knowledge that negotiating meaning is an important element of a naturalistic inquiry and given the RCAT secretary was also a researcher on the UiO project. Importantly, such conversations focused on generic findings and impressions and the confidentiality of participants was prioritised throughout. In one instance, this may have influenced the course of the RCAT initiative. This was when I identified a need among RCAT members to see more involvement from

the core developers' team. After communicating these findings with the RCAT secretary, a meeting with the core developer was arranged. It is unclear to what extent this would not have happened otherwise.

4. Conducting a retrospective study on DHIS2 in Tanzania

This case involved a 3-week visit to the UDSM Tanzania node in February 2018. The visit involved an intensive 2-day exercise with four senior members of the team and combined workshop elements with focus group discussions. In addition, interviews were held with members from HISP Tanzania team and with various ministries and partners. One partner presentation was attended, and one field visit was made to a district official and lower level user of the system. This case produced 11 formal interviews, a focus group document (developed by participants), a series of field notes, pictures and a timeline.

The opportunity to study the DHIS2 implementation in Tanzania over time was a way for me to contrast both what I had learned from the Sierra Leone implementation, as well as the RCAT initiative. The Tanzania case was an example in the wider network of a strong local developer team that successfully managed to sustain and locally adapt a nationwide DHIS2 implementation over time. Having a clear idea of the daily work practices of implementers from my trip to Asia; understanding the challenges of negotiation changes to the DHIS2 core platform; and the limited capacities of ministries to maintain DHIS2 implementations in the absence of local capacity enabled me to understand the role of local developers in sustaining a local implementation of DHIS2 in relation to all the previous insights and scenarios. It was at this stage I considered my multiple case approach could be finalised.

4.2.3 Interview Process

I conducted the following types of interviews (Lindlof and Taylor, 2002):

- a) Ethnographic (informal and impromptu questions posed in the field)
- b) Informant interviews, whereby I had (repeated) conversations with experts whose particular knowledge helped me make sense of what was happening in the field
- c) Respondent interviews where I asked participants to share their own perspectives and experiences

In the early, explorative stage of my research, I relied heavily on informant interviews with experts and users to gain insights in their practices, challenges, roles in the network, relationships with others and the software. These interviews were predominately located at expert and regional academies, and the University of Oslo (either during events or in offices). Later in the research, I had witnessed many of the topics that came up during interviews with my own eyes (as I will discuss in section 4.2.5). This allowed my interviews to become more informal. At this stage, I had met many of my informants several times, and I was able to ask more in-depth questions as we travelled together or focused on specific challenges and cases (such as during the RCAT). These varied from ethnographic interviews as well as respondent interviews – some of which occurred as a result of co-authoring with key informants (I will come back to this in section 3.3).

In total, I conducted 56 formal interviews (figure 4). Notably, some HISP nodes were interviewed several times (for instance, I interviewed members of the same HISP node in Zambia, as part of the RCAT and in Vietnam). Occasionally, an interviewee had multiple roles (for instance, a member of a HISP node was also a member of the core team) in which case only one of these roles was counted.

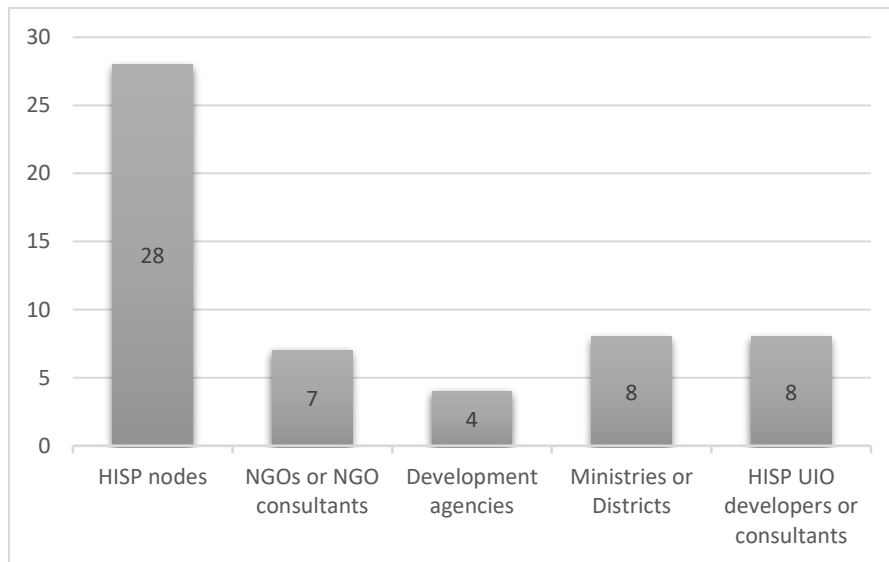


Figure 4. Number of formal interviews

Most informant interviews were recorded. I would listen to interviews multiple times. In the beginning, I would transcribe all the interviews in full. I would code the content of the interview which helped me absorb and filter through a large amount of data that I was not yet able to process based on field experiences. An example fragment of an interview I coded is provided in table 3.

Table 3. Example coded interview transcript

Transcript:	Descriptive/ N-vivo code:	Value code:
<p>I am not sure exactly of the time, but it goes back to 2008, early, I'd say... At that time, well. Of course, before that I was working for HISP [country x] I was on the team there... and the requirement was to collect data in smaller, in break ups or what they call multi-dimensional.....(...) Or to put it the other way, earlier DHIS was collecting like... to give you an example, how many people have malaria or how many are vaccinated for ...(...) type a or something like that. There was no way to get... if you say a hundred people are vaccinated, how many of them were male? How many female? Out of the male, how many were under the age of 5 or this kind of break up. There was not that feature -back then. So, this was needed for [country x], it was important for [country x] so I just did that... and then I joined the PhD. team.</p> <p><i>So, you already developed something for HISP [country x] that was able to capture more details, more break ups [yeah] Did this have a name? this feature?</i></p> <p>It is called multi-dimensional module of DHIS... it's part of data entry but... we just gave it multidimensional, the name... Earlier it was just one dimension... so I just did that and then joined the PhD. That time I first....The topic for the proposal I submitted was to take DHIS to TB, malaria, HIV, ...because earlier it was just aggregate figures so my ambition was to make it for different scales like TB, malaria... and then while I was in this process, and of course multidimensional was being implemented in [country y], I went to [country z]. In [country z] we ...they were all kind of... looking for a system that helps them to eh... track what kind of service is provided.</p> <p><i>'Who was they? HISP [country z]?'</i></p> <p>Yes HISP [country z], different states. Because [country z] that time DHIS was in ... I could be wrong with the numbers, around 20 or something states so some of the states were looking for assistance like that. In one of the states I was talking to the health extension workers and they were – we were providing a demo to them and they were telling me ‘ yeah, fine you have a good system but what I want is a system that tells me when is the due date to my pregnant women?’ meaning they were looking for a system that helps them track So that was another... you know, push and then... I started to... my PhD. was also there, and then I had already started working on the break ups [multidimensional]... and then I ...also went house to house with the health extensions worker and what I noticed back then was that the health extension worker, in the first three weeks of the month, she got house to house and then (...) do the name, what is provided, when... and the during the last week of the month, she has to sit in the office and to tally. After she did tally, then she had to put that into dhis2. So that was quite a lot of work for her. And then during the last week was very stressful for her because she has to generate, make the report ready, in just one week... something she had been working on the whole month. When I – this was again another push for me to go further.</p>	<p>Time > 2008 Job > HISP country team Tasks Feature development 'Multidimensional' details Country need > country x Job change > PhD Naming PhD. topic (different) scale Multidimensional implementation Shared need HISP country z Communication Health workers Demo Feedback Need health workers 'another push' motivation PhD Previous work experience Observation workpractice Observation interpretation/ findings 'a lot of work' 'stressful' Time constraint 'Another push'</p>	<p>(potentially long) Process Job function HISP country team requirements > identifies needs Country need (related) > origin need identified PhD. acts as catalyst Country Z shares needs identified Collaboration HISP network Health workers share need And are enabled to articulate this need 'push' seems to refer to - confirmation of the relevance of need identified across various actors: 1)Dev-requirements (scale, need for details) 2)Health worker requirements 3)Accumulation/confirmation of shared needs across network + accumulation of exposure and skills</p>

Legend: Design related/ Job/Role related /Process related/Related to needs/Related to motivation/Related to network/ Approach/ Method

As I moved out of an exploratory stage (which had felt as if I was trying to make sense of an entire network all at once) I became more comfortable with the content of interviews and processing interview data came more naturally. I no longer needed descriptive/NVIVO coding in order to identify value-codes in the form of fieldnote reflections taken after conducting interviews and after listening to interview recordings or reflecting on interview notes. I also began to understand the value of what was often not said in interviews.

In part, this shift had to do with the way participant observations and triangulation became increasingly central in my work as the research progressed and interviews became of a more informal nature. I will discuss this more in section 4.2.4. This shift also made up for some of the limitations I experienced using interviews (I reflect on this some more in section 4.2.5). An exception was the Tanzania case, where conducting multiple interviews with different actors was essential to construct a timeline as well as to triangulate perspectives on what had happened and why. The very ability to apply such triangulation in retrieving organisational memory in Tanzania had everything to do with the presence of a local team – which for instance was not the case in Sierra Leone and made organisational memory was lost when key actors in the project left their positions (and therefore what had happened over time was much more difficult to reconstruct).

4.2.4 Observations

I have conducted several types of observations throughout the research in different contexts, which I will elaborate upon in this section. I have conducted these observations with various motives. For instance, during DHIS2 academies, I was primarily interested in the information and message being presented to the participants from representatives of the organisation; the role of experts (core team, champions and HISP nodes); the dynamic between participants and experts as well as each other (especially feedback); the types of participants attending academies and their skill levels. I was also interested in how the environment was created around certain objectives (for instance, enabling group discussions). In some instances, video-recordings of presentations made for the organisation were accessed and used in support of observations made directly.

During meetings of the core team or key informants, I was both interested in their focus and developments, as well as their challenges. Documents and other material outputs and interviews would be used to further reflect upon these observations, and the other way around interview data made that I was especially mindful in the field to observe dynamics or aspects mentioned in

interviews with my own eyes. During field visits, I would keep a diary and take notes of my environments and encounters. An example of one of the field notes that I turned into a vignette is shown below (image 2).

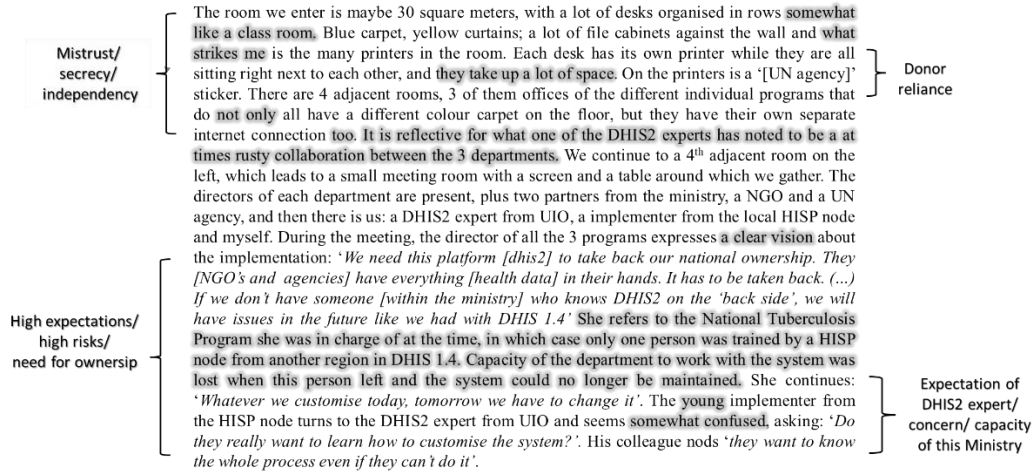


Image 2. Vignette

In this vignette, I have highlighted my own interpretations to contrast the thoughts that occurred to me about the scene from what was directly observable. On the side, I noted down what a scene told me about the phenomena I was studying. Observations during field visits also included learning about the culture and the country. For instance, the power cuts at my hotel room; experiences like chatting to taxi's drivers (image 9) or watching local tv (image 10), getting tired of ordering the same breakfast every day; the noisy construction work that was done right outside the hotel in the middle of the night; the trouble it took to find an electronics shop and buy a wireless access point; unwinding with the DHIS2 implementers at the end of a long day with a drink or a chat.

These observations were not data that would go into my research, but experiences that helped me relate to the participants and enabled me to understand better what it was like for the DHIS2 implementers to spend time away from home and in foreign countries as part of their jobs. An important part of my fieldwork occurred in taxi rides from and to sites in which I was able to pick the brains of DHIS2 implementers about their expectations of the day or how they felt after the previous one. Sometimes it was also an opportunity to pick the brains of taxi drivers themselves, or even fellow passengers. One day, I shared a taxi-ride with a lady from an NGO who could tell me a lot of about her experiences with end users without me having access to them in this country.

Another taxi driver would regularly drive members of the ministry and was able to tell quite a lot about their living conditions and what life was like in general. For instance, how difficult it was to find the main hospital even though it was the largest in the country. Upon telling us, he was able to drive us there to show us.



Image 3. Taxi rides during field visits

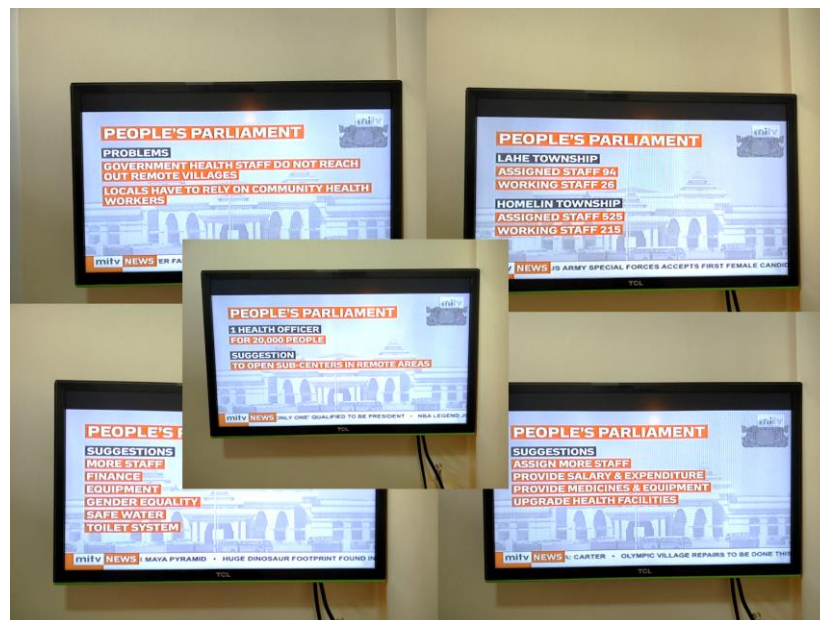


Image 4. Watching local tv in my hotel room

Oates (2006) points out several ways in which being both a participant and a detached researcher can be challenging in conducting research. Not only is there a constant search for a balance between reminding participants you are doing research, and the intention to observe ‘normal’

practices without disturbing or influencing these with your presence. There is a tension where on the one hand, you want people to know why you are there, and on the other hand, you also need them to forget.

For example, although I would introduce myself in most cases (with exception of some instances where situations unfolded spontaneously), participants of DHIS2 academies came to participate in a training and must have quickly forgotten about my presence and I would not want it otherwise; they had paid a lot of money to be trained in the software and this should be their primary experience. By discussing my research interests and objectives with the coordinator of the academy and wider community, and making this collaboration known to participants where possible, I have attempted to make use of the established trust between participants and the organisation and minimise any risks from or concerns about my interference.

There is furthermore a risk that the ‘strange’ (or new) becomes familiar, and constantly attempting to see yourself as well as their organisations as others would (Oates 2006). I have attempted to cope with these challenges by consulting my supervisors about this; seeking different and especially critical perspectives from colleagues or peers less involved in the project (in a similar or significantly different role) as well as reflecting on my own process throughout the research. In line with Oates recommendations, I have attempted to take verbatim quotes as much as I could which helped me to remain close to what was expressed (rather than my own interpretation of it), however, to incorporate these in publications was difficult due to space limitations and the complex, layered nature of the topic. I have furthermore applied triangulation by comparing what I observed and my interpretation with similar situations or other forms of data, and or by discussing the observation with key informants.

For instance, I noticed during a regional DHIS2 academy there where primarily Monitoring and Evaluation (M&E) staff, program managers and technical people present. I would then look at the participant list to see if this observation was accurate and compared this to the participant lists of several other academies. I would talk to the experts (trainers) to hear their experiences in comparison to other academies, and how the distribution of professions and skills in the audience had an influence on the program and compare this to my own notes. Back in Oslo, I would reflect on my understanding with the coordinator of the DHIS2 Academy I attended, to find out to what extent the observed was ‘common’ or unique for this academy. I would also compare this with a

feedback report on the DHIS2 Academy shared by one of the experts and follow the email responses from other trainers that followed from it. In this example, my discussions with key informants, their opinions, and reports functioned as triangulation for my data, while it was also part of my overall research observations.

Given the above, I ended up conducting many different types of observations. I have observed groups and various kinds of meetings, whereby my role as an observer varied both in length as well as between being known and somewhat unknown. In the last case, although all my key informants were aware of my presence as a researcher, they may not always have remembered this during discussions as relationships became more familiar and I experienced in some instances that I became ‘part of the team’. This experience was a reason for me to put in place an extra form of triangulation, by asking key informants to act as a representative of the ‘expert community’ in reading my publications. Here, my publications acted as a medium through which I could triangulate my interpretations of the data.

4.2.5 Research Roles

As evident in the previous section, I have taken on primarily two roles as a researcher: one as a *participant-observer* (studying people as they go about their work practices, for example during the training academies). However, in most cases, I have been conducting this role of a participant – observer as a *practitioner-researcher* (Oates 2006) (as discussed in section 4.2.2). The immersed nature of my role as a researcher may have had a limiting effect in one-to-one interviews with external actors who somehow depended on their relationship with the organisation I was deeply immersed with. These actors may have been less open with me in their responses as a result. At the same time, my involvement enhanced the quality of my interviews because increased my knowledge of complex and challenging interview topics. But perhaps most importantly, it helped me to move past the limitations of the interview method.

A professor from UIO and developer within the project captured this as follows during our discussion about the value of interviews: ‘*When you interview people from HISP because there are also so many publications and they are heavily involved in the theory and publishing, there are some difficulties in getting some new sort of interesting ‘real’ stuff. Many people will sort of say what they write about too.*’ A participant-observer role helped me get access to ‘the real stuff’ by allowing me exposure to multiple perspectives. For example, during an DHIS2 academy, there

would be a slide on the architecture of DHIS2 in which the development process is portrayed as very systematic, straight forward and linear. When experts were discussing the same architecture among each other, they would perceive it to be much messier, organic and chaotic. For instance, in one meeting a participant described the architecture of DHIS2 '*much like a mud house. [Core developer] is always trying to fix things and some of it is somehow always escaping*' while making movements with his hands as if he was trying to hold together a mud house whilst other experts in room responded slightly entertained and were in silent agreement. When written about in a paper later, the same model would often appear quite linear and neat again.

4.2.6 Analysis Process

In a naturalistic inquiry, grounded and emergent theory is preferred over a priori theory. Therefore, 'all theory should be grounded at some stage before it is applied' (Lincoln and Guba 1985 p.16). This suited my aims to understand networked development in an ICT4D context, and each theory I came across that could help me understand specific aspects of networked development had to be 'tested' based on my data. This mosaic emerged from the data; the way one paper emerged from the previous one. The question that underlies the use of each theory is: how does this work in this context?'. As a result, I found out more about generification processes in ICT4D, collective action in ICT4D, action research in ICT4D and bricolage in ICT4D – all of which together taught me more about the phenomena of networked development. Ultimately, ANT offered me the right tools to move beyond such fragmented understandings and discuss what I had observed about this phenomenon in a holistic way.

The writing process was an important part of generating findings and tracing the borders of my research. In naturalistic inquiry, the researcher is considered the primary instrument (p 16). In my case, the writing was a primary instrument for my own process as a researcher. In particular, the writing process helped me to continuously go back to the overall picture and keeping an eye on how the different pieces fitted (or failed to do so) in relation to each other. This puzzle did not fall naturally together in the end. Instead, one piece emerged from the other.

Another challenge is the question naturalistic researchers must ask themselves of 'whose constructed realities are the right ones?'. Applying Actor Network Theory as an analytical lens (elaborated in chapter 4), I was forced to recognise my work was also 'a translation'. This also meant an acknowledgment that things could always be otherwise and there is not a single 'truth',

as every truth is a construction that can also be reconstructed. This matches the notion in a naturalistic inquiry that the constructed reality of the researcher can never be fully shared, as the researcher can furthermore never fully escape his or her own view. This also aligns with recommendations from Karasti and Blomberg (2018) in constructing the field.

In dealing with this challenge I have attempted to gather as many different realities as I could. I have attempted to expose myself to bits of reality from researchers; PhD. students, several kinds of users, funders, NGO's, both those who cheered and those who critiqued the undertaking I was studying. In addition, I gathered documents, video's, theses, training material – any material that could provide me with a 'slice of life' from the context that I studied. This matches the way a naturalistic inquiry proposes that all aspects of a reality are interrelated. I did not combine them to identify a cause and effect relationship, but to understand what common meaning they could provide without considering such meanings generalizable.

Sharing these constructions is furthermore considered essential in naturalistic research. This means the naturalistic researcher must develop constructions that are compatible with those whose setting is being investigated, and also the study's intended audience (Erlandson, 1993). In order to share my constructions with those whose setting I studied, I had regular consultations with key informants; peer debriefings and member checks (Lincoln and Guba 1985 p. 31). My publications also became a forum for this exchange. In addition, I made it a strategy early on to involve research participants or informants as co-authors. I also deliberately made sure that 2 of my publications were directed at practitioner audiences (Fruijtier 2017 and Fruijtier and Senyoni, forthcoming).

4.3 Ethical Considerations

The research design was assessed by the Norwegian Social Science Data Services to ensure data gathered that might contain person-sensitive information would be handled, stored and transferred correctly. In addition, to protect participants from harm, I made sure that I discussed my research plans and interaction with participants with both supervisors as well as key informants who had experience within the field and with the participants I would meet and interview. For respondent interviews I always asked written consent; with exception of cases where those mediating access for me could make it explicit consent had been negotiated pre to the interview (for instance, in Tanzania, where officials could be reluctant to sign forms and therefore consent was obtained verbally or via email exchange pre to the interview). In a rare number of cases when I strongly

suspected informed consent was not obtained (for instance because the level of English of participants was too limited) interviews were not recorded and I would merely take down field notes about my experience of the interview.

Where appropriate, I would offer key informants to work together with me as co-authors (this was facilitated by the way the project at the heart of my study was a university-based initiative). These co-author relationships were not only of benefit to the quality of the research findings and the research process, they also helped ensure publications would not cause any unintentional harm (without compensating research outcomes). In addition, these relationships were also of benefit to the co-authors who had acted as key informants. As a result of co-authoring, they often enjoyed being challenged to reflect on the ‘familiar’ as well as experience reciprocity. In Tanzania, I furthermore made sure the research was valuable to the hosting organisation – that could use the research as an opportunity to announce a follow-up event with its partners in the Ministry. Partners were informed research findings would be distributed during this event, which would furthermore offer the organisation an opportunity to celebrate their work, share it with partners, and strengthen relationships.

During my field visit to Asia, I had explicit consent to shadow DHIS2 experts who would work with several clients and whom I relied on to negotiate access for me with their clients. The government of this country was the largest client of these implementers during the period I was there. However, what I did not know until I arrived, was that very few arrangements were in place. It became clear to me that the nature of the implementation work itself was of such an ad hoc nature, field visits to clients and plans were subject to sudden changes and clouded in uncertainty. I had met with one key government official from this government during a DHIS2 academy in addition to 15 other partners we expected to work with during the field visit scheduled to this country (which happened a week earlier than planned and was cut a week short too). During this meeting, my visit to the country was agreed. However, upon arrival, I was also aware that not all government officials we met were aware of this agreement.

For instance, it was not always clear whether those present in meetings had been made aware of my role or whether such an introduction would have been appropriate. As such, information about my role and my introduction were often based on the knowledge and judgment of the implementers I shadowed whom negotiated my access. For them, this was equally complicated.

I noticed that some of the DHIS2 implementers I shadowed deliberately introduced me as ‘University of Oslo’, leaving out my role as ‘researcher’. As it turned out, government officials of this government tended to be quite suspicious of working with foreigners and Westerners in particular, which already caused some difficulties for the implementers in doing their jobs. They, for instance, explained to me that drawing attention to the fact a Western researcher was present would have increased this distrust and I realised this could make their work even harder. Explaining to these officials that the investigation would not focus on their case per se (but on the work of the implementers) could have been an option, but in this case could also easily have damaged their sense of pride. In addition, meetings with these officials would ‘happen’ suddenly and often unplanned as a result of many factors (an experience which, from an ethnographic point of view, was valuable in itself).

I would participate in these meetings when they happened because I reasoned the focus of my data collection was on the work practices of the implementers, how they dealt with challenges, and not on the challenges of working on a specific case per se. I considered working with such governments that could be suspicious to Western or foreign consultancy was nevertheless an important part of their work which was often of a cross-cultural nature. I also considered focussing on the work practices and not on the details of this case would make that data gathered did not contain any sensitive content. In addition, it was incredibly hard to wrap my head around the specific circumstances of the work over a very short time-span, and every meeting helped me piece together a richer picture of what their work involved and how different aspects of it were related. At the same time, in piecing together his puzzle I lacked the ability to openly interview government officials in my role as a researcher to learn more about their perspective.

In response to these dilemmas, I made sure to keep a low profile, not to make any notes in meetings when discussions seemed tense and not to take pictures in which individuals were recognisable (except when permission was sought in advance or if it concerned a public event where taking pictures was appropriate). In some cases, the participants had the advantage that one of the implementers spoke the local language. As a result, participants would often switch from English to their own language and it was difficult for me to judge whether it was because it allowed them more privacy or whether it was simply easier for them. Having to depend on the person I was shadowing to also translate in these situations meant I could only ask questions about such conversations afterwards, which at times was complicated.

As a result of the previous challenges, I decided not to write or publish about this case and not to mention the country by name in this thesis. I tried to write about the case anonymously but soon experienced that I needed to draw on all my data in order to write up my findings properly. This included the parts that I felt I had gathered in the presence of those officials of whom I cannot say with certainty they knew data was being collected about them. However, even if I had done so, the absence of the perspective of this government as a client would have left important holes in the previous picture.

Alternatively, I could have chosen to completely focus on the implementer experience. However, I had grown much admiration and respect for the implementers I was able to accompany and doing so would have required a level of detail in my writing. I did not feel this was appropriate or part of their expectations in welcoming me to tag along. What made my decision not to write about this field visit difficult was that an important part of my ethnographic knowledge would remain hidden as a result. Not writing about what I learned also did not seem to value the time and energy of my key informants who had allowed me to shadow their working lives almost day and night. To compensate for this, I have constructed a ‘slice of life’ based on a 2-day training conducted during this field visit with a local NGO who was fully aware of research activities too and was happy to provide permission to take- and use pictures taken. This slice of life (see section 3.3) provides insights into the important role that DHIS2 implementers have in supporting local actors in using the system for their unique cases.

4.4 Limitations

Importantly, this study is also subject to limitations. First, while other levels were taken into consideration as much as possible, this study was limited by narrowing its focus on the level of third-party developers in their role of mediating between global and local processes of scale. A more in depth understanding of core development as well as the user experience would no doubt have been of tremendous value in this study. However, with the limited resources and time available, a focus on third-party developers suited the objectives of the study to explore this inter-dimensional aspect of scaling processes. Second, had other cases been studied in this network, different dynamics would have been revealed. Nevertheless, including additional cases would not have changed the way this study has aimed to contribute to the understanding of the dynamics that were identified and their relationship with sustainability.

Excluding the Asian case from my findings nevertheless posed a significant set-back. On the one hand, the secondary data gathered from Sierra Leone provided an important opportunity to complement my insights in the network without being in the ability to travel there myself. At the same time, a lack of first-hand knowledge of the case significantly limited my ability to interpret the data. Data analysis processes in this paper were restricted to a consideration of events to leave as little room for interpretation as possible. On the other hand, the ability to draw on the experience of a colleague who had much longer and wider exposure to processes within the DHIS2 network was also considered to in many ways increase the quality of this case.

Given these limitations, it is relevant to reflect here to what extent a naturalistic inquiry suits the study of II. Whereas entering II research with an ‘open mind’ is important to find out what aspects generate further interest, this will generate a lot of side themes (that will not immediately reveal themselves as side themes as they appear) which can be considered a downside. Consequentially, much time is spent picking up these themes, walking around with them for a while in efforts to ‘feel out’ the main phenomena of interest. Not only can this process be quite stressful in nature, you can end up spending a lot of time searching for this relationship before concluding it does not belong in the ‘core box’ of themes worth pursuing. That said, as stated by Karasti and Blomberg (2018), II phenomena will always be too large to produce ‘truthful’ representations (which from an ANT perspective would be considered the case in any research regardless of a phenomena’s perceived size and scope). As such, any II inquiry - including this one - will always be limited in that it will present a collection of interesting interrelated facets that say a little about a lot, and hopefully, a lot about a little.

4.5 Summary

In this chapter I have presented the research process which was undertaken for this study. It outlines the rationale for the selection of a naturalistic inquiry approach and explains how this led to an emergent study design which can be characterized by longitudinal engagement in various aspects of the HISP that can be broadly split in two phases. These consisted of an exploratory phase that led to on the selection of a number of cases where explored in detail. Research decisions are explained, including the process of selecting the previous cases, the gathering of insights through a series of observations and interviews and my own role in this. I outline the process which was followed in order to triangulate data as much as possible through peer debriefings, member

checks and close collaboration with gatekeepers. However, the chapter also accepts that these accounts could only be presented through my own interpretations and discusses the role of my analytical lens in this regard. The chapter concludes with a consideration of ethical issues and limitations of my approach, which I use to reflect on the wider applicability of a naturalistic inquiry approach to study II phenomena. The next chapter will take a closer look at the various dynamics and characteristics of the information infrastructure I have studied as it evolved and scaled.

5. Case Description

This chapter aims to provide an historic overview of both technological transformation as well as changes in the organisational structures around DHIS2 as it scaled. This is important because DHIS2 did not start out as an information infrastructure. Neither did it *become* an infrastructure: it was *infrastructured* by different actors, following different events and decisions over time. My attempt in providing insight in this infrastructuring process will focus on the development of ‘DHIS version 2’ (also referred to in short as DHIS2). However, it is important to mention that DHIS2 was preceded by a DHIS version 1 (‘DHIS1’).

The development of this first version of DHIS was initiated after the fall of the apartheid system in South Africa as a joint action research project between UiO, University of Western Cape, University of Cape Town and the Ministry of Health in South Africa. This collaboration happened under the HISP and was motivated by a shared goal to turn the fragmented and centrally governed health services inherited from the apartheid into integrated and to some extent locally governed health services that would serve a new South Africa. Following participatory approaches whereby designers closely collaborated with health practitioners in the field, a desktop based DHIS was developed and, over time, successfully implemented. This success led to the formation of a South-Africa based NGO to support the implementation, as well as an export of DHIS1 to other countries.

In the remainder of this chapter I will discuss the scaling process of DHIS2 and the tensions this created in terms of its flexibility. At various points in the chapter I will refer to the way scaling activities were approached around DHIS1 in comparison to scaling activities applied around DHIS2. I will also discuss the influence funding has had on this scaling process, which will become more evident in individual cases that are flashed out in more detail in chapters 6 and 7. I will end the chapter with a short ethnographic account of what the local implementation of DHIS2 entails.

5.1 How DHIS2 was Started and Expanded

In 2006, development of DHIS2 was initiated at the University of Oslo. DHIS2 was a web-based version of DHIS1 to only use open source technologies. As a result of this development, the main hub in the network shifted from South Africa to HISP UiO, who led the development of DHIS2 and secured funding for both action research and more implementing-oriented activities around DHIS2. The new DHIS2 software represented another big difference: It was web-based as

compared to the desktop-based DHIS1, and no longer primarily developed with one country in mind but sought to take in innovation and requirements from all implementing countries.

The experience and success of DHIS1 with its strong emphasis on capacity building and participation, as well as the ability of HISP to fund the implementation were essential in securing this pilot site (Puri, Sahay and Lewis, 2009). Following a successful pilot in Trivandrum district which was characterised for its participatory approach, DHIS2 was scaled up state-wide to all 14 districts.

This resulted in an accumulation of experiences from distributed yet relatively similar settings (such as Sierra Leone and Kenya) DHIS2 developers gained experience in creating a more and more generic software product. This was illustrated by Titlestad (2009) as illustrated in figure 5, in which ‘PD’ refers to a participatory design approach through which developers engage with users in customising the software to local conditions of use.

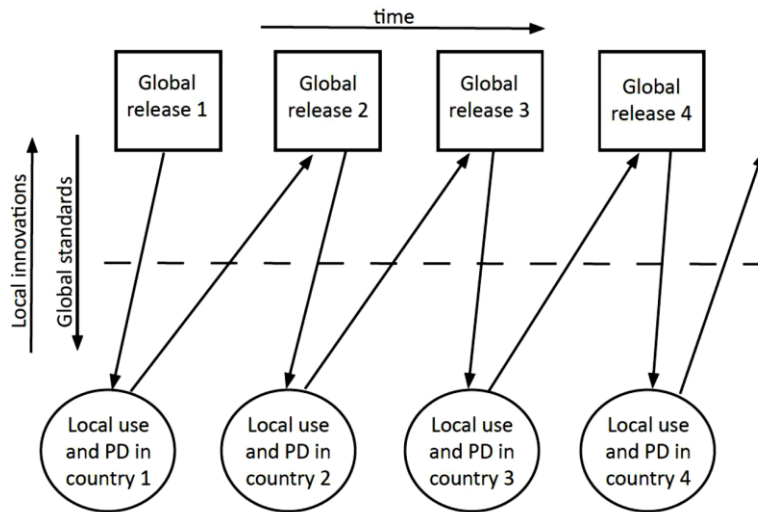


Figure 5. Participatory design approach in DHIS2. (Titlestad et al..2009, p. 42)

Gizaw *et al.* (2017) later conceptualises this process as one of ‘open generification’ through which core developers (in collaboration with local developers and researchers) develop novel innovations and features which they integrate into the core, based on specific use cases in various countries. Generification was coined by Pollock *et al.* (2007) to describe the identification of various user-requirements from vertical domains in traditional (non-open) software development. Specifically, generification concerns the process through which input from different user (or developer) groups of a product are channelled, filtered and prioritised to inform generic design features that work

across a diverse range of organizational contexts (Ibid.). Generification could thus be seen as the compromise reached as an outcome of negotiating between ‘particular’ and ‘generic’-, or ‘local’ and ‘global’ values. However, as the word ‘trade-off’ implies, this is not only a logistical but also a political process. Openness in Open Generification refers to the way all countries used the same open source code base to facilitate their use requirements. As a result of this practice, which was still to a large extent enabled by research funding and PhD. scholarships, DHIS2 slowly developed into a comprehensive toolbox.

The rapid growth of DHIS2 implementations began after Kenya implemented the first online instance in 2011. Kenya had also received funding from HMN for a HIS assessment and planning process. They had been struggling with their current HIS, which consisted of a semi-online tool to transport excel files from district computers to a national server and were looking to implement a different solution which met several criteria. Among others, this solution had to be web-based; useful for conducting an analysis of the data and be of technical support. While initially leaning towards DHIS1, researchers from HISP UiO who had worked in Sierra Leone saw the potential for utilising the good nation-wide mobile internet in Kenya to set up DHIS2 as a “cloud” instance. Contrary to the Sierra Leone implementation, which faced many logistical challenges in synchronising offline district-implementations of DHIS2, Kenya could reach the whole country with one centrally installed instance. The Kenya-requirements pushed UIO researchers to make a new transition, from a desktop-based to a cloud-based system which would be Kenya’s heritage to the DHIS2 ‘dynasty’. This shift from desktop-based to cloud-based significantly improved scalability (Manya *et al.* 2016). The chart below (figure 6) shows the growth of countries using DHIS2 (bars), followed by a steep increase in developer team capacity (line).

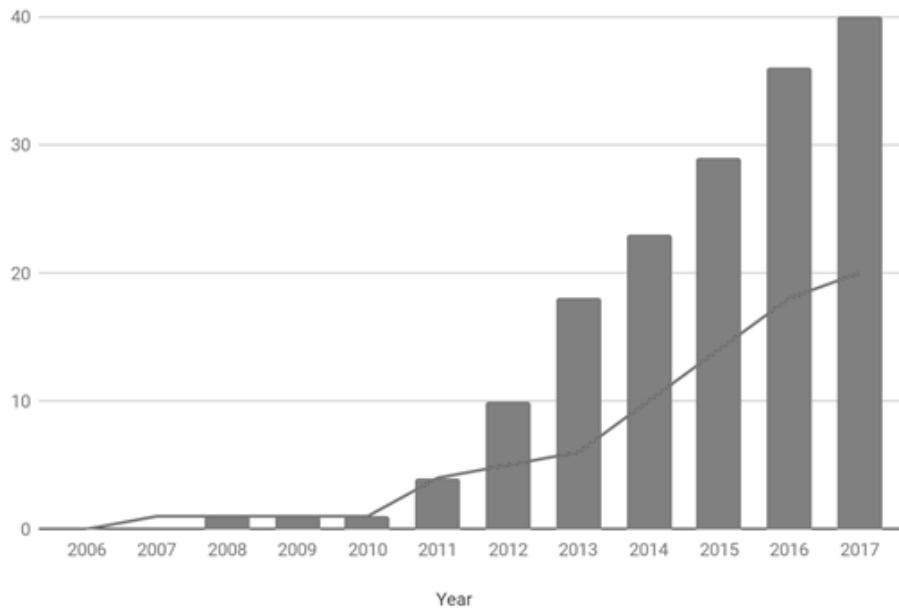


Figure 6. DHIS2 expansion (Internal documentation HISP UIO, untitled)

Looking back, the development of DHIS2 caused a shift in attention. Thus far, the focus had been on the development of local capacity around local solutions and weaving a networked infrastructure between them (as evident in Braa *et al.* 2004). Now, the attention of researchers had to be divided between creating local capacity to make a standardised solution work locally; *and* the continuous development of a standardised solution. This was significant because it meant that the previous process (as illustrated in figure 5) would not be sufficient anymore. First, because according to Roland *et al.* (2017 p.20) *‘It was no longer enough [for developers from UiO] to engage in participation on the ground, since ‘the ground’ constituted many different realities.’* Second, an increase in users meant the previous situation in which parallel projects simultaneously provided different input to core development resulted into a cacophony of noise. One developer describes the example of a graphical user interface and features which were carefully modelled based on the situation in Uganda, which were picked up by design teams in other countries to fit other requirements. As a result, Roland *e al* (2017) observed how *‘one particular user interface changed back and forth several times, due to teams in different countries each adapting it to their needs. Some of the core central developers were caught in the middle, constantly changing the software and increasing complexity’*.

In addressing these tensions, the core team applied a more platform-oriented software architecture whereby both local developers and core team members would start using the platform’s

capabilities to make applications using open APIs. Architecturally, a software platform can be understood as *‘the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate’* (Tiwana, Konsynski and Bush, 2010 p. 676). Application platform interfaces (API’s) are programming interfaces that developers use to write applications. While in the DHIS2 case, open APIs were exposed for others to use, adaptations would be fed back into the core code and affect everyone else.

5.2 The Influence of Scale on Local Support

As part of the Network of Action approach that surrounded DHIS1, local implementations and capacity building processes were conducted by researchers in implementing countries, in collaboration with staff at the ministries or local developers – for instance through university collaborations. This was possible as several local MSc. programs had also been established during this period to contribute to the overall capacity around health informatics in the countries. However, the growing number of countries that adopted DHIS2 made it soon become impossible to meet all training demands with this model. The logistics of carrying out in-country trainings to a growing user base, with the same amount of staff at HISP UiO, became too complex and expensive. This led to two developments.

Network of Action activities (enabled by PhD scholarships and MSc programs) had proven useful in the creation of so called ‘HISP nodes’; typically, one or a collection of people organised in some legal entity, so that they can take on consultancy projects in their home country and abroad. These nodes vary in size and capacity, experience, (formal) relationships with local government, the extent to which they engage in (specialised aspects of) technical (software development) work locally or internationally. As they multiplied, these nodes also became both more formalised and internationally oriented, with more or less specified roles in the wider HISP network. One example is HISP Tanzania. Extending the team of up to 14 developers, this entity is now active in West Africa in general, facilitating standardised training programs called DHIS2 Academies, and collaborates at the international arena together with HISP UiO and large international NGOs.

Previously, to introduce DHIS2, researchers and implementers had leveraged on these foundations. Now, they relied on them in maintaining them. Whereas DHIS1 had depended on the support of a

South Africa based team from the very start, the introduction of DHIS2 – and especially its scale – required that the network of local developer teams would also rapidly expand.

Today, HISP entities are separated from other local developer teams that may offer DHIS2 related support to Ministries in the form of a Memorandum of Understanding (2017). This agreement recognises what up until then had been informal practices in which HISP nodes collaborate on the open source software development of DHIS2; national, regional and global capacity building activities including hosting and arranging DHIS2 Academies and developing teaching curricula and materials; implementation support to Ministries of Health, health programmes and others; development of integrated health Information architectures and strengthening of health information systems and joint research and academic activities by linking researchers, students, projects, universities and health authorities.

This allowed researchers at UiO to shift their responsibilities in to holding regional trainings was implemented where a few representatives from various countries would come together for intensive training. Participants would learn from each other and meet with global developers and international trainers, and then go on to conduct in-country training themselves. These trainings became known as DHIS2 Academies. Today, there are approximately 20 DHIS2 academies held annually all over the world, covering an ever-expanding portfolio of topics and levels of experience. In addition, an interactive on-line DHIS2 academy platform was launched recently (academy.dhis2.org) which is used to help users prepare for on-site academies as well as reach users who may not be able to attend them.

In addition, PhD. and MSc research was applied a strategic tool not only in the development of local client systems but also to maintain the infrastructure surrounding the software development globally. PhD. and MSc students would often return to the developing countries where they were recruited from, with the purpose to contribute to strengthening implementation and institutional capacities and potentially support local master's programs (as evident in the 'HISP UiO Business Plan for DHIS2 Core Resources 2016-2021 p. 5'). At the time of writing, 45 PhD. candidates have graduated (5 a year on average between 2006-2016) with 3 or 4-year scholarships each). Many of them would become advocates and users of DHIS2 as part of their future careers, occupying key decision-making positions within ministries or establishing social enterprises in support of DHIS2.

These developments proved vital in realising as well as coping with the growing number of countries adopted DHIS2. It soon became impossible for the researchers and developers at UiO to meet all training demands with the Networks of Action model. The logistics of carrying out in-country trainings to a growing user base became too complex and expensive. This urged researchers at UiO to shift responsibilities in to holding regional trainings and maintain local DHIS2 implementations toward the wider network of HISP nodes and consultants. The core team at UiO would concentrate on the development standardised functionality in relation to the platforms' core and the development of a standardised application of use to the wider community can be shared in a DHIS2 'app store'. These applications were located in the platform's customisation layer (Roland *et al.* 2017). A support structure (including DHIS2 academies but also resources such as development tool-kits) emerged to support the development of custom applications as extensions of the DHIS2 core.

Whereas funding structures supporting the Network of Actions approach (before the development of DHIS2) had primarily come from NUFU (a Programme for Development, Research, and Education) this gradually shifted with the development of DHIS2. In 2015 the main funding came from development agencies whose interest is predominantly in the solution/ change created by the network, rather than its research aspect. As part of this development, academic pursuits received less funding than previously. The change in funding is illustrated by the chart below (figure 7), showing both an absolute and relative decrease of research-oriented funding, which had predominately come from the Norwegian sources. Since 2013, most funding to HISP UiO came from NORAD, PEPFAR and other large international organisations active in the global health arena.

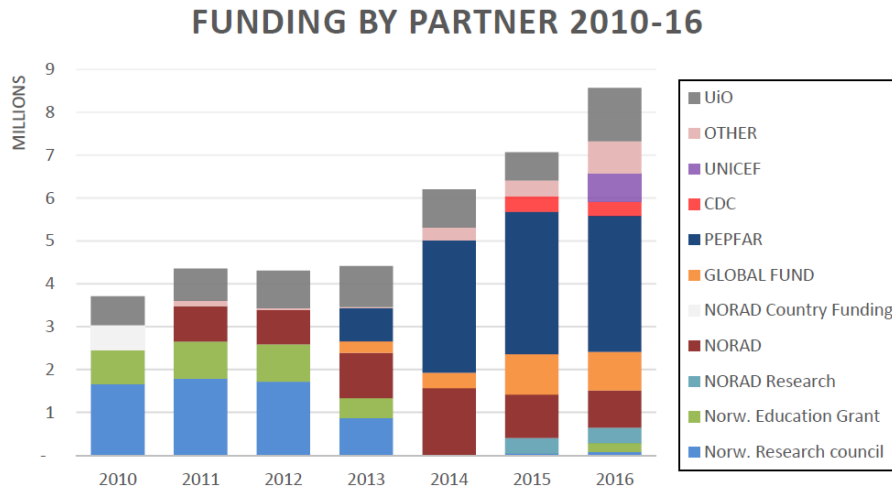


Figure 7. DHIS2 funding by partner. (HISP UiO Business Plan for DHIS2 Core Resources 2016-2021 p. 21)

As the clientele of the network shifted towards international agencies and NGOs (“funders”), several of these organisations have increasingly become advocacies for the software in terms of support and implementation for their own use. Many of these funders implement DHIS2 as their system for internal reporting and accordingly provide funding to HISP-UiO for the development of the DHIS2 software. Others allocate resources for the strengthening of health information systems and capacity in developing countries more generally; others offer small scale support to individual country DHIS2 projects or the development of specific modules. According to a HISP assessment conducted in 2016 (page 4-5), this decrease in funding for research and scholarships has put innovation at risk, pointing out the importance of maintaining a focus on research.

Figure 8 illustrates the dynamics between various stakeholders involved in the development and implementation of DHIS2 that have been outlined in this chapter and table 4 provides an overview of their roles and capabilities in influencing these processes.

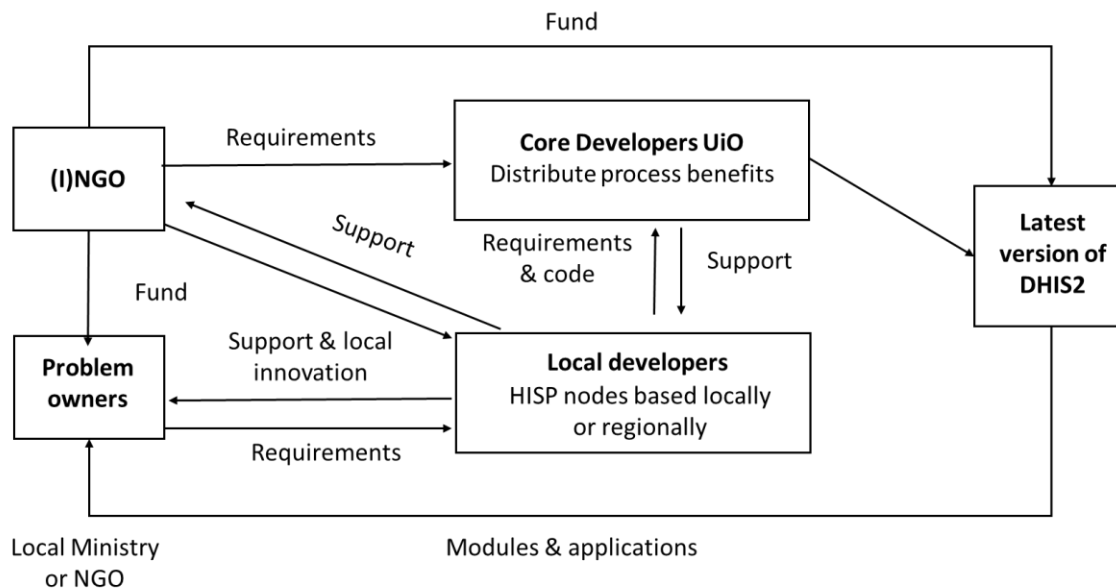


Figure 8. Project organisation

Table 4. Stakeholder involvement

Stakeholders:	Description
Ministries of Health	<ul style="list-style-type: none"> Typically do not have the money to fund new requirements nor the capacity to specify them once pilot projects end May or may not be represented by local developers (in country or region) Ability to customise software without support differs but is generally low Faced with contextual challenges (political changes, disease outbreaks etc)
Local NGO's	<ul style="list-style-type: none"> Typically operate on a project-basis Funding available for specific implementation over limited period of time Attract support of regional or local developers based on funding (within or outside of the HISP network)
HISP nodes and local developers	<ul style="list-style-type: none"> Primarily based in the South Train local users and rolling out or customising DHIS2 Represent Ministries and local NGO's in defining requirements. Often have deep knowledge of DHIS2 and are trainers during DHIS2 academies Often faced with funding challenges Capacity to develop code for new requirements differs. Tend to have strong relations to the core DHIS2 development team though this also varies; Tend to be present at an annual training event, the 'DHIS2 Expert Academy', where they can promote their requirements.
INGO's	<ul style="list-style-type: none"> Offer support to the development of the software core without specifying requirements

(who may be donors)	(minority) or have the capacity to fund the software development that solves requirements (majority).
Donors	<ul style="list-style-type: none"> • Provide funding based on projects with specific deliverables and a process where the status of each requirement is followed up closely. • Typically have a high capacity to understand the software and the ability specify new requirements. • Tend to be present at an annual training event, the ‘DHIS2 Expert Academy’, where they can promote their requirements.
Core developers	<ul style="list-style-type: none"> • Primarily based in UiO • Develop new features primarily led by funding • Interest in high quality features/code developed locally (which can be integrated in the core or the app-store) • Communication with local and regional developers based on project basis or during academies or personal relationships
PhD and MSc. Researchers UiO	<ul style="list-style-type: none"> • Develop or strengthen strategic relationships with other stakeholders (HISP nodes, NGO’s, donors, ministries) • Contribute to software development or implementation via action research approach, often on a project-basis • Document learnings • Tend to move to new positions in the wider network • Some ability to communicate requirements based on relationships and co-location with core developers • Funded through donors or, less so, by independent research bodies

5.3 A Day in the Life of a DHIS2 Implementer

I will end this chapter with a composite narrative² that provides insight into the work practices of HISP implementers as they tailor the system to a local use case. In this case, the composite narrative is an actual ‘slice-of-life’ presentation, which faithfully draws on the data to illustrate the main patterns observed across the data. While the specific approach (‘blueprint approach’) observed in this narrative is not necessarily representative for the work of other DHIS2 implementers, it was selected because it makes a significant aspect of the work practices of a DHIS2 implementer visible. Notably, a facet of the work that is not illustrated in this narrative is the way the process of tailoring the software to a local context may require features that are not

² As noted by Jarzabkowski et al. (2014 p. 278) ‘a composite narrative draws upon a wider corpus of data and may be developed to show the pattern in a rich “slice-of-life” fashion that remains unfragmented in order to make the tale as meaningful as possible for the reader’. The aim of this composite narrative is to reveal some typical patterns or dynamics found across multiple observations through one particularly vivid, unified tale that provides a conceptually generalizable account.

enabled by the software in its present stage (this process is discussed in detail in paper 5). In this case, implementers are required to develop workarounds in the form of local adaptation and/or request changes to the core of the system.

Myself, two implementers from a regional HISP node and one Southern based consultant from UIO (who will later join this HISP team) are in the office of a local NGO in a country in Asia where neither of us speak the language. Thankfully, the hand full of staff members who have gathered in the room speak excellent English. For the developers, it is the first time they experimented with 'blueprints': Excel sheets that form an empty system on 'paper' and, when filled in correctly, can be used by developers to create an overview of all the information they need to customise the system. They took the idea from a large international NGO that rolled out DHIS2 worldwide and created 'blueprint' documents as a means for experts to manage the changes within different instances. Normally this blueprint will only exist in the head of the DHIS2 developer. However, now that more organisations became interested in integrating different systems and programs, the merging of all their requirements creates a complexity that requires documentation. Documenting it after the example of the practices of this INGO furthermore enables the designers to involve a Ministry that insists on being involved. One of the designers explains: 'it helps us to create transparency'. The following section contains a composite narrative of the translation of local practice during an NGO workshop to create a 'blueprint' for a system instance.

The 2-day NGO-workshop starts with the display of an empty 'blueprint' (Google sheets) document – taken from the INGO example – and cleared by the experts so it can be customised for this particular case. The document displays columns with titles (that match some of the terms the participants in the room have learned during a training 2 weeks ago that made them familiar with the systems 'language') that all have a place in the system: data element names, short names, option sets, categories. The implementers will initially use the document to show how all elements of reporting practices process have a counterpart- element within the system. They do this by starting with a paper reporting form (image 5) and show how they retrieve a data element from it (in this case the 'TB' data element).

**National TB Program
Quarterly Report on TB Case Registration (TB - 07)**

Name of townships/code no. _____	Patients registered during _____ quarter of _____	Date of completion of this form: _____
Region/State: _____ Name of Township TB coordinator _____		
Area population CNR (Bacteriologically confirmed) = $\frac{\text{Block}(1), \text{Row}(1+3)}{\text{Population}} \times 100,000$ (Per 100,000 pop.) CNR (All TB cases) = $\frac{\text{Block}(1), \text{Row}(1+2+3+4)}{\text{Population}} \times 100,000$ (Per 100,000 pop.)		

Block 1: All TB cases registered during the quarter except Transfer in patients

Type of disease \ Type of patient	New		Re-treatment Cases						Total		Grand Total
			Relapse		Previously treated (excluding relapse)		Unknown previous treatment history				
	M	F	M	F	M	F	M	F	M	F	
Pulmonary, bacteriologically confirmed											
Pulmonary, clinically diagnosed											
Extra pulmonary, bacteriologically confirmed											
Extra pulmonary clinically diagnosed											
Total TB Case											

Image 5. Reporting form (fragment) that needs to be translated to DHIS2.

This data element is part of an entire row in the blueprint that can be filled in based on other parts of the form and the reporting procedure it is part of. After this example, the team starts to fill in the rest of the blueprint themselves by identifying data elements in their forms and transporting them to the right place within the blueprint.

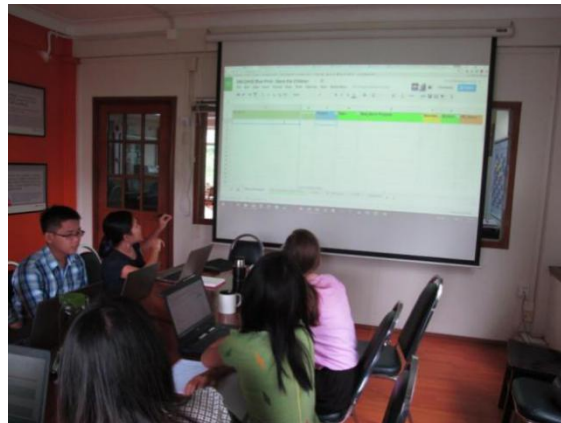


Image 6. Creating a DHIS2 'blueprint' for practice-based data

Next, the experts spent the remainder of the morning checking the created file in relation to the forms where the elements come from. From data elements, they now move to working on another aspect of the blueprint; category combinations. For instance, one participant expresses: 'for this one [data element on the blueprint] we use under and over 15 years of age [category option on the blueprint for this data element]'. Retrieving practice elements and translating them to technical ones is not necessarily a clear-cut exercise, and some need to be defined more specifically during the process. For example, it is unclear to the implementers which paper form is used by townships, which by

villages and which by the private sector. However, this not documented anywhere. Luckily, there is a staff member in the room that knows.



Image 7. Discussion about the form on the screen

A whiteboard is then used to retrieve that knowledge. Only after the whiteboard exercise, the DHIS2 expert guiding the session is able to find out there is a third category, whereas previously it appeared there were only two.



Image 8. Whiteboard with workflow (reporting)

The discussion does not merely concern a one-way translation of practice into technology. For instance, it becomes clear to the implementer that data can be broken down per volunteer, mobile clinic, RDT/ microscopy. However, he asks: do those entering data want to report it that way, as it will create an extra work load? A closer look over a filled form reveals that there are a lot of zeroes. The implementer then suggests asking those entering data not to enter zeros as this will save them a lot of time. As a result, routines are changed. Next, he draws what the design will look like in the system: first the users will select the right township, then the data set (for instance Malaria report) then the organisation type and then the service type. To clarify, he briefly uses the demo to show what it will look like on the interface.

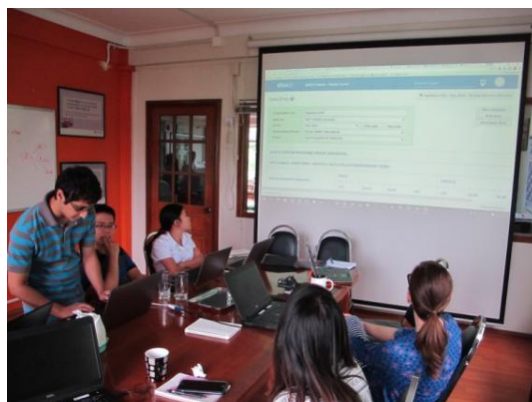


Image 9. DHIS2 demo of a similar example of what the workflow on the whiteboard will look like.

The next part of the blueprint concerns ‘indicators’ and follows a process similar to the ‘data elements. After a brief explanation about what an indicator is (because some of the staff use the term differently) and demonstrating an example row on the screen, the staff split up in the same groups to fill in this column within the blueprint.

Looking at the second part of the blueprint document, the DHIS2 expert leading the session asks many questions to check the information. Is this equal to that? Does this total mean both positive and negative tests? Next, to him, a colleague is trying to import the ‘category options’ decided on from the blueprint document into the system – a demo instance which can be put to use later. Once it is finished, the participants can see the result of their own work in the system.

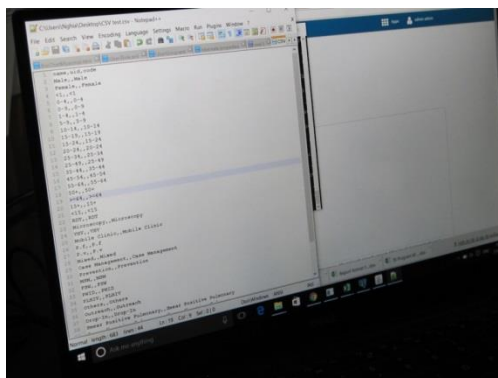


Image 10. Screenshot of system ‘import’. On the left: the import file; with DHIS2 on the background on the right.

Eventually, the elements in the blueprint taken from the paper forms, which were deconstructed to reveal the practices each element on each form referred to indirectly, will be reconstructed with the elements (meta-data) in the system. An example of this re-construction taken from the official DHIS2 user manual is provided in image 11 (DHIS2 User Manual).

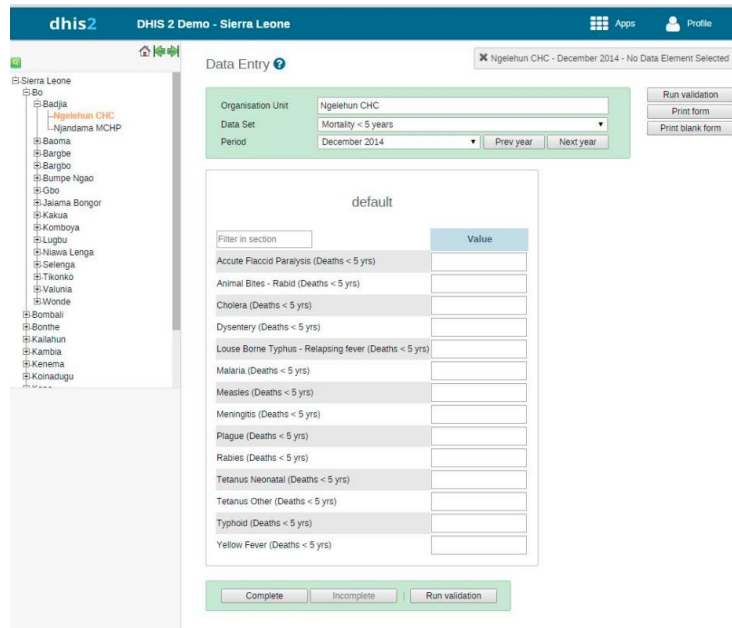


Image 11. Example of a 'data set'

5.4 Summary

This chapter has discussed the scaling process of DHIS2 and the tensions this created in terms of its flexibility. It furthermore draws attention to key events which were influential in this process:

- We see action-research was applied as a vehicle that enabled a series of successful implementations during which valuable features were added to early models.
- This in turn caused a spike in funding opportunities from large international NGO's and developmental organisations with interests in specific applications, which caused a significant increase in demand and placed less significance on research operations.
- A number of changes were made in order to cope with an increase in demand:
- regional training academies were introduced which played a key role in the ongoing development of a network of regional and local developers that could support the ongoing implementation and development of DHIS2.
- Architectural changes were designed to enable local developers to add local functionality in order to cope with a rise in demand. However, this also made it more difficult for different developers to contribute to the system with new functionality over time.

The chapter furthermore identifies the key actors involved in the development and implementation of DHIS2 and explains dynamics between them. The chapter concludes by

providing the reader a glimpse of what this looks like in practice in the form of a composite narrative that was derived from my data.

6 Findings

6.1 Summary of Selected Papers

This thesis comprises a collection of 5 papers. These papers deploy different analytical approaches, methodologies and theory and engage with different aspects of scaling processes and sustainability of ICT4D intervention. The overview in table 5 furthermore illustrates how these papers emerged from different research stages (this table is an extension of table 2 discussed in section 4.2.2). In this chapter, I aim to both capture the contributions of these papers as well discuss how the sum of them generate a greater understanding of the networked phenomena they have in common. In the words of Blomberg and Karasti (2018), they piece together the ‘field’ this research was able to cover as part of the vast and complex terrain of the information infrastructure that goes by the name ‘DHIS2’. To achieve this, I will revert to my analytical lens in section 6.2.

Paper 1. Explorative Stage

Fruijtjer, E. and Pinard, M. (2016), ‘Collaborative Development of Global Information Systems: Toward Community Based Generification’. *The Electronic Journal for Information Systems in Developing Countries*, 73.

Paper 1 emerged during the more explorative stage of the research and their main function in the research was that their findings raised more questions. This paper was centred around the following question:

What mechanisms facilitate generification processes [selection and prioritisation in software development] by a globally distributed open source community?

Paper 1 provides an overview of change and adaptation processes around DHIS2: the actors involved at various levels of the software implementation and development cycle and the channels and mechanisms used to communicate changes made or required. The community exercise that was conducted as part of the research for this paper mapped out the concerns that were present in a growing DHIS2 ‘community’ about a growing system. This paper is about the stretchmarks of scaling processes in which more users also means 1) initial users (and their technical representatives) are confronted with a situation in which their needs have changed over time and

Table 5. An overview of papers produced in relation to insights gathered at various stages of the study

Exploratory phase:		Case-studies		
What did I observe?	Papers (2):	Questions this raised:	Findings	Case:
The role of (action) researchers was important in the processes I was interested in and changed over time	Frujtter, E. (2017) titled: 'Action Research Innovation: Open Synergy?'	What was the role of action research and how did it change over time?	Action research was a crucial element in tailoring DHIS2 and its scaling. However, action research was not applied to increase local capacity beyond the involvement of the research.	Frujtter, E., Sæbo, J. titled: 'The Role of Action Research in Making ICT4D Sustainable.'
How the core team managed flexibility of the core changed over time and this became problematic for some local developers (and the representation of ministries) as funders had become more involved.	Frujtter, E. and Pinar, M. (2016) titled: 'Collaborative Development of Global Information Systems: Toward Community Based Generification.'	What influence do local developers have on core development processes and what is the influence of funders?	Action research was a crucial element in increasing the capacity of local developers beyond the durability of research involvement (enabling 'opportunity-based bricolage').	Frujtter, E., and Senyoni, W. (2018) titled: 'The Role of Local Bricoleurs in Sustaining Changing ICT4D Solutions.'
Local ministries are reliant on either local or global developers for the implementation and development of local DHIS(2) instances.	Both papers touch on this and dynamic.	How do these relationships unfold and what does this imply in terms of capacity?	The flexibility of DHIS2 decreased over time to a point where local developers have no significant formal influence on the development of core functionality which is mainly driven by funders.	Frujtter, E. (in review) titled: 'Open Development: Game-changer or Sugar-coat? In review for ITD special issue on 'ICTs for promoting sustainable information society and harmony'.
The emphasis of creating flexible applications on top of the platform (in response to increased flexibility of the core) had increased	Frujtter, E. and Pinar, M. (2016) titled: 'Collaborative Development of Global Information Systems: Toward Community Based Generification.'	(How) are local developers able to create flexible applications on top of the platform?	Local developers have a key role in tailoring local systems, mediating user requirements and building regional capacity of users	Frujtter, E., Sæbo, S., titled: 'The Role of Action Research in Making ICT4D Sustainable.'
			Local users are reliant on external expertise and capacity of users can change rapidly (for instance due to political changes)	
			Local developers have a key role in sustaining local implementations and tailoring systems over time. Universities are enabling environments to sustain local developer teams	Frujtter, E., and Senyoni, W. (2018) titled: 'The Role of Local Bricoleurs in Sustaining Changing ICT4D Solutions'
			Being able to develop flexible applications on top of (rigid) platforms requires a relatively stable funding climate which may be generated as a result of the strategic application of both technical skills and the ability to develop strong alliances with local partners. A bricolage-approach lends itself for the realisation of such dynamics over time.	Frujtter, E., and Senyoni, W. (2018) titled: 'The Role of Local Bricoleurs in Sustaining Changing ICT4D Solutions'

2) realise their ability to customise the system has changed. Simultaneously, users (and developers a-like) experience of an increase in distance from the development process. Findings reveal challenges arise when the change flexibility goes down and is not compensated with a rise in use-flexibility (despite open source development processes). This imbalance was most tangible at the point in the development process where user-representatives attempted to communicate their needs to core developers. This was mainly because this point was clouded in uncertainty. User representatives experienced a lack of transparency - whereas on the other hand core developers struggled to prioritise the information that reached them. There was a need to identify 'generic' needs among the needs communicated; whereas users felt generic was code for 'needs that pay'. They wanted to participate in the selection process but in order to do so needed to understand what was expected of them. Based on these findings, we (as this paper has two authors) theorise that ICT4D development processes need to be cyclical in nature and that 'open' (sourced) ICT4D solutions become more 'closed' as they scale. This is because the option to create forks becomes less relevant when users need to benefit from upcoming versions. As a result, we argue the development processes become the concern of a wider collective³.

Paper 2. Explorative Stage

Fruijtier, E. (2017) Action Research and Open Innovation: A Synergy? In: T.A. Mapotse (Ed.), *Cross-Disciplinary Approaches to Action Research and Action Learning*, IGI Global, 19 – 39.

Publication 2 is a book chapter that emerged as a result of my role in the research community to facilitate lectures in the action research method. As part of this task, I was exposed to many writings produced by researchers and students in the DHIS2 community for whom action research appeared to be a medium of engagement and innovation. The question this raised for me was: what is the role of action research in this community, and especially in mediating between a diverse range of (local) user needs and (global) core development? This chapter was my effort to understand the locality of AR and its role in global processes. This chapter was centred around the following question:

³ Based on these findings, I developed an interest in understanding of collective action in 'open' development – which formed the basis for paper 5. I also became interested in the skills required from user representatives to participate, and what is what like for them to obtain them. This informed paper 4.

(Where) does a fusion between Action Research and Open Innovation lead to a synergy?

As the development of DHIS2 becomes the effort of a team of developers and a network of practitioners, the role of the researcher changes. The initiating researchers are now supervising and introducing new action researchers and Action Research projects to support implementers and problem owners to improve the system. Based on case data, the traditional Action Research process ended when DHIS moved from South Africa onward to other countries, where the solution became part of new Action Research projects that started and ended. It being a book chapter, I had the freedom in this publication to play with ideas about what a methodological conceptualisation of this new role could look like – while at the same time pointing out the limitations, I perceived in practice for researchers to proceed in this direction. Based on this, I theorised an extension of the AR method in which it could complement what I discuss as ‘open innovations’ (Chesbrough 2003). The term ‘open innovation’ is used to refer to the blurring boundaries between organizations and between them and consumers has led to new ways of innovating. I wanted to understand whether open innovations that emerged from AR processes were similarly blurring the (already somewhat blurry) boundaries separating the action research method from other forms of innovation.

Somewhat similar to paper 1, this chapter uncovers stretchmarks of the action research method as the interventions that it produced are scaled up. The chapter explores ways in which 1) action research can complement ICT4D innovations as they scale, and 2) ways in which innovation strategies can offer action researchers an opportunity to make sure research has an added value and informs ICT4D processes. However, I lacked knowledge on what this changing role meant for individual implementations. Whereas I proposed systematic action research to safeguard the social value of research and research ‘action’; I also identified a risk that networked forms of action research could become a cover to scale a solution, disseminate learnings and attract funding⁴.

Paper 3. Sierra Leone Case

⁴ This is why in paper 3, I decided to focus on the role of action research in the sustainability of ICT4D solutions.

Fruijtjer, E., Sæbø, J. The Role of Action Research in Making ICT4D Sustainable (unpublished).

Paper 3 addresses the role of the HISP network (as led by HISP UIO) in sustaining the DHIS2 implementation in Sierra Leone. This paper describes two parallel developments: the emergence and evolution of Sierra Leone's local implementation of DHIS2 and the global implementation of DHIS2. The paper sought to understand the dynamic between these two developments. This paper was centred around the following 2 questions:

RQ1: What client system infrastructures do AR based ICT4D projects generate to enable clients in taking AR solutions forward?

RQ2: How does scaling AR efforts as part of networks affect the creation of client system infrastructure around AR interventions in low resource environments?

The initial process of implementing DHIS2 in Sierra Leone (2007-2010) was funded by a single donor, HMN, and carried out by action researchers from UiO in their role of DHIS2 experts. This actor furthermore created strong legitimacy for the project, being a partner of WHO. HMN established partnership with HISP UiO who brought in the technology: at the time an early version of DHIS2. These actors together provided most of the capacity for the project; in the form of HMN-funded technical staff, HMN and UIO funded researchers (developers); and they furthermore developed the capacity within the Ministry. The DHIS2 software at this time was still very much in its infancy. The partnership with HMN in Sierra Leone and its success then added to the legitimacy of DHIS2 as a credible solution - and the interests of new parties were raised. At this stage, the spotlight of the network moved toward Kenya which because of its enabling environment became a test case for a web-based version of DHIS2. This became another key factor in the spread of the solution and growth of inter-client system. As part of this 'chain-reaction,' more donor funding is attracted; more core staff is hired, and more features are added to the solution which in turn gains more attraction. The contrary happens for the local implementation in Sierra Leone, which lacks internal capacity to recover from a technology break-down that occurs after the initial implementation is completed. Sporadic involvement of various external DHIS2 consultants created a life-line for the project with 'quick fixes' that are insufficient and potentially even harmful in getting the system up and running again.

Because the paper focused in the role of action researchers in creating sustainable ICT4D solutions, one of our interests was in the ‘client system’ that was developed as part of research arrangements that were part of the DHIS2 implementation. Client system infrastructure is understood as the self-help competency of client systems (such as governments) required to ensure the evolution of local ICT4D implementations.

In Sierra Leone, the client system relied on highly unstable elements and external capacity (HMN-funded technical staff, HMN and UIO funded researchers (developers)). First, the paper finds that a successful client system infrastructure may significantly contribute to the development of a wider global network; aiding its legitimacy, its intervention (in our case technology); its capacity and funding, that are magnified as more client systems (in the form of country implementations) are added. The other way around, we see such global networks may be able to provide ‘life-line’ support when country client system infrastructure crumbles. At the same time, this ability is compromised by two of the previously mentioned trends, namely: 1) joining of more client systems (which disentangle the risk and dependency of infrastructural elements to require a single client system to remain successful) and 2) moving ‘spotlights’ of funders which can direct support of a global infrastructure toward or away from individual client systems. The paper finds crucial elements of the client systems in Sierra Leone fall into place when this spotlight is on them, however, it may move away and move back again without much certainty. The Sierra Leone case illustrates how support from the global DHIS2 program may not provide solutions for the periods of ‘darkness’ that may fall on client systems and local ICT4D implementations more generally.

Paper 4. Tanzanian Case

Fruijtier, E., and Senyoni, W. (2018) ‘The Role of Local Bricoleurs in Sustaining Changing ICT4D Solutions’, *International Development Informatics Association Conference*, Springer.

What made the Tanzanian case particularly interesting was that it was generally considered a best practice example by others in the HISP network. As such, this case provided an alternative scenario to the one examined in the Sierra Leone case in which local capacity was insufficiently developed and lost over time. Similar to the Sierra Leone case, the deployment of DHIS2 was also one of the oldest in the network and (again in contrast to the Sierra Leone case) knowledge about what had happened over the years was preserved. UDSM Tanzania has been actively extending DHIS2 with

innovative ‘work arounds’ in addressing needs emerging from local use cases that the ‘core’ of the system failed to facilitate in time. While such work arounds are typical for the practices of (most) other nodes in the network, the ability of UDSM TZ to contribute to the ‘DHIS2 app store’ with generic apps that can be used elsewhere in the network made this node unique for this node at the time of writing. This furthermore makes it an interesting case because this meant local developers depended less on the core team to add new functionality to the core of DHIS2. This paper was centred around the following question:

*What design approaches may enable the long term, organic and evolutionary development
ICT4D projects?*

The UDSM TZ case seeks to understand the role of local developers implementing ICT4D solutions (in this case, DHIS2) in their local contexts. The Tanzanian case is an example of an action oriented-improvisational process that pushes an ICT4D implementation forward while faced with scarcity, chaos and uncertainty. The paper depicts the ICT4D process as one in which piecing together alliances and adapting to volatile environment is crucial for the ability of local developers to be creative, innovative and novel – and thereby, secure their presence in sustaining ICT4D implementations. The local developers adopt a highly agile way of working that is able to produce quick results. However, this also leaves them vulnerable to funding gaps. The previous circumstances make the local developers re pushed to draw on their own creativity, move boundaries and develop strategic collaborations with others.

Although in itself a risky undertaking, the Tanzanian team managed to create strong alliances with strategic partners such as ministries as well as with the technology itself in order to survive in a climate characterised by unaligned stakeholder interests; funding limitations; pilot-orientations; technical biases and limited local capacity. Doing so, they pave the way for an evolution of their mode of operation which becomes connected with their ability to sustain the previous processes and enables them to expand their operations and the capacity of the team. On the one hand, this case illustrates how focus of funders on visible achievements poses a risk to the sustainability of ICT4D projects. On the other, it offers insight in a unique approach (following a 3-stage bricolage process) in which this focus can eventually be used to the benefit of local developer teams.

Paper 5. Roadmap Country Advisory Team Case

Fruijtjer, E. (in review) Open Development: Game-changer or Sugar-coat? In review for ITD special issue on ‘ICTs for promoting sustainable information society and harmony’.

This paper follows up on the interest raised by paper 1 in the possibilities of a collective action (‘community-based’ approach toward software development processes in ICT4D and the role of open models in enabling or potentially constructing it. Specifically, this study explored to what extent open source development practices can balance on both pillars – open models as well as collective action – in line with objectives to realise development outcomes. It looks at the pilot of a so called ‘Roadmap Country Advisory Team’ (RCAT) initiative which was introduced with the aim to enable a select group of HISP nodes to advice the UIO management team on country requirements that should be on the roadmap for the following DHIS2 release. This paper was centred around the following question:

What challenges do ICT4D projects face in applying ICT-enabled open practices that enable collective action?

While RCAT members were well capable of coordinating collective action them with the opportunities provided by technological advancements of the networked information society, the initiative was not properly nested as part of organisational rules (and sanctions) in place. This left them unable to ensure their advice received the follow up envisioned at the start of the pilot. Despite initial suggestions from RCAT members and process commitments made in the initial stage, mechanisms to ensure commitment from the development team and transparency about RCAT requirements in relation to the rest of the roadmap were either not included in its design or neglected during its implementation. As a result, the effect of the RCAT to ensure ministry needs were better represented in the development process was neglectable.

I found that orchestrating the increased participation of the most vulnerable users in ICT4D development processes can be challenging in nature and potentially unrealistic in the current funding climate that surrounds ICT4D development and implementation. In doing so, the paper challenges ideas that the potentials of open source development and platforms in ICT4D development generate more collaborative, de-centralised development processes, arguing they rely too heavily on open models alone and fail to acknowledge complexity issues. In the paper, I propose that unlocking the potentials of open models in development requires the coordination of key stakeholders in the international development arena.

6.2 Synthesising Research Findings

Having discussed each paper individually, I will apply an ANT lens to explore how findings from my papers together provide insight in the translation processes through which the networked phenomena they have in common comes into being and is (or isn't) sustained. I will draw on my analytical lens to discuss how scaling sustainably requires translation processes through which a global user-base is attracted and maintained (section 6.2.1) and that enable the establishment of local user base or 'network' around IT4D solutions (section 6.2.2). In section 6.2.3. I will also discuss that there is a tension between these two highly intertwined translation processes that facilitate different parts of the scaling process (scaling in size and in scope) ultimately serve different interest, and observe that this tension has an important function when we understand these two trajectories to be part of a single network – or information infrastructure.

6.2.1 Trajectory 1

I will start with a discussion of the processes through which DHIS2 was scaled in size. The DHIS2 case started as a custom solution as a result of the successful problematisation of a situation. As it travelled across different use cases at the hands of action researchers and (and as) DHIS2 implementers, an increasing number of interesting features were added as a result of customisation processes. The focus was on enabling change flexibility through which the solution would adapt and become more flexible to use. As a result of this process, DHIS2 became a comprehensive toolbox. Initially, this toolbox was designed to facilitate the needs of ministries of health. However, once a vast user-base was created and its success stories increased, it became popular among a range of international development partners willing to also contribute to the development process with resources.

At this stage, the scale of the system was such that it no longer became feasible for the core team to accommodate individual country needs and change flexibility started to go down. For those users who would also contribute to the core development process, this was compensated with an increase in use-flexibility. These resourced users come from the international development community, and features added would not necessarily be those needed by local ministries although they would still benefit from improvements. Technically, less resourced users were also able to compensate for a decrease in change flexibility with an increase in use flexibility. The platforms source code and web-API were freely available, enabling local developers to innovate without the

involvement of the core development team. However, as discussed in section 2.4, this proved to be challenging in practice.

In the ‘infrastructuring’ of DHIS2, the technology is an active translator. While the technology does not actively problematise a situation, it becomes an ally of the action researchers who implement DHIS2 and one could say, is able to enrol them and mobilise them in its ‘interest’ as follows. The technology turns into an obligatory passage point when it becomes intertwined with the solution of the problem. It is this rhetoric through which other actors are able to interest others and mobilise them (in the ICT4D field). In turn, the evolution of the technology (turning into a platform) makes that this thesis identified platformisation as a possible solution to a sustainability problem. Yet the fact technologies become embedded and are able to create lock-ins, reflects how they become ‘representatives’ (spokes-actors) for other actors.

This trajectory (table 6) reminds strongly of Callon’s case (1986 p. 13) in which he describes how the larvae of the scallops anchor themselves; are counted, registered on sheets of paper, converted into figures, into curves, into tables, turned into an article, analysed and discussed during conferences, and *‘if they are judged to be significant, three researchers are authorized to speak legitimately for the scallops of St. Brieuc Bay: Pecten maximus does, in fact, go through an anchorage stage.’* Only, in this case, patients become charts, become numbers, and become countries on a slide of a DHIS2 implementer in a donor meeting or of a researcher in an academic conference. In a way, the technology also dictates what can and can’t be done, as qualities of flexibility and control are inscribed into them. What makes this furthermore complicated, is that there is not ‘one’ technology; not one DHIS2. Users are running different versions of the software and approaches toward their implementation differ across time and space.

Table 6. Analysis Trajectory 1

<i>Moment of translation:</i>	<i>Findings:</i>
<i>Problematization</i>	<p>Action researchers at UiO successfully problematise a situation and make themselves indispensable to other actors (initially Ministries) by defining the nature of the problem those actors face (a locally customised health information management solution) in achieving their goals (global health outcomes) and by identifying a way forward (local development and maintenance through collaborating with local developers and creating university alliances). This does not mean that the initiators are directing the other actors; they merely identify a common interest and position themselves successfully as translators of that interest. They create a client system infrastructure that enables research environments and at the same time, enables locally viable solutions. Problematization becomes stronger over time, as a result of an increasing number of implementations.</p>
<i>Interessement</i>	<p>DHIS2 initiators in the role of researchers and developers borrow force from their technology ally and turn themselves into its representative. By interposing themselves as DHIS2 experts, they lock the other actors into place. Furthermore, they attract funds and legitimacy from funders and draw from collaborations with local developer teams, thereby weakening the links of other actors to alternative interpretations and strengthening their focus on the problematised.</p>
<i>Enrolment</i>	<p>The initiating researchers as DHIS2 experts put interessement into practice by actions (multiple-site implementations with Ministries all over the developing country world) that define the roles that are to be played and the way in which others will relate to one another within the network. Large funders turn to the University of Oslo for expertise and support of the system. The network is established, and the role of the action researcher deteriorates while the role of a growing team of management and core developers increase.</p>
<i>Mobilisation:</i>	<p>The initiating researchers at the University of Oslo borrow the force of their agent allies (INGO's, funders and broad support by Ministries) and turn themselves into their representatives or spokesmen. It is through the University of Oslo that core development of the system and therefore the interest of various actors are negotiated.</p>

6.2.2 Trajectory 2

Second, there is the trajectory through which local implementations are expanded as they are adapted and sustained by local developers – in the role of bricoleurs (Ciborra 1992). These bricoleurs move through different stages along with changes in the development process depending on the user-base attracted. In cases like Sierra Leone, action researchers or external consultants act as local bricoleurs and come and go depending on short-term funding opportunities. These are not sufficient in sustaining a system over time; at most they will keep the system ‘alive’. In cases like Tanzania, local developers are engaged in the project (for instance as action researchers but this should not be a requirement) who, through their permanent presence, are able to sustain the system over time. However, this permanent presence is relative as it is under constant threat as a result of funding gaps.

In order to cope, local bricoleurs need to expand their initial user-base. This may happen as a result of the successful interestment and enrolment of a large user such as a ministry, who may inspire or even require other users in the field to join. It may also be that bricoleurs manage to extend their services across the borders of their own countries, to support countries that do not have local support – such as in the case of Sierra Leone. The difference is that short-term funding from development partner projects may enable local developers to support ministry systems despite funding gaps – which is only possible when developers are based locally and develop strong relationships with such ministry users such as in the Tanzania case. In other cases, the survival of the local developer team may be under threat as a result of too much demand from a new wave of users as a result of the successful enrolment of an initial user base. This may overwhelm a local team which – as a result of the short-term nature of funding and unpredictable nature of demand, may not be able to expand their capacity in times when there are high bursts of interests of new users. Such tensions may result in innovative solutions – for instance, in the Tanzanian case, a re-use strategy toward innovation.

As a result of this re-use strategy, the HISP Tanzanian team was furthermore able to continue to seed demand in various places, rather than depend on it to arise outside of their own control. It is only at this stage, one could say the team moved out of a survival phase and into one where a local network is generated that secures their long-term presence and therefore the ability to maintain local implementations. What is remarkable about this strategy is that it relies on a changing pool

of development partner presence (which are opportunities to re-use innovations) – whereas previous strategies were threatened by it. In addition, it enables them to share their innovations with other users in the network that have similar use requirements but lack the ability to develop applications for them.

However, it is unlikely other nodes in the network benefit from short-term funding opportunities rather than suffer from them. Without local developers being able to keep up, there may be an overall imbalance in use and change flexibility and developers may become stuck in implementer roles with limited space for innovation required to customise the system to fit the needs of its local environment. While the implementation of the system (technical sustainability) may become sustainable as a result, this may not be the same case for the local developer teams themselves who depend on new projects and use-cases to attract a network of users that is large and heterogeneous enough to bridge funding gaps (financial sustainability).

Importantly, the re-use strategy of the Tanzanian team was also a result of the way they specialised in app development using the web-API. In the wider HISP network, this is a rare strategy – as one Tanzanian developer explained to me during the RCAT process, when elaborating on why a collective voting system for requirements would not work in their advantage. It is the web-API which makes use-flexibility an option, and without the other developers in the network being able to take advantage of it, their use-flexibility is limited to apps developed by others (currently HISP Tanzania, the core team or international NGOs) that are made available in the Appstore by the core team. This only happens when apps developed are generic enough, which – as noted in paper 4, requires a long-term vision and large investment on the side of the HISP node. Many nodes are not positioned to make such investments, which is problematic if core developers wish to see their infrastructure successfully morph into a platform-based ecosystem.

The Tanzanian case illustrates the following pattern of translation (table 7):

Table 7. Analysis Trajectory 2

<i>Moment of translation:</i>	<i>Findings:</i>
<i>Problematisation</i>	Local developers, as action researchers and by collaborating with ‘global’ action researchers, make themselves indispensable to other actors (in this case the Ministry and its partners) by defining the nature of the problem those actors face (a locally customised health information management solution) in achieving their goals (global health outcomes) and by identifying a way forward (ongoing development and maintenance). This does not mean that the initiators are directing the other actors; they merely identify a common interest and position themselves successfully as translators of that interest.
<i>Interessement</i>	Local developers manage to lock others into place by successfully weakening the links to alternative actors or alternative interpretations (other IT solutions and the existing MTUHA system) and strengthening their focus on the problematised (a new solution is needed and at hand).
<i>Enrolment</i>	Local developers put interessement into practice by actions (pilots, national rollout of the system) that define the roles that are to be played and the way in which others will relate to one another within the network (they put the Ministry in charge but become the horse in front of the wagon). This also involves actively making the technology work in a local context.
<i>Mobilisation:</i>	Local developers borrow the force of their agent allies (Ministries and NGOs) and turn themselves into their representatives or spokesmen in the interest of all involved. The Ministry now requires other actors (development partners) to make use of the services of local developers, and local developers make sure the Ministry is involved by the development partners that require their support. Importantly, the local developers have also successfully been able to mobilise the technology (borrowing its force and turning it into an ‘ally’) in ways that it now enables them to continue the translation process (problematised new situations, and so on).

6.2.3 ‘Discomfort Zone’

What is furthermore interesting about these findings is also that there is a stage which is uncomfortable for everyone involved. Once a ‘global’ solution is locally implemented, local

developers need to maintain both the solution as well as their own teams in the face of funding gaps and an increase in demand of heterogeneous users which they need in order to sustain processes started. This stage is also challenging for researchers at UIO, who see themselves turning into consultants in trying to keep development processes going while searching for the scientific value in their practices. Meanwhile, successful local implementations mean a new set of interested and more powerful users is enrolled which core developers need to keep processes started running and their organisations afloat, while trying to support an existing user base who often struggle to attract resources for the ongoing support and scaling of their pilots.

In short, at this stage, all actors are in transit. Parallel trajectories are both helpful and unhelpful to each other; the initiating researchers are supporting implementers while research scholarships offered to local ministry implementers and local developers are also draining local teams from their brightest minds. In addition, the presence of external researchers and experts may hinder the identification of local developers and therefore growing local capacity; whereas local researchers or implementers may actually drive the previous process. On the other hand, external (initiating) researchers may be key in grooming local actors/ researchers.

Similarly, local developers may benefit from a changing user base of international NGOs in enrolling local NGO projects and therefore increasing diversity of their user base; whereas on the other hand, when not coordinated by ministries, such demand may at times also hinder their ability to support ministry users whose projects may be more sustainable on the long run. Importantly, the influence of international funders and NGOs on the requirement process may hinder local developers in pushing their own requirements; whereas it may also stimulate new innovations. In other words: it's complicated.

In the mix of this tension, there are potentials depending on how these processes align and synchronise. Potentials for core developers to counter a decrease in change flexibility with an increase in use flexibility; potentials for local developers to properly nest their organisations; and potentials for action researchers to redefine their roles. The hard part is breaking out of this discomfort-zone. In order to do so, the actors must rely on each other. Core developers rely on local developers to increase capacity in use flexibility of ministries – something they may need to help facilitate. The other way around, local developers will find they need to rely on each other, and on core, developers to enable generativity that will make it easy for them to innovate. Action

researchers will find they need each other and collaborations in the network to be of value in researching infrastructural aspects and contribute to social change. Ideally, both core developers and local developers would also need to rely on input from action researchers in identifying and solving tensions and imbalance in maintaining ‘ideal’ levels of discomfort in moving toward more sustainable dynamics.

6.3 Summary of the Research Findings

In this chapter the findings of a set of 5 papers have been discussed. Insights were drawn from papers individually in the first part of the chapter, followed by an understanding of their collective insights in relation to the scaling process of DHIS2. Applying an ANT lens, the scaling of DHIS2 is unpacked as a translation processes through which both a global and local user-base is attracted and maintained in varying degrees. These trajectories and tensions as well as enabling dynamics between them can be summarised in figure 9. As well as depicting the two translation processes through which users are enrolled at local and more global levels, this figure aims to illustrate how the papers detailed in earlier sections offer insights in various aspects of these processes.

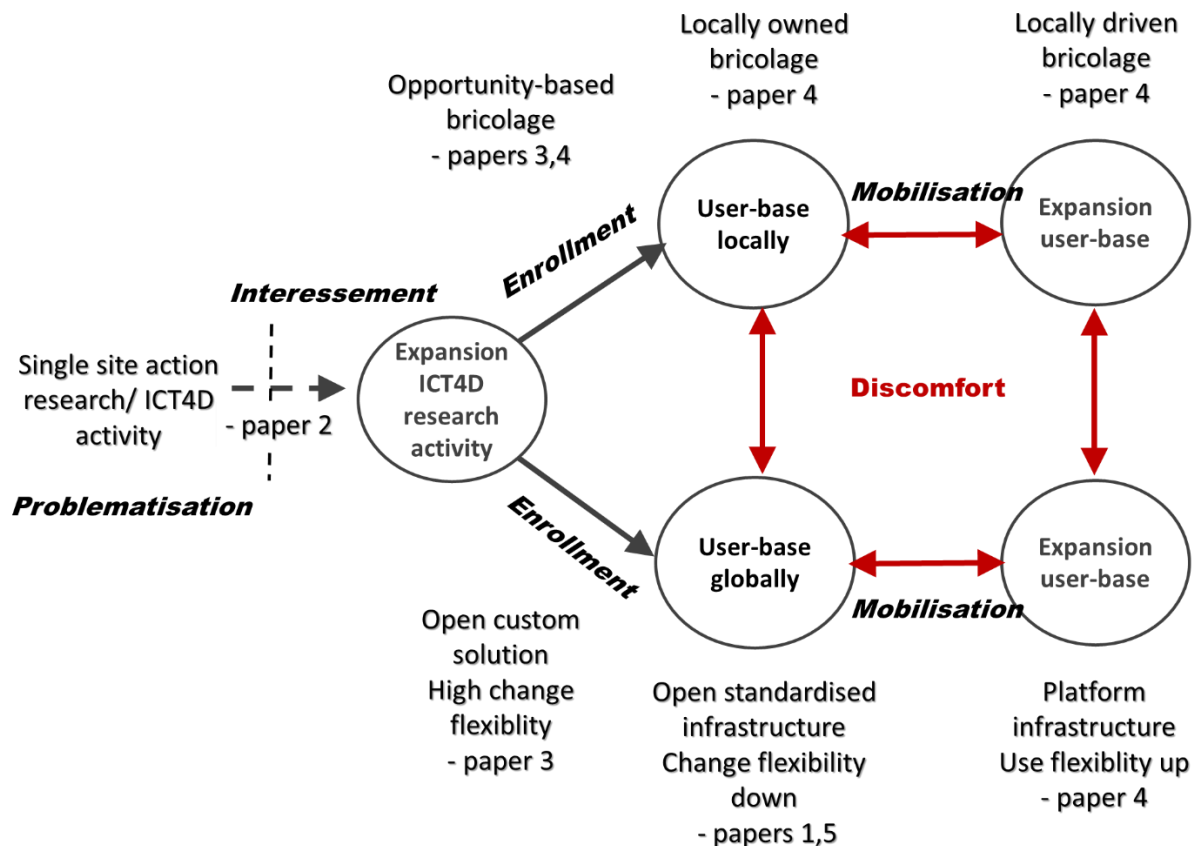


Figure 9. Synthesis of research findings

- From left to right, this figure starts with paper 2 which describes the (action research) origin of DHIS as well as how the HISP project expanded as more and more users from different countries were enrolled. It focused on the methodological implications of this expansion on the action research approach that started it. From here, two parallel trajectories start to emerge.
- Paper 3 focused on the role of a specific local implementation (in Sierra Leone) in this expansion that failed to enrol a stable local user base. This in contrast to a different local implementation (Tanzania) which managed to both enrol as well as mobilise a strong local user base through an evolving bricolage-based approach that was described in paper 4.
- These two different cases reflect a tension discussed in paper 1 and 5 in which infrastructures need to enrol and mobilise users both locally as well as at more ‘global’ levels. These papers illustrate the limitations of a flexible architecture in resolving this tension.
- Paper 4 finally looks at how this tension may be balanced when local projects are able to mobilise enough local users from where they can reap the benefits of a more global user-base and vice versa.

In figure 9, the highest levels of sustainability are a result of a balanced distribution of use flexibility once central and peripheral components of the II has matured (depicted on the right side of figure 9). The chapter also identifies a role for action researchers in monitoring (progress toward) this balance as a result of their systematically engagement in the network. The analysis presented in the next chapter will build on these trajectories, taking a closer look at how these interdependent networks are formed at each stage and are ultimately intertwined.

7 Analysis

In Callon's case (1986, discussed in section 5.2.1), the actor-network fell apart because the fishermen in St. Brieuc Bay started fishing again after some time. However, they did so at a very particular time: Christmas. What this shows about Callon's case, is that the fishermen were absently present in the network of the researchers. They were in the ability to make the entire network fall apart, and yet, they were missing in the plans of the researchers who did not foresee the threat that Christmas day posed to the network. And not only the fishermen: in a way, the entire french society and its traditions were absently present, in which scallops are considered an essential part of the Christmas menu. Rather, the research question of the researchers (the problem definition) around which the entire network was shaped, was defined by the researcher who wanted to understand how the scallop population could be saved from extinction. However, their research should have included an understanding of the motivations for the fishermen to fish for scallops. They may have sympathised with researchers because being able to fish for scallops in the future was in their own interest, but they could not afford not to fish for scallops at a time when the market for scallops was at its peak.

The reason I bring up this story here is because, until the Tanzania case, this research was subject to a similar weakness in that it attempted to address a collective action problem in understanding and enabling sustainable scaling processes. The research question was motivated by findings from the exploratory phase, in which the DHIS2 community of user representatives wanted more influence in the design process. Similarly, the RCAT intervention attempted to respond to these needs. However, funders and the extent of their influence on core development of DHIS2 was absently present in this network and the RCAT intervention and revealed through the RCAT case. The DHIS2 developers and management sympathised with this objective yet depended on their contracts with funders in order to sustain the development process on a daily basis.

This forced me as a researcher to look for another absently present group in the network; those that were able to work around core development, who had been able to turn a reduction in change flexibility at one interface into an increase in use flexibility at another. Of course, to enable this, flexible (platform) architecture is critical. However, even more critical, is that local developers are able to establish alliances that allow them to build capacity to innovate locally. The very same pilot-oriented donor/ NGO projects that make efforts to grow local capacity so challenging are

Absently present in the success of building local capacity. The alliance between a ministry and a university enabled local developers in Tanzania to thrive in an environment that is characterised by short-natured donor funding. In contrast, without such alliances, this short-natured donor funding is a threat to ICT4D projects. This is evident in the Sierra Leone case, in which action researchers relied solely on short-natured donor funding.

What is important then, is discovering the various constellations within a network that actors are part of, and how these relate to each other. By constellations I mean a composition of relationships between actors. Put simply, an actor is enrolled in and therefore part of the reinforcement of one network, until he is enrolled in a stronger network as a result of which reinforcement turns into 'betrayal' that happens because connections in the first network are weakened. However, as I will discuss in this section, betrayal or the risk of betrayal is not necessarily a bad thing. As such, the label of 'betrayal' in ANT is somewhat problematic. Also, because it adopts the position of one, dominant network that is 'betrayed'. As evident in section 6.2.4, this research proposes to discuss the previous tension as 'discomfort' in recognition that networks consist of multiple constellations that are in dynamic with each other. I will elaborate this in the next sections in more detail.

When we look again at the dynamics in figure 9, each circle can be seen to represent a constellation that gives rise to a new stage in the translation process. These constellations are dominating the network at different times in its evolution, enabling each other as well as conflicting with each other. This tension is responsible for the evolution of the network. Following an ANT perspective, these constellations can be understood as Obligatory Passage Points that define the formation of a network and the action that follows through which all interactions between the actors in the network are mediated (discussed in section 5.2.1).

In the following sections, I will first use this lens to explain how the previously discussed trajectories of the technology itself, of local implementations and action research, are founded in different OPP constructions that each have unique qualities in enabling a network scale in scope and size. This was illustrated in figure 10. Figure 10 can be seen as a new layer of figure 9.

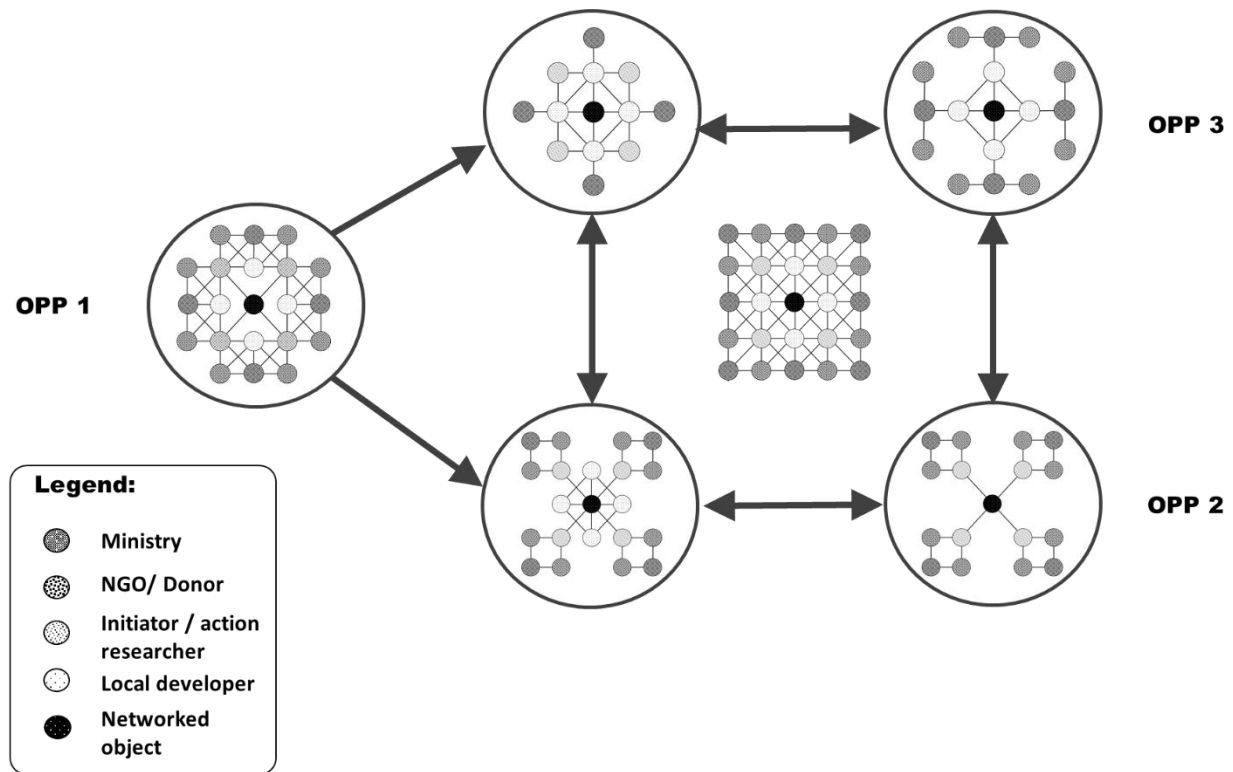


Figure 10. An ANT-analysis of scaling processes in DHIS2

7.1 Obligatory Passage Points

In figure 10, we can see that OPP 1 is highly dispersed on the outside (with actors interconnecting and therefore sharing power positions), whereas the centre is rather exclusive in nature. Both the constellations in between OPP 1 (on the left) and OPP 2 and 3 (on the right) represent a stage at which both OPPs still shared some of this complexity. While the actors were already mobilised and enrolled in their positions, actors are part of the periphery of OPP positions in which one or the other dominates. On the right side of figure 9 these constellations have settled, one could say these OPP positions have crystallised into a more extreme and refined state, with less overlap occurring between the two. Alternatively, the OPPs can be seen to move away from their heritage (OPP1) and develop more unique characteristics and places of their own. Because these states are not too dissimilar from each other, I will focus on discussing the ultimate states of these OPPs (2 and 3) onwards for the sake of clarity.

Importantly, because different components of the network are in different ‘moments of translation’, the network will be a mixture of ‘all happening at once’ (illustrated in the middle of figure 10 by an illustration of all the connections that are possible within the network in its totality).

We could imagine the different nodes of the network at the heart of the previous constellations to flicker like a gambling machine. I will nevertheless untangle these dynamics further in the following sections, with the logic that understanding what is happening in various parts may enable insight into their individual progression from the left to the right of figure 9 (and simultaneously, figure 10).

To explain this, it is useful to first look at what is at the boundaries of the network. Here, we find ministry and NGO-led programs that aim to achieve development goals such as ‘Global Health’. These actors require that data travels, whether or not in a coordinated way, in order to monitor and evaluate progress in relation to such goals. For instance, from the level of clinics and communities back to program managers for informed decision making. At this periphery we find the ‘installed base’ (figure 11); practices that are deeply ingrained in routines, unique use requirements that are context dependent, politics, and highly unstable resources.

The situation that is successfully problematised in the case of ICT4D intervention, and sometimes by action researchers. Or, in the DHIS2 case, by both. They establish that in order to reach the previous objectives, peripheral actors require a certain technology that furthermore presents a better alternative than the present situation or alternative solutions at hand. From here, a process starts of weaving connections a specific solution (for instance DHIS2) as a technical object and those actors who implement programs in a complex and challenging environment. Ciborra (1997) would refer to this as alignment (discussed in section 2.1). Importantly, this relationship involves a dynamic between local and global which requires that it is flexible enough to remain locally appropriate as the network grows and as use requirements change over time. These connections are woven based on OPPs.

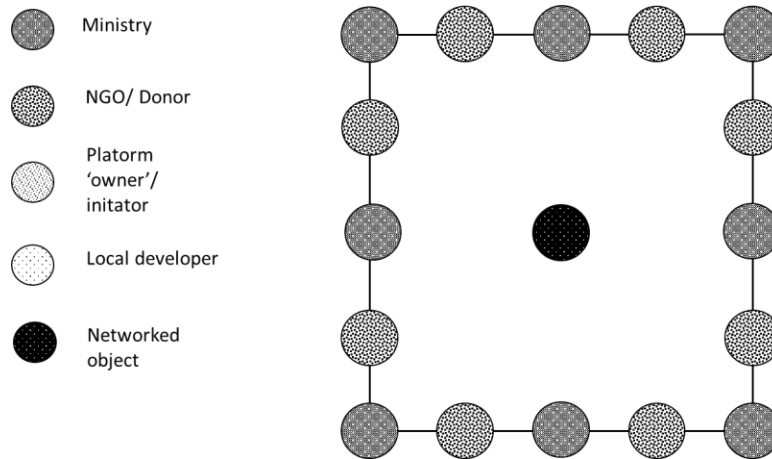


Figure 11. The installed base

7.1.1 Obligatory Passage Point 1: Scaffold and Bootstrapper

The first OPP that emerges in the HISP network is action research-induced. The OPP in this network of actors starts off around a solution encapsulated by the initiating actors in the role of action researchers, who act as a scaffold that is designed to enable local experts to join the initiators in the OPP construction to and act as representatives of the networked object. They can make local adaptations, and the researchers claim responsibility for the objects ‘core’ which improves as they take it to different use contexts. This was illustrated in figure 12.

This means that in its core, this approach is suitable to scale both in size and scope – which is at the heart of the Networks of Action argument (Braa *et al.* 2004). This network within the network obtains similar functions as the initiators, in that they become a spokesperson and further mobilise the network. In this case, the notion ‘to adopt an innovation is to adapt it’ (Akrich 1992 p. 209) could not be more suitable. In the words of Akrich (1992 p. 209) *‘[the stake is] to identify the users who are in the best position to transform the innovation and to bring it to meet the demand of other users. To interest and to transform are two faces of the same reality.’* While in theory the code is still open sourced, the access of local developers to the technology is reduced compared to DHIS1 which was designed to function rather independently from other installations. As noted in chapter 2, the open source approach in which software ‘forks’ are attempted to be integrated into the core proves ineffective as both the size of the network and with it the demand for new functionality and complexity of the core increases.

In addition, action research is not systematically applied to create long-term local capacity. In the Sierra Leone case, we see that attracting high levels of knowledge and skills to smoothen the adoption process involves donor-funded staff who have the availability and resources to devote themselves fully to the implementation process, but also tend to operate based on unstable and short-term commitments. Despite a failure to systematically develop local capacity, action research proves an effective way to grow the network regardless of whether all individual use-cases can be sustained. As argued in paper 3, this makes that the role of AR in contributing to sustainable ICT4D is more of a network-generating nature in which a critical mass (or network) is created around the use of AR-based solutions. One could say the AR method becomes an effective bootstrapping approach (as discussed in section 2.2). First, because users willing to adopt a technology need to be identified in stages because they hold different interests and persuading them requires solutions to be tailored to their use-cases. Through this tailoring process, the core of DHIS2 is improved. However, in this constellation, there is a single OPP around the software.

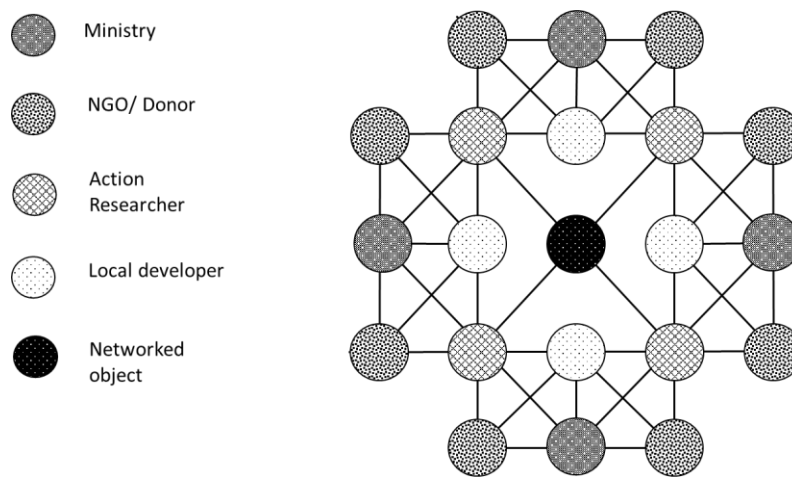


Figure 12 . OPP 1: Scaffold and Bootstrapper

Two more constellations emerge as the technology moves out of the previous ‘bootstrapping’ phase in which change flexibility was facilitated by researchers and core developers at UIO, which had an important function in enrolling a critical number of users. Through this process, the technology matured into an infrastructure. However, this OPP proved to be not solid. It was of a temporary nature and generally more focused on the networked object at the centre than on the capacity of actors at the periphery.

7.1.2 Obligatory Passage Point 2: Enabling Control

The previous techno-centric focus is amplified in OPP 2, which was illustrated in figure 13 and will be discussed in the next section. At this stage, a critical user base is reached. This not only allows for a reduction in change flexibility, it is also necessary to make the core of the system more stable. A platform architecture is deployed and nurtured to make sure fewer changes to the core can be compensated for a more modular use interface which can be expanded. In addition, increasing scale of the user base as a result of the previous OPP has attracted a new user base. This user base is receptive to a business model which enables the initiators to build an organisation on a more sustainable model in which dependency on decreasing research funding is decreased and the function of the research ‘scaffold’ weakens. Instead, development increasingly follows a ‘premium’ model in which use flexibility for contributing users is accommodated by core developers and made available to a larger user base without such privileges.

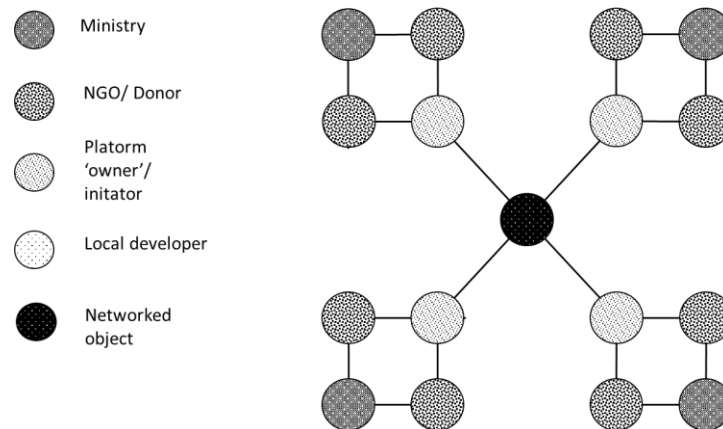


Figure 13. OPP 2: Enabling Control

7.1.3 Obligatory Passage Point 3: Enabling Flexibility

The formation of the previous OPP implies that use flexibility for less-resourced users depends on a growing base of local developers. The Tanzanian case is an example of a case where use flexibility of ministry users (as non-contributing users) is secured through a parallel model which allows for local innovation. This was illustrated in figure 14.

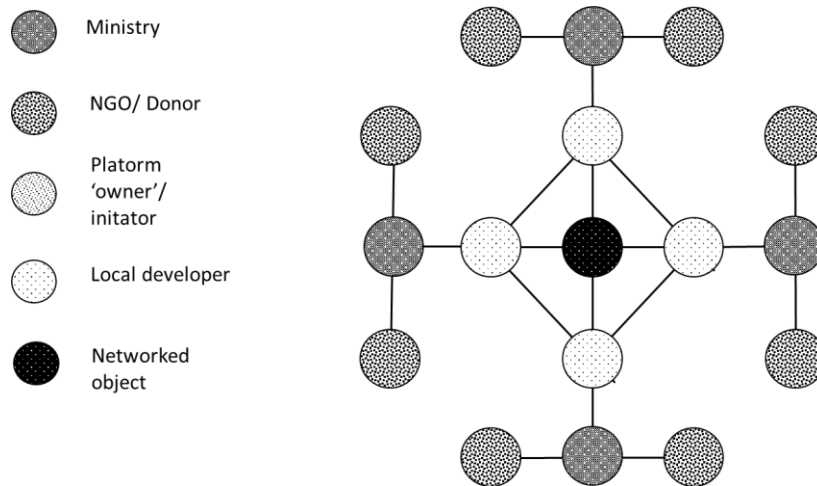


Figure 14. OPP 3: Enabling Flexibility

As mentioned, this model in some ways emerged in response to a tension with the previous OPP in which control was increased and change flexibility reduced. As discussed in section 6.2.1 enabling use-flexibility without depending on UIO required a re-use strategy that made it possible to extend the initial user base locally. This re-use strategy was a result of a strong existing user-base, which had emerged from a somewhat serendipitous pattern of through which alliances were forged and experiences were accumulated within the team. Notably, this approach would not work had there been multiple HISP nodes active in one country. The mutually beneficial relationship between implementers and ministries needs to be based on strong, monopolistic alliances- which is why universities as public institutions are generally a good format to provide technical support. However, there are no indications in my data that other constructions would not work equally well, as my data on such alternative constructions is limited.

7.2 Why Scaling Should be Uncomfortable

As apparent in chapter 6, part of my thesis has focused on taking away tensions and discomfort (with for instance collective action strategies) to distribute decreasing space for change flexibility more evenly among different user groups. However, it was not until the Tanzania case that I realised that discomfort was also an essential aspect of scaling processes of ICT4Ds. Having said that, it is important to make sure discomfort is not excessive – too much discomfort and networks or specific ties within the network will collapse. This was illustrated in figure 15. This means that the tension resulting from different OPP constellations in the network ideally remain in the middle

of the bell-shaped curve and prevent that any of its actors are too comfortable or too uncomfortable. For instance, external consultants will be more likely to be located on the left-hand side of the bell-shaped graph because they do not have to worry about their long-term engagement as a result of short-natured contracts. Paper 4 discusses how local developers may be at higher risk of landing on the other end of the graph where survival is under constant threat and hampers local innovation.

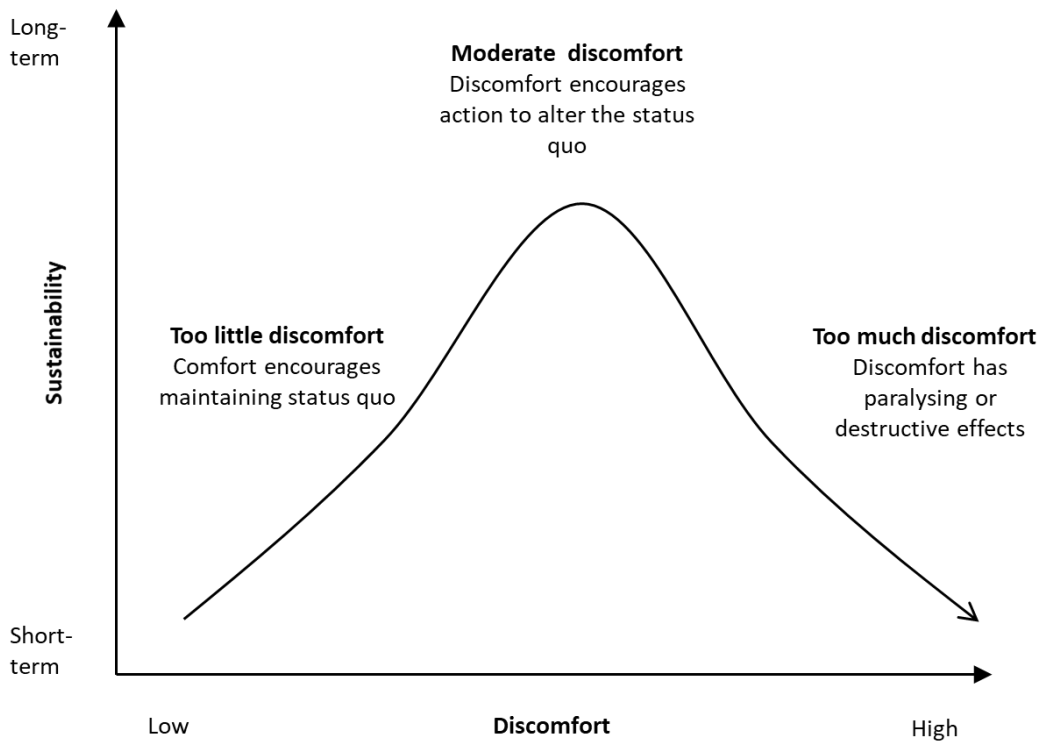


Figure 15. Relationship between discomfort and sustainability

As mentioned in section 2.1, sustainable levels of scale are not a state, it is a dynamic ‘working relationship’. This is related to the way a somewhat ‘healthy’ amount of discomfort is perceived to depend on whether discomfort contributes to the generation of momentum or paralyses it. Ideally, in networked ICT4D, there are four actors that get uncomfortable: the action researcher, the core developers, the local developers and the networked object itself (in this case, DHIS2) which shapeshifts in the tug of war between the previous actors, resisting some requirements and being surprisingly enabling of other. Potentially, other actors like NGO’s and ministries would also experience such cycles, however, data from this study alone is too limited to incorporate these actors into the equation.

Like Callon and Law (1997 p. 172) write, it is often uncertain how entities (networked objects)

will behave without trying it out in practice. What form it might take, whether it is going to act like a real agent, resist, and modify the actions of others. This case also illustrates how ICT4D infrastructures as artifacts are equally shaped by its network, while at the same time acting upon the network in that inherently too has politics embedded into it (Winner 1980).

7.3 Summary

This chapter has explored the scaling of a large scale ICT4D project as a translation process in which translators place themselves in obligatory passage point positions that may shift over time. These obligatory passage points can be used to bootstrap a new solution; exert control and/or enable flexibility and all have an important function in building networks needed to sustain large scale ICT4D. Depending on the construction of these obligatory passage points, local networks may be sustained or break down. This analysis has revealed that:

- Efforts to sustain a global network require different obligatory passage points than efforts to build and sustaining local networks, and one can serve or hamper the other at different points in time. A flexible architecture can be a pre-condition for enabling a shift in obligatory passage points, but not a determinant.
- Action research may be used to start the network and enroll enough users. It risks that it places external researchers at obligatory passage points which may cause the network to break down once they leave. However, it can also be used to transfer obligatory passage points to local developers which may be used to hold the network together at times of pressure.
- Local networks may help global networks to grow in size and global networks may help local networks to grow in scope. While there is a healthy tension between the two, growing large scale ICT4D solutions in sustainable ways requires that both dynamics are nurtured over time.

8 Discussion

Findings in this thesis align with the picture sketched in the literature in which scaling is important for ICT4D solutions to become sustainable, however that scaling alone may not necessarily contribute to local capacity (Avgerou 2007) and can potentially even hamper it (Sahay and Sahay 2006). The Sierra Leone case in this study exemplifies that scaling a solution globally may provide individual countries with a safety net when faced with highly unstable and complex funding arrangements. While the scaling of ICT4D may increase the extent to which local governments become locked-in (Wade 2002), it does not increase their ability to facilitate changes necessary to their local systems in response to changing conditions of use. Accordingly, to confuse the sustainability of a solution with its scale in size would (and has in many ways) strip(ped) the word of any meaning. Strategies are needed to ensure those depending on local ICT4D implementations can keep up with changes that are needed over time.

Against this background, **this study has aimed to understand how ICT4D projects may become sustainable both as a result of - and despite of scaling processes.** It has sought for optimal levels of scale (both in size and scope) that enable local capacity and improvisation. The following research question was formulated to guide this quest:

What strategies would enable global ICT4D solutions to scale in a locally sustainable way?

To answer this question, this study was led by objectives that aimed to understand the dynamics between processes through which ICT4D solutions are scaled in size (expand their user-base) and in scope (enable dynamic networks around implementations).

In section 8.1, I first discuss how these dynamics are, in essence, power dynamics, in which processes (and accordingly strategies) of scale in size and scope may have both disempowering and empowering effects on each other. I then introduce terminology that enables researchers and ICT4D implementers to have honest debates about who benefit from scaling processes. In section 8.2 I unpack these dynamics in more detail and develop an understanding of how to design for sustainable levels of scale.

8.1 Understanding Scaling Strategies as Power Tools

Scaling strategies have the potential to both challenge as well as enforce existing power dynamics that surround ICT4D solutions. This becomes important when we consider the extent to which different users benefit from ICT4D interventions beyond the initial stages of ICT4D projects. In other words, scaling strategies have the ability to *(re)distribute sustainability*, in terms of *for whom* ICT4D are, become and remain sustainable as they are scaled up.

In relation to this, researchers have pointed toward the potentials of platform architectures to make large scale ICT4D more collaborative and responsive to a variety of needs (Braa *et al.* 2007, Reilly and Smith 2013). It is along these lines that Sanner (2017) points to the potential of generativity to create sustainable ICT4D solutions. However, this concept emphasises potentials of technology to facilitate unanticipated innovation through unfiltered contributions from broad and varied audiences. Similar to discussions around flexible standards (Braa *et al.* 2007) these benefits are perceived through the lens of initiators of scaling ICT(4D) solutions.

Findings from this study indicate that collaborative approaches, though in theory facilitated by flexible and open architectures, are unlikely to flourish in practice as a result of unequal funding arrangements and power positions. Without local capacity to innovate, flexible architectures remain rigid and users must compete for the attention of initiators of technologies to understand and respond to their needs. One way to think of this relationship is by comparing it to a candle. The wax has a potential to be liquified providing the environment can generate the right conditions (heat) needed to access its liquid state. Similarly, the real flexibility of a potentially flexible architecture is acquired in levels of use-flexibility. Accordingly, the mere presence of platform architectures won't alter the distribution of use flexibility among its users when change flexibility is reduced. This happens when ICT4D solutions are scaled and morph into large (platform-based) information infrastructures.

To illustrate this, figure 16 presents 3 scenarios that depict how the mere presence of the (platform-based) technology is only the foundation which allows for a range of dynamics to unfold in which use flexibility is more or less accessible to various actors.

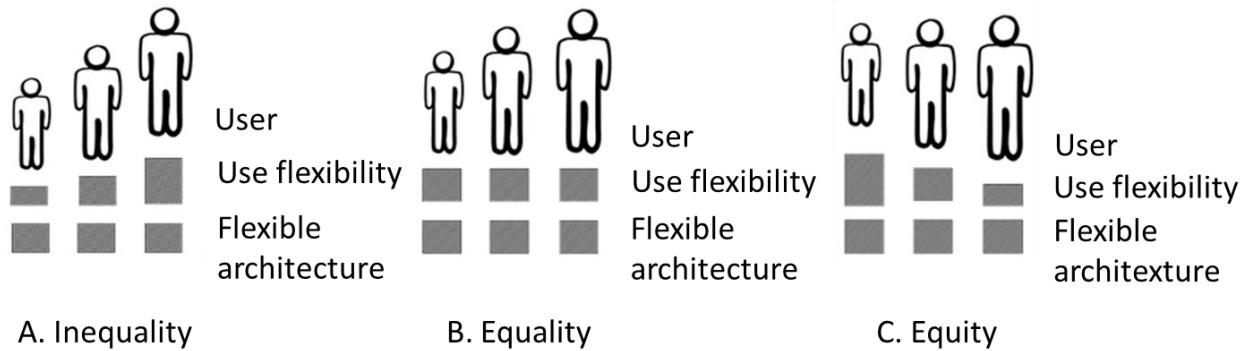


Figure 16. ICT4D use-flexibility scenarios

This means that strategies attempting to enable use-flexibility through flexible architectures are inherently flawed when the ability to change architectures is reserved for a select group with means to access initiators of ICT4D projects. In the following sections, I will discuss how these findings have two important implications.

First, they require increased recognition of the vulnerability of those in need of ICT4D solutions –often low resourced and understaffed governments or local NGO’s whose project-based activity may be clouded in uncertainty– among those leading and studying the implementation of large scale ICT4D. In particular, *during different stages of the design and scaling process*. To this end, I propose that the introduction of helpful terminology can be a relatively easy but potentially powerful first step in enhancing our understanding of how this vulnerability is affected as ICT4D projects scale.

It is with this rationale that I re-conceptualise ‘client system infrastructure’ in paper 3 as a term to discuss the development of a permanent level of activity around ICT4D solutions through which they can be locally maintained, adapted and extended (scaled in scope). As such, this terminology sheds light on a blind spot in present conceptualisations of sustainability that are based on limited understandings of scale (as a matter of size) or the mere exposure to flexible technologies without consideration for local capacity needed to access it. Specifically, I believe this terminology will enrich dialogues on how to scale ICT4D sustainably in primarily two ways:

- 1) By emphasising adopters of ICT4D solutions (such as governments) in low resourced countries are *clients* (in contrast to for instance a ‘beneficiary’ perspective) and part of a dynamic *system* that will change over time.

- 2) By stressing the need to think beyond ‘projects’ and consider what *infrastructure* needs to be in place in order for ICT4D interventions to be locally sustained and adapted.

Second, the notion that clients need infrastructure to receive, maintain and truly benefit from ICT4D solutions reflects a need for local actors to develop strategies that help them cope with funding gaps and knowledge gaps left behind by external experts. What is missing nevertheless is a workable strategic process that seeks to reveal how the generative potential of flexible architectures may be accessed to make solutions work locally, for individual users, over time as they are scaled. In the next section, I will attempt to address this vacuum.

8.2 An Alternative Approach Toward Scaling Sustainably

In order to sustain large scale ICT4D implementations, scaling strategies need to be designed with the aim of scaling ICT4D solutions locally. This study finds that in order to generate levels of local capacity needed to sustain an ICT4D solution locally, client systems don’t necessarily need to become independent from external funding sources; they merely need a way to attract a steady pool of *diverse* funding sources.

To achieve this, this study identifies two more conditions in addition to having access to flexible large scale ICT4D solutions. These are the ability to form strategic alliances (such as partnerships with local ministries) and the ability to show quick results. These two conditions need to be woven together, as elaborated in paper 4. Figure 17 symbolises how these conditions form a trinity of strings that together create a rope that grows in strength the more results are achieved and alliances are formed. The rope may be seen as an analogy that reflects the sustainability of the process. When some strings break, others will hold the rope together (at least for some time) protecting the ICT4D implementation from immediate collapse. This may enable local developers with just enough breathing space to bridge whatever capacity was lost. As such, this approach may protect grassroots approaches against the disabling influence of funders pointed out by Ali and Bailur (2007). This was illustrated in figure 17 (note that there is not an order to the layers of the strings).

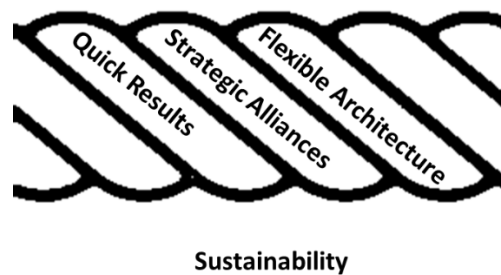


Figure 17. Sustainability in ICT4D symbolised as the strength of a stringed rope.

This study has identified that weaving this rope benefits from grassroot approaches that may be used to bootstrap systems locally, providing they evolve in a bricolage-like manner (Ciborra 1991), in which pilot projects present both a burden and an opportunity to build alliances that include ministries in developing countries as well as the technology itself. There is a strategic element to this tinkering in which opportunities are recognised and utilised and improvisation happens with resources available. When we continue to imagine the analogy of the rope, this would involve a local organisation climbing that rope and tying knots at various heights that enable them to pause, fall back, regroup and gather strength in order to climb further.

This was explained in more detail in paper 4. The Tanzanian case discussed in this paper illustrates a critical mass needs to be attracted and then successfully mobilised to attract a second ‘wave’ of users to cement the first user-base and achieve irreversibility. In this case, the limited change flexibility of the system enforced workaround strategies around its use. What made this case unique, was that this heterogeneity was, in some sense, designed for. A bootstrapping period that preceded the development of a critical mass (in order to convince the Ministry of Health) set the stage for a booming interest from a variety of users once a critical mass was reached. The fact the team was faced with a sudden rise in demand meant workarounds required a strategy of re-use, which as a result became generic enough to be incorporated back into the platform or added to its app store (increasing change flexibility again).

Based on the previous process, I develop a strategy to scale ICT4D solutions sustainably that extends the bootstrapping approach (Aanestad and Hanseth 2000). I conceptualise this approach as ‘bootstrapping both ways’, which can also be referred to in short as ‘2-way bootstrapping’. This strategy is based on findings that indicate that scaling sustainably is not only a matter of reaching a critical mass for information systems to reach developing infrastructure characteristics but about

extending it if they are to become sustainable in low resource environments. As such, a 2-way bootstrapping strategy is based on the notion that sustainable scaling process consist of two dimensions of scale (size and scope), and accordingly describes the attraction of a critical mass of users across these two dimensions to create robust global solutions that remain locally diverse.

The ‘global’ trajectory of ICT4D through which they are scaled in size enables information infrastructures to develop, mature and stabilise following the attraction of a critical base of users is needed to nest infrastructures into many environments (as discussed in paper 3). However, findings indicate that a similar pattern is just as crucial for the ‘local’ trajectory through which adaptation is enabled as a result of the development, maturing and stabilisation of local implementations as a result of the ability to expand the local user base (as discussed in paper 4). Rather than accidental, I propose the development of such trajectories should be part of a planned approach to make the infrastructure locally sustainable.

Figure 18 illustrates how change flexibility is reduced as a result of the successful scaling of a solution through a bootstrapping process. It also displays how, when change flexibility is reduced for the user once a critical mass was reached, use-flexibility needs to increase for ICT4D solutions to adapt to local use requirements. When a critical mass is obtained, a second bootstrapping process (which occurs in parallel) is needed to expand it locally in order to generate the use-flexibility needed to compensate for a loss in change flexibility. By strapping infrastructures to a heterogeneous user base, local developer teams are enabled to cope with the fragmented and short-term nature of resources available.

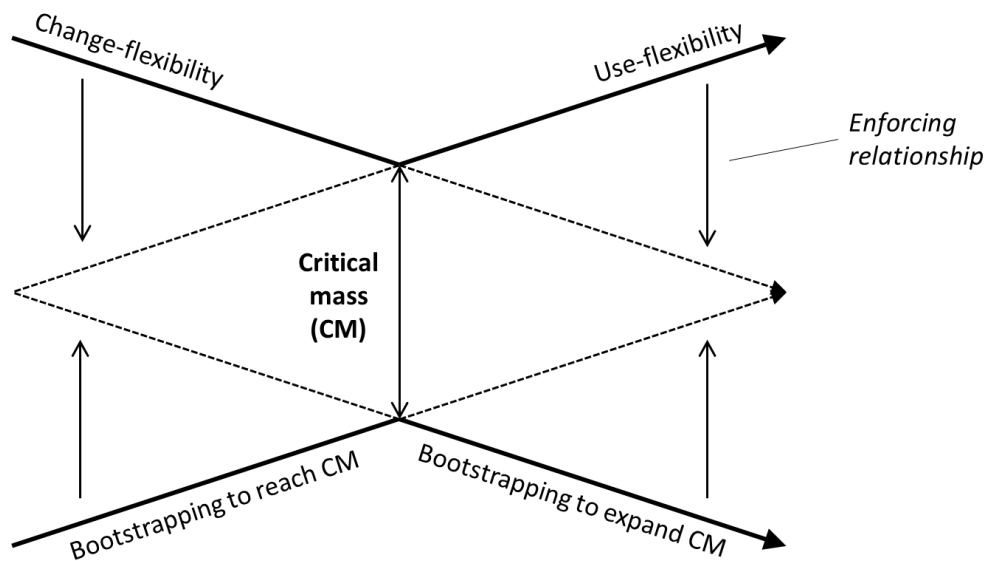


Figure 18. Bootstrapping and flexibility dynamics (inspired by Latour, 1999 p. 71)

Central to a 2-way bootstrapping strategy is the understanding that local capacity to maintain and develop II takes time to grow and needs a structure to lean on until it can stand on its own; yet at the same time, not forgetting to plant the seeds while this structure is put in place. After all, the objective of the scaffold is not to replace the tree. The scaffold owes its existence to the seed in the ground and the prospect of the tree. *If it weren't for the seed, the scaffold would be pointless.* Forgetting to plant the seed would be embarrassing and a waste of hard work, and yet in the ICT4D domain it is still an all too common mistake. On the other hand, the ability of the scaffold to protect the young sprout is limited; it will have to develop its own defences during periods of heavy rain or drought by adapting to its environment.

Following a 2-way bootstrapping approach, seeds sown during early stages of local implementations allow for local developer teams to represent Ministry users later in combatting an imbalance in use-flexibility once the platform is up and running. When this aspect receives less or unequal attention (for instance because the focus is on continuing the expansion of the 'global' user base as part of the Networks of Action approach by Braa et al. 2004), these users will miss out when local developer teams need to be ready to respond by increasing use flexibility independently from core developers (also discussed as generativity). This is important for them to attract a critical mass of users locally, thereby ensuring that the local roots of global infrastructures become irreversible in their local context.

What makes a strategy of bootstrapping both-ways different from how the concept has been conceptualised in the literature so far (Aanestad and Hanseth 2000) is that it theorises the bootstrapping process may be used to scale ICT4D sustainably providing a crucial aspect of the process is implemented *beyond* the critical mass of homogeneous users reached to root the system. Importantly, it also suggests that the selection of users required to ‘pull up’ a network around an ICT4D solution initially (Aanestad 2002 p .36) needs to change over time in order for that network to adapt and grow in size and scope. While the concept of bootstrapping recognises that the users that are part of initial networks through which information infrastructures are ‘bootstrapped’ are not equal to each other (Aanestad 2002), the concept of bootstrapping both-ways furthermore elaborates on this inequality by emphasising that these networks need to develop stakeholder-constellations that enable both control and flexibility (as exemplified with a series of changing OPP constellations in chapter 7).

The enforcing relationship between change flexibility and use flexibility is theorised to be a result of moderate levels of discomfort in the network (as discussed in section 7.3). However, as illustrated by the DHIS2 case central in this study, the networks that information infrastructures encompass can hold various levels of discomfort that can result in both destructive and reinforcing dynamics. Importantly, this also implies the success of bootstrapping has a momentum, in which the expansion of the global mass of users’ needs to align with an expansion of the local mass of users. In addition, while action research can be used to create such momentum, findings also point out a risk that networked forms of action research (Braa *et al.* 2004) disproportionately benefit the sustainability of ICT4D in size as opposed to simultaneously required trajectories of local scale in *scope* (as argued for in paper 3).

8.3 Summary

This chapter returns to challenges set out in the introduction of this research which outlined:

- Efforts to sustainable scale ICT4D are complicated by tensions inherent to II, namely: the need to scale in scope and size as well as reduce and stimulate flexibility for various users over time and;
- Knowledge about how these dynamics play out as ICT4D become infrastructured is limited.

As reflected in the literature discussed in chapter 2, it is easy for researchers to focus on architectural potentials in the midst of this tension and forget about who benefits most from flexible solutions and the capacities this requires over time.

In line with objectives to understand how scaling strategies may be used to nurture ICT4D locally during different stages of scaling process, this chapter formulates a response to the previous knowledge gaps by reflecting on efforts undertaken in this study to unpack the scaling of II as longitudinal networked undertakings between funders and external experts and their ability to both hamper and enable the development of local capacity needed to scale ICT4D infrastructures locally.

The second part of the chapter offers ICT4D implementers and researchers a way to design for and study sustainable dynamics of scale from the start (as well as retrospectively) by ‘bootstrapping both ways’. This approach expands current strategies available to ICT4D implementers and researchers to ensure their large-scale solutions gain strong footings in developing country environments and, in line with their premise, (continue to) serve the needs of those who need it most. In addition, this study enhances the vocabulary available to researchers in support of their attempts to develop a language that allows them to discuss sustainability and scale as intertwined phenomena in all their complexity while maintaining a user-centric focus throughout.

9 Conclusion

In 2016, the Chilean architect Alejandro Aravena won a prestigious prize; not for the parts of the building he designed and built, but for the parts that he left out and that enabled that building to grow without his involvement in the future. The low-cost houses he developed invite home owners to expand their houses, equipped with all the essentials, as their resources and families grow and what they look for in a home changes over time.

Sustainable Information Infrastructures resemble these emergent houses in that they start with a flexible architecture and, as noted by Star (1996), need to become *‘an unambiguous home—for somebody. This is not a physical location nor a permanent one, but a working relation— since no home is universal.’*



Image 12. Half a home. Chile, 2013, by Alejandro Aravena's Elemental practice.

Source: <uk.phaidon.com>

This thesis has sought to understand this working relation to learn what strategies would enable global ICT4D solutions to scale in locally sustainable ways. This effort was developed in 5 papers that unpack both the frictions and synergies between the local and global operations of a large-scale information infrastructure (DHIS2). Findings of this work offer researchers as well as ‘home-owners’ of large scale II with a strategy to build the ‘other half of the house’.

This work is based on a limited amount of empirical data derived from a retrospective analysis of longitudinal DHIS implementations in Tanzania and Sierra Leone and insights in the overall

collaborative development process as orchestrated by core developers in Oslo over a 3,5-year period. Specifically, findings offer insights into how local implementations of global large scale ICT4D may continue to be developed organically and driven locally as they grow more complex over time. Based on these insights, the study contributes with an alternative strategy toward scaling ICT4D projects, referred to as a ‘2-way bootstrapping strategy’. As the naming suggests, this strategy extends the bootstrapping concept as introduced by Aanestad and Hanseth (2000) in that it engages with scaling processes along both dimensions of size *and scope* and elaborates on the importance of their dynamic in realising sustainable growth of ICT4D.

Practically, this strategy offers ICT4D project managers and ministries insights that can help them to understand the sustainable course of their II implementations. Such knowledge is considered especially important given developing countries are increasingly locked-in to using large scale (platform based) ICT infrastructures. The holistic nature of this approach offers an alternative to existing strategies that are based on one-dimensional perspectives of scaling processes of ICT4D solutions or foreground the role of flexible architecture in contextualising large-scale solutions. Theoretically, this strategy offers those studying large complex ICT4D infrastructures a way to navigate the grey area that exists between strands in the ICT4D research domain that examine technology transfer and its embeddedness separately.

The real developmental impact of ICT4D solutions will be related to how sustainable their implementation is for those whose problems they are aimed to solve. While researchers have pointed out threats of short-term funding arrangements for local ICT4D implementations, this study identifies a need to better understand the various ways in which funding arrangements around large scale IC4D solutions affect their local implementation long-term. Accordingly, the influence of such arrangements with an emphasis on the development of local capacity and the role of local innovation would be another pertinent topic for further research.

I furthermore hope that the findings presented in this thesis will encourage researchers to engage in honest and constructive debates about the sustainability of ICT4D solutions that are grounded in understandings of who benefits from scaling processes. Further studies that are focused on analysing shifting power dynamics in the networks that surround ICT4D as they are scaled over time could be valuable in progressing this debate further.

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Appendices

Appendix 1

Fruijtier, E. and Pinard, M. (2016), 'Collaborative Development of Global Information Systems: Toward Community Based Generification'. *The Electronic Journal for Information Systems in Developing Countries*, 73

COLLABORATIVE DEVELOPMENT OF GLOBAL INFORMATION SYSTEMS: TOWARD COMMUNITY BASED GENERIFICATION

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ABSTRACT

This paper examines generification in open source software development of information systems for low resource environments. The challenge addressed is that of designing generification processes in which key aspects of generification – information flow, selection and prioritisation – involve a distributed community. The objective of this study is to understand how this challenge is dealt with in practice, with the aim of expanding the current analytical scope available to researchers to study generification processes as well as the guidance available to practitioners to address its practical challenges. Doing so, we build on the work of Gizaw et al (forthcoming) who broach a debate on more ‘open’ generification. We propose a reconceptualization of open generification by being more specific on its conditions and process aspects. Open, we argue, is about closed generification circuits that enable a ‘community based’ generification process.

Key words: Generification, Open generification, Open Source Community, Global Information Systems

1. INTRODUCTION

In collaborative software adaptation, the process of making IT artefacts suitable to requirements or conditions for its use is the act of (groups of) individuals who are required to correlate social and technical processes in the interest of designing functional information systems (Scheil 2008). Open source software (OSS) communities are apparent examples of such collaborative efforts given the high degree of cognitive independence among actors and effective coordination of knowledge and actions required for successful decision making within these environments (Yoo & Kanawattanachai, 2001 p.188). However, a shared interest in partaking in design does not imply unanimity. The collaborative development of complex systems is a dynamic process underpinned by actors’ different ideologies, that influence the development and scalability of the system (Constantinides & Barrett 2014).

In the negotiation of common interests, a global network of stakeholders involved in the act of collaborative IT adaptation faces two challenges inherent to (two opposing requirements of) system development. These are 1) the development of a system for use across an organisation requires the negotiation of shared interests (focussing on harmony) and 2) the development for use in particular parts of that organisation requires the negotiation of solutions that fit best to a local context (focussing on availability of alternatives). The software development and adaptation process thus involves a compromise between harmonic requirements and local alternative solutions.

The process of compromise in software development whereby a diversity of ‘local’ requirements of different user groups of a product are channelled, filtered and prioritised to inform ‘global’ design features that work across a diverse range of organizational contexts is also referred to as ‘generification’ (Pollock et al. 2007). Generification could thus be seen as the compromise reached as an outcome of negotiating between local and global requirements.

We know that in firms, the generification process of selecting and prioritising user needs tends to be shaped by management (ibid.). In comparison, open source development

design processes are perceived to be much more participatory. Nevertheless, given the aim is to cover universal aspects of local requirements (Camara & Fonseca 2007), this approach is equally bound to addressing a selective range of user needs. Here, the word ‘community’ in describing open source communities becomes problematic due to its implication of a sense of unity (Gherardi 2009) when in fact, this unity requires the constant negotiation of conflicting interests in order to develop a generic product. Especially when an open source community involves many different stakeholders, interests may differ greatly. For instance, there are also dictator-led communities in which decisions on direction, focus and contributions are made by visible leaders (Bacon, 2009 p.222).

This creates a paradox in OSS communities that are concerned with the development of a generic product, as more ‘bottom up’ generification processes need to channel the needs of a wider community. The challenge is how to deviate from issues associated with a top-down process of generification whereby information from different user groups is valued differently by managers (Pollock et al. 2007). The objective of this study is to understand how this challenge is dealt with in practice, with the aim of expanding the current analytical scope available to researchers to study generification processes as well as the guidance available to practitioners to address its practical challenges. Doing so, we build on the work of Gizaw et al (forthcoming) who broach a debate on more ‘open’ generification. In steering the research toward achieving its objective, the following research question was formulated:

What mechanisms facilitate generification processes by a globally distributed open source community?

This paper proceeds by outlining a discussion of current conceptualisations of generification in networked practices in section 2. A description of our methodological approach in section 3 is followed by a description and analyses of the empirical material gathered in relation to the collaborative adaptation of a FOSS called DHIS2 in sections 4 and 5. In section 6, we examine how a process perspective can be used to contribute to a networked understanding of generification. We conclude our paper with concrete suggestions for researchers who wish to take this debate further.

2. LITERATURE REVIEW

In the previous section it has become clear that the generification process is concerned with the trade-off between particularisation and generification that requires eliciting general requirements from the particular requirements of a few users; assessing how particular these requirements from the few users are and whether diversity should be built into the system or if functions meeting these particular few should be customised locally (Johannessen & Ellingsen 2009). As the word ‘trade-off’ implies, this is not only a logistical but also a political process.

Generification processes within collaborative development processes as part of OSS communities have been subjected to a limited amount of research. As noted by Lanzara & Morner (2003 p.1), ‘*open-source software development poses a theoretical challenge to conventional ways of conceptualizing knowledge processes within and across organizations*’. The authors (ibid.) have attempted to bridge aspects of this gap by developing theory on how virtual communities of open source developers use tools for distributed collaboration. However, this analysis limits itself to an information transfer approach to knowledge sharing and does not consider the selection process of this information central to generification.

A recent study that specifically focuses on the generification process of an open source community was conducted by Gizaw et al (forthcoming) who, in an attempt to challenge the top-down nature of generification processes, introduce the concept of ‘open

generification' as a more democratic alternative. Open generification acknowledges the need for and the feasibility of generic software and in addition proposes an alternative model for the governance of it. They define this form of generification as follows (ibid. p 1):

'Open generification is not about managing the community of users attached to a software package by homogenization or segmentation, but aims at addressing the diverse needs of the community the software is expected to serve.'

Open generification aims to challenge the limitations of what we could perhaps consider to be more 'closed' generification, characterised as top-down (dominated by the software vendor) and 'somewhat manipulative' as it treats user groups differently (ie. not according to their needs, but according to their customer value). Their analysis complements our knowledge of generification in a valuable way, by emphasising the importance of perceiving the development of generic systems from the user's point of view. Following a process of embedding, local developers can create local alternatives that suit local user needs. This 'embedding' then informs a process of 'disembedding', through which management decides which local alternatives need to be made generic (integrated in the 'global' product).

One of the important strategies in this process emphasised by Gizaw et al. (ibid.), is to decrease the level of dependency between actors by facilitating the development of local alternatives. Emphasis is on the FOSS characteristics of the product itself, which enables a way for global developers and local developers to negotiate features through a process of embedding and disembedding. The FOSS characteristics allow for innovation outside the realm of a central actor which can be fed back into the generic software and therefore transferred to other settings. We have conceptualised the (open) generification process in figure 1 as follows:

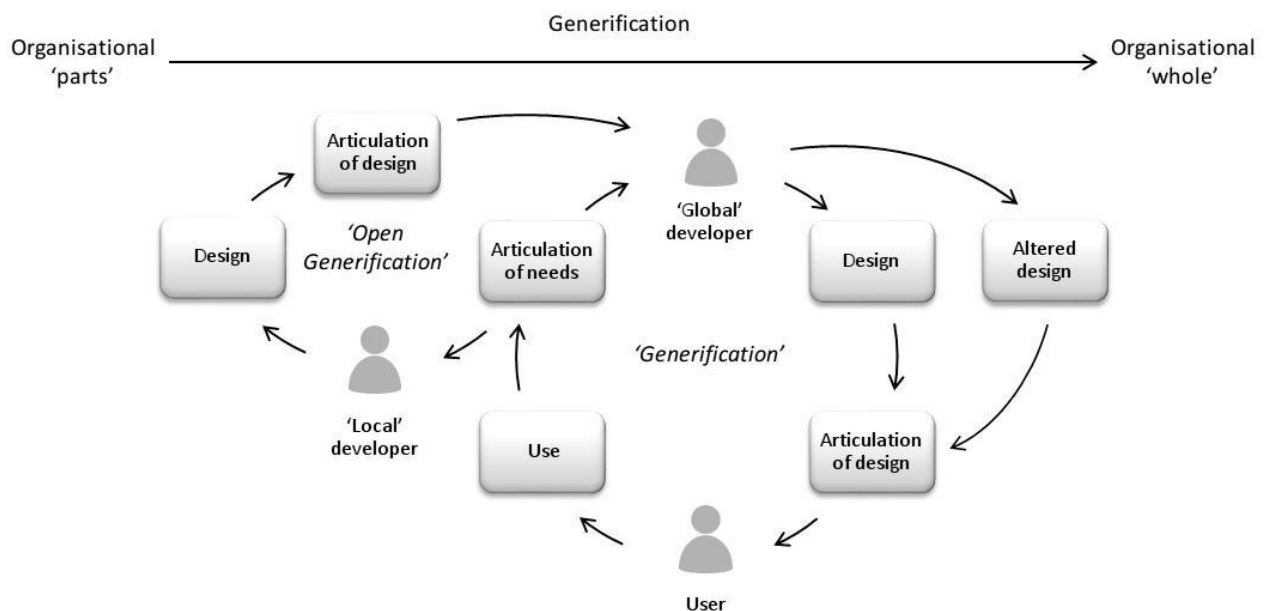


Figure 1. Conceptualisation of the Generification Process

Figure 1 illustrates a design cycle that starts with a (global) 'designer who articulates a design, which is then tested in use. This in turn generates feedback for the global designer following a generification process. In Open Generification, local designers improve the design (creating a 'branch') to meet user expectations and communicate this back to the

global designer instead. What makes this process ‘open’ is the porous membrane provided by accessibility to the core code for external developers through which local ‘alternatives’ can be built and made generic. Open generification in this sense involves a shift in attention, from managing the requests of several types of users to managing (‘disembedding’) the requirements of a community of local developers instead. Since disembedding is part of conventional generification, it is unclear to what extent this process is not prone to the same limitations of being top-down in nature and motivated by the added value of user representatives.

We are inspired by this work, which we perceive to be the groundwork for our study. However, we also identify some aspects of the open generification process that require further exploration. Unlike Lanzara & Morner (2003), it remains unclear to us what mechanisms and tools are used to orchestrate the open generification process. How is ‘embedding’ and ‘disembedding’ enabled and disabled? We foresee such insights will generate a more in-depth understanding of what gives generification its ‘open’ nature, other than the characteristics of the software product or the type of community involved compared to more traditional generification processes.

In our analysis, our conceptualisation of the open generification process differs from the conceptualisation offered by Gizaw et al (forthcoming) in one important way. In the example used by Gizaw et al, the local designers access the core code to create a ‘branch’ (also referred to as forking of the core code). A fork occurs when developers take a copy of the source code of the software and start independent development on it, creating a distinct and separate piece of software. This becomes problematic when a fork created to address a local problem may not be brought back into the source code of the systems’ generic core. As discussed by Manda et al (2014), the disadvantage of developing such software ‘forks’ is that the user eventually can no longer benefit from later versions of the system and the advantage of consulting the wider community, which is especially critical with a high release pace. However, in the case discussed in the study by Manda et al. (ibid.), these disadvantages compete with the situation of the user that may require urgent adaptation, which is why generification processes that adequately channel user needs are crucial.

Accordingly, we will conceptualise the ‘open’ nature of this process not to depend on designers branching and negotiating the branch to be part of the ‘trunk’, which as seen in the case example provided by Gizaw et al is a difficult process. Instead, we depart from the assumption that local designers do not touch the trunk and instead propose suggestions to it in the form of ‘blueprints’ which can be seen as proposed pieces of code that can be pieced into the source code. This changes the conceptualisation of open generification in important ways because it reflects on the traditional ‘generification’ aspect inherent to ‘open generification’ rather than the alternatives it offers to generic design. This implies that in figure 1, the ‘design’ box on the left concerns a blueprint (or an application on the software platform that does not depend on integration) and not a ‘branch’ of the source code.

Interestingly enough, descriptions by Johnson et al. (2013) of the very same empirical setting that inspired the conceptualisation of the ‘traditional’ generification process (Pollock et al. 2007) has overlap with conceptualisations of ‘open’ generification by Gizaw et al (forthcoming). A commonality between these works is that a group of ‘power users’ (Volkoff et al 2004) or local designers in the case by Gizaw et al (forthcoming) play a central role in communicating needs of the user community. In the case of Johnson et al (2013), we furthermore see these mediators are able to increase their influence in the generification process over time. Johnson et al. (ibid.) conceptualise these mediators as ‘prosumers’; collective fora which – though providing the space for independent action and innovation by users – are managed by the company who enables (influential) relations as well as disabled them. However, Johnson et al. (ibid.) note how this nevertheless requires collaboration with

the user community. Their work highlights how consumer-company interactions are complex evolutionary duals in which users attain skills to promote their idea's to designers, and designers attempt to remain control over their user communities. Having access to the same empirical case which inspired the 'open generification' approach, this research will explore the grey area that emerged between these cases in search for specific aspects of the embedding and disembedding process that make generification processes more open.

3. METHODOLOGY

This study is a naturalistic enquiry of participatory processes within the networked development of a free and open source software called DHIS2. A naturalistic inquiry is founded on the primary belief that phenomena should be studied in context (Frey, L., Botan, C., Kreps 1999 p 258). In line with this approach, both authors have been longitudinally involved in the activities of the HISP UIO node within the network over a period of respectively 1,5 (primary author) and 3 years (secondary author). During his involvement, the second author has experienced working closely with the development team within HISP UIO as a DHIS2 Academy and Community Coordinator. This insider perspective has been an invaluable contribution to understanding design processes and practices related to DHIS2.

3.1 Data Collection

Longitudinal exposure has enabled the authors to gain a real life understanding of processes within and outside the HISP UIO development node. During this time we made observations; participated in many presentations; conference calls with external experts and had informal field consultations with key informants. Both authors have furthermore participated in so called 'DHIS2 academies' which enabled access to various actors at different levels of the network and exposure to interactions between them. Observations during these events were documented in the form of descriptive field notes and included a one-day field visit to a local NGO. In addition, we had access to the tools used by the community for collaborative development; email lists with interactions between users, local developers and core team developers; various documentation (ie. strategic document, evaluation report) and a large volume of publications (including MSc and PhD theses) to deepen our understanding of development processes surrounding DHIS2.

The evidence presented in support of this particular case was derived primarily from 4 sources. First of all a series of recorded semi-structured interviews conducted with 10 experts, key informants and users of the software (table 1). Interviews lasted approximately 1 hour and were all recorded with exception of one interview which was documented manually. Secondly, a focus group was held with 5 HISP nodes and experts hosted by the second author in his role of DHIS2 Academy and Community Coordinator. Third, a community assignment was designed by the authors to derive input from a group of approximately 70 participants of a 6 day DHIS2 expert academy which hosted a selective group of primarily DHIS2 experts and developers from all over the world.

For the community assignment, the community present during this expert academy was divided into different user groups and assigned the task to first gather and then select methods for the community to address some of these challenges identified. Groups were formed based on their common knowledge (ie. (I)NGO's, consultants, HISP nodes, core team, researchers etc). A shared folder in *Google Drive* was used as a medium for both the authors as well as the participants to access the achievements of the various groups. The different group assignments were then collated and results were themed (ie. roadmap, documentation, translations, bug action, training, apps etc). New groups were formed based on random selection and asked to come up with practical suggestions in relation to one of the themes.

Table 1. Interviews

No.	Participant affiliation	Topics covered:
1.	HISP node (country A)	- Role and responsibilities
2.	HISP node (country B) / Ministry of Health	- Enrolment into community - Adoption & adaptation of DHIS2
3.	HISP node (country C)	- What does being a HISP node entail (when relevant)
4.	HISP node (country D) /HISP consultant	- Types of users reached and their capacity/skills - Collaboration with other nodes and core team
5.	HISP node (country D)	- Attendance of- and experiences during academies (when relevant)
6.	HISP node (country E)	- Tools and fora available for collaborative development (when relevant)
7.	NGO (country E/ user)	- Provision of user trainings (when relevant)
8.	Ministry (country E/ user)	
9.	Consultant (donor community)	
10	Consultant (HISP UIO)	

3.2 Data Analysis

Interviews, the focus group discussion and field notes taken during the expert academy were transcribed, coded and themed. The outcomes of the first part of the community assignment were summarised under three categories (table 3 left column), and compared with practical solutions from the second part of the assignment (table 3 right column). This categorisation was not an outcome of the exercise, but emerged from the analysis. This resulted in the overview provided in table 3. Processes are highlighted in *italic* when they were already ongoing during time comments were raised, processes in **bold** are emphasised by the community involved in the exercise as having priority.

After condensing the raw data we focused on eliciting relationships between the various stages of the development process and the types of actors involved. This stage of the analyses involved identifying and mapping out the various layers of the distributed community of actors involved in the generification process. To construct our analysis, we distinguish across two layers of the adaptation process; the different type of adaptation and the different actors involved. We follow the terminology of Grisot et al. (2014) and Star & Ruhleder (1996) to zoom into four types of adaptation: adaptation ‘*of, in and on*’ the system. An extra dimension, adaptation ‘*to*’, was added to describe those development processes which attempt to enable information systems to connect to other information systems and therefore relate to its placement in a wider ‘ecosystem’ of systems. This was illustrated in figure 2.

In addition, the various actors involved in collaborative software adaptation process may be perceived to broadly represent meta-designers; collaborators; contributors and consumers as categorised by Fischer (2009). This was illustrated in figure 3. The scope of this paper focuses but is not limited to those levels of participation which essentially describe the generification ‘agents’ in globally distributed software design. These agents are located at ‘contributor’ and ‘collaborator’ levels which mediate between the invisible users as consumers and developers as meta-designers. It is therefore at these levels (Gizaw et al (forthcoming) refer to these levels as ‘local developers’) that requests and needs can be elucidated to enable a generification process

We then adopted a process perspective in order to gain a deeper understanding of the dynamics between these actors, their involvement and the stages of the development process and the mechanisms at their disposal which enabled this involvement. This led to a second series of more detailed, holistic displays (figure 4) that captured the phenomena that was observed. Finally, an abstraction of these more detailed displays led to the creation of a conceptual framework (figure 5) that enabled us to enter a dialogue with the literature.

4. CASE DESCRIPTION

DHIS2 is an free and open source software tool (FOSS) to collect and analyse health data which is accessed at local, regional (district) and national level for monitoring and evaluation purposes. The development of the DHIS2 is the result of a collaborate effort between the University of Oslo and a wider network of partners united under the Health Information Systems Program (HISP) to improve health systems in low resource settings. DHIS2 is primarily used by Ministries of Health (MoH) and large international NGO's. Today, the HISP initiative is comprised of a global network of actors from over 60 countries.

In the development of DHIS2, a FOSS approach is complemented with a platform strategy (Manda et al. 2014; Braa & Nielsen 2015). The FOSS approach encourages a wider community of users to contribute to the IT artefact which serves as a generic solution for all. Flexibility of the software product enables the user to highly customise the software's interface. A platform approach enables those users who require customised requirements that cannot be integrated to the core to extend the software to develop their own applications with the opportunity to share them with the wider user community (Braa & Nielsen 2015).

4.1 Adaptation 'of, in, on and to' DHIS2

The various elements of the platform approach, which will be discussed in more detail in this section, are meant to address one of the major challenges of implementing a FOSS approach in the given global context which have previously been discussed in relation to 'forking'. Enabling others to contribute to the features of the platform or extend it with their own applications is meant to solve part of this problem.

Adaptation '*of*' the system refers to the development and improvement of DHIS2. This process is primarily driven and controlled by HISP UIO with new versions of the system being released quarterly, fuelled by input from the wider community of local developers and partners. The other forms of adaptation (adaptation *on*, *in* and *to* the system) are to a high extend dependent on adaptation processes of the core. Over the years, a network of HISP nodes has gradually emerged and is increasingly being strategically formed for the purpose of decentralising these aspects of the development process (Braa & Nielsen 2015).

Customisation of the interface of the system, discussed in this paper as adaptation *in* the system, involves making the system fit for local use. This requires all kinds of actions related to setting up the system such as creating organisation units; indicators; data elements, dashboards; authorisation of user-groups; pivot tables; designing tracker programs and forms and defining access rights and authorisations. Setting up and maintaining the system may be done by local or regional HISP nodes, or may be organised by the users themselves.

DHIS2 academies have become central efforts in engaging the DHIS2 community in strengthening the capacity of national and regional users to successfully set up, design and maintain DHIS2 instances ('*in*' adaptation). These intense training programs on use and adaptation of DHIS2 target users both at beginners as well as more experienced levels. A training database ('trainingland'), which is based on a fictional country, enables participants of academies to explore the functionalities of the software. 'Regional' academies are to be distinguished from 'expert' academies which are hosted once a year. Expert academies have a more conference type of set up in comparison to the other academies, with less emphasis on training and more on collaboration and ingenuity.

The ability to extend DHIS2 instances with applications enables local developers to solve challenges they face in the adaptation process through the development of extensions and applications *on* the system. This is different from apps that belong to the system's core platform which is formed by a collection of 'core' apps. Apps that are externally developed are predominantly designed locally for individual use (customisation). Nevertheless, a small

selection of apps that is applicable for more ‘global’ use is made available in a DHIS2 ‘app store’ where they can be shared with other users. Adaptation ‘to’ refers to the coordination of interoperability of DHIS2 in relation to various other systems as part of a larger information system infrastructure (‘architecture’). Such efforts are necessary to make data available to all relevant users across systems composing the broader architecture. This will require not only technical gateways but also harmonization of definitions and dimensions in order to combine the data in meaningful ways. Of, in, on and to dimensions of the adaptation process are illustrated in figure 2.

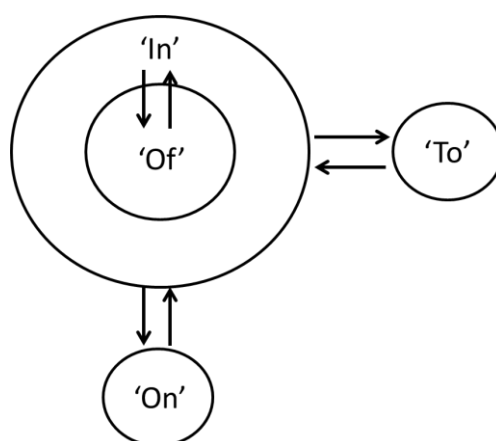


Figure 2. Dimensions of System Adaptation

4.2 A Community of Generification Agents

In the absence of formal procedures, the concept of a ‘node’ in the HISP network is subject to different interpretations. Braa and Nielson (2015) discuss how the expansion of the nodes in the HISP network has become more diverse. Development nodes (outside the HISP UIO there are currently 3) focus on the development of the core system. Together with the core team members at UIO, they would categorise as ‘meta designers’ in figure 3. Implementation nodes comprise of (teams of) developers primarily concerned with designing for local or regional requirements and can be seen as a focal point for DHIS2 support in a certain country or region. Some nodes comprise of both (core) developers and implementers. Nodes may also provide (non-technical) public health or health management related support.

Within figure 3, these nodes would often have the role of ‘collaborators’. The term ‘contributors’ is used to capture those users with knowledge ‘in house’ (or outsourced) to customise the software or with the capacity to hire their own developers. These users are therefore capable to actively interact with the design and negotiate their needs with either the core team or local HISP nodes. This is in contrast to users who lack this interactive capability and would categorise as ‘consumers’. The capacity of contributors and collaborators may vary. Within the developing country context in which DHIS2 is implemented, international non-governmental organisations (INGOs) automatically categorise as power users (Volkoff et al 2004) given their vast capacity to hire their own developers to customise the system. Other contributors may be local NGO’s or Ministries (sometimes with the support of (I)NGO’s).

In the following sections we will look more closely at how these generification agents (are enabled to) represent user groups. Doing so, we will adopt a more critical lens in attempting to understand how this networked generification approach, though arising from a ‘bottom up’ tradition, also has its issues that require attention, especially as interventions in these environments (and this one in particular) mature.

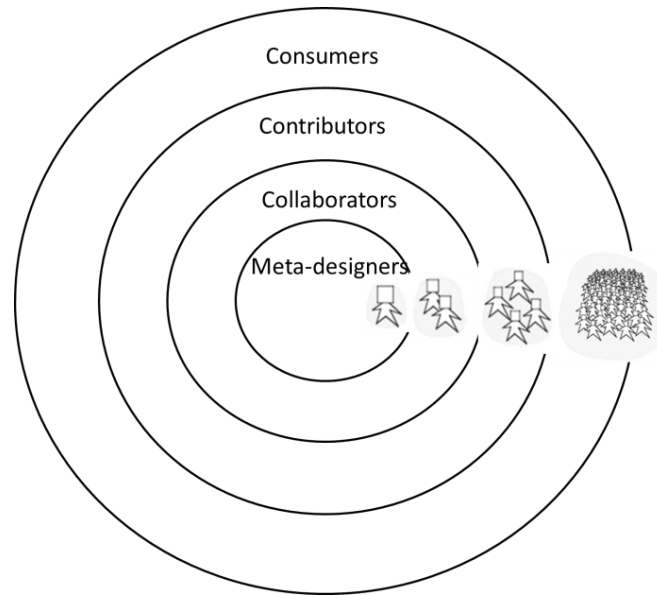


Figure 3. Generification Agents (Adapted from Fischer 2009 p.7)

5 FINDINGS

The previous section provides an overview of the types of actors involved in various dimensions of the collaborative development process of DHIS2 and their level of involvement. We will build on these insights to identify the mechanisms at the disposal of these actors at different development stages which enabled this involvement, in order to reconstruct the infrastructure through which generification is enabled.

Figure 4 maps out the various routes a request can travel once the original generification cycle between designer and user is broken and extended. We can broadly identify 3 ‘adaption’ circuits, where different types of adaptation blend with various actors in the role of generification agents through a variety of mechanisms. A potential direct link whereby design features come to the attention of designers through use was illustrated with a dashed line since this relationship did occur in the data but was not further explored in line with the study’s scope. In this section we will elaborate in more detail on the present mechanisms that enable generification as part of the adaptation process.

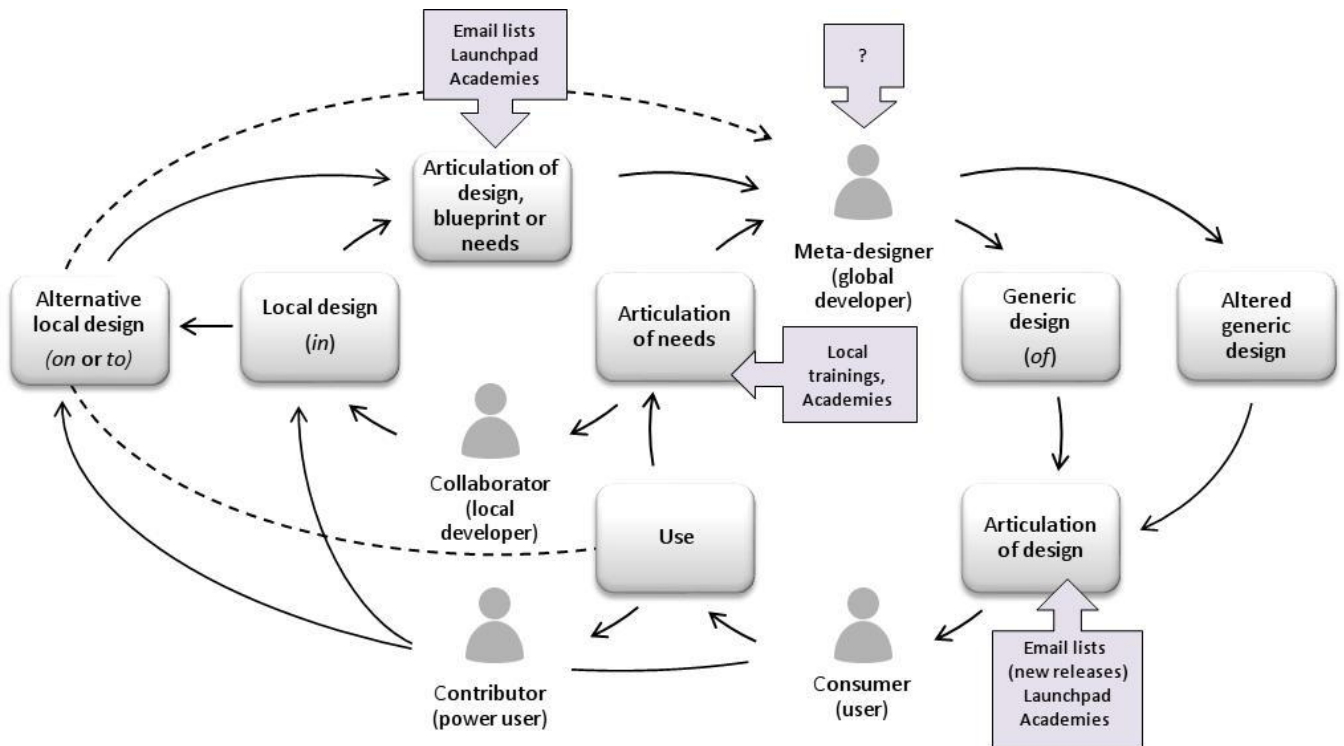


Figure 4. Multi-dimensional Generification Process and Mechanisms

5.1 Mediators

The term ‘generification agents’ used earlier is illustrative of the role that nodes and consultants, as well as individuals that would categorise as contributors, play in mediating between local design and generic design that happens at core level. As seen in the following example, these actors become focal points and representatives for users who experience certain needs while using the software in their daily practice.

‘For us [local node], we have been in charge of overseeing all messages and feedback communication within DHIS2 [referring to messaging functionality](...)That user feedback is not automatically exported to Oslo [HISP UIO], but we can present the same thing as an experience or as a requirement in a different forum [where it gets communicated to HISPUIO]’.

HISP node representative 1 country D

This example furthermore illustrates how these agents become the first step in a generification process through which these needs are channelled onwards. In their mediating role, they are required to negotiate between what is required in practice and what is technically possible or desirable, as seen in the following excerpt:

‘We usually call it ‘asking for juice’ like... Being in a meeting or in a training and someone goes: ok, so this can be done, why doesn’t it do this? So usually we call it like someone wants a juice in a cup and you want the DHIS2 to pour you juice.. Because some functionalities can be very complex.. (..) You sort of mediate, if you think this is something that is nice to have and it can be done as a developer and then you can present it to the higher level and maybe help writing a blueprint for it’

HISP node representative 1 country D

The availability and accessibility of mediators to end users (consumers) varies, as is their mediating capacity. For instance, (local) NGO's or Ministries may have different experiences in the ability to 1) identify end user needs (for instance during local trainings) and then 2) channelling them up to either regional nodes; directly to the development team, or -where possible- cater for them themselves (through for example app development or customisation of the configurable layer). In addition, the level of support provided from a HISP node to these users may vary depending on the capacity of these nodes and the capacity of users to attract support. To better understand this mediating capacity, we need to have a look at the mechanisms in place for actors to act as generification agents.

5.1.1 Collaborative Platforms

Most of the process of suggesting or implementing adaptations to the generic core takes place on two collaborative platforms, 'Launchpad' or 'Github'. These platforms are primarily used by collaborators and to some extent by contributors to communicate with meta-designers and other developers to report bugs and suggest and monitor the implementation of new features. One collaborator describes:

'If I have a requirement then I won't send an email [referring to the user lists] but I can create a formal blueprint within the DHIS2 Launchpad account (...) If you write a blueprint it gives some sort of discussion forum for people to discuss (...) set priorities and those kind of things.(...) [If it gets prioritised] then I can see: Ok, this is scheduled for [version] 2.9 or for the coming two releases..'

HISP node representative country A

From this excerpt it becomes clear that being able to write a blueprint increases the ability of developers to convey their requests. It also is illustrative for the way local developers act as mediators in channelling user needs. This is important given the way most users without a technical background will not understand the 'language' spoken on Launchpad, as explained by the following developer:

Launchpad is mostly a developers thing (...) it is quite easy to use. Most people know you can use it for registering bugs, but this collaborative development; writing blueprints, suggesting for additional features.. These kind of things - most people [other than the nodes/ consultants] either they don't know they apply or they don't know how to use it..'

HISP node representative country A

However, the platform is not used as a ticketing system and decision-making processes are not always transparent, as noted by the following participant of an expert academy:

It is impossible to understand how bug reports are addressed [by the core team], some take eight years and some are addressed right away (...) The same with blueprints: there has to be a rough assessment'

HISP node representative country C

In addition, an analysis of the activities on Launchpad shows that bug reports or new blueprints are not always allocated to a specific developer in the network and as a result a certain amount of 'ghost' blueprints and bugs 'hang' in the system somewhat indefinitely.

5.1.2 User-list

There are several email lists, of which the 'user list' and 'developers list' function as communication channels between contributors, collaborators and meta-designers. These lists

enable directly seeking assistance from other community members or developers in addressing challenges. Developers lists are mostly used by HISP developers (n= 462) whereas the user lists is used within and to some extent across community layers by both nodes and a diversity of technical users (n= 970)¹. These lists are places where meta-designers articulate new designs. The other way around, these lists are media for local developers (be it contributors or collaborators) to comment on design choices. This is illustrated in the following excerpt from the user list posted by a meta-designer:

DHIS version [2.xx] is out with a lot of great new features and improvements... [28 improvements listed with screenshots and link to demo plus further information on documentation]

To which one of the collaborators replies:

WELL DONE - some highly useful new features, which hopefully also will resolve long-standing bugs/issues (e.g. like problems we've had with approvals)

Occasionally, the user list will prove an effective medium to request specific feedback from the community on future plans to make changes to features 'of' the system (in relation to the system's 'roadmap'). In some other cases, such plans surface in discussions about certain features. For instance, an email thread on the user list that starts as a 'common' type of question requesting assistance regarding the creation of an 'aggregation query builder', received the following response from a meta-designer:

In fact, aggregation query builder is already scheduled to be removed in version 2.23 and will be replaced by program indicators. Admittedly there are a few cases where persisted aggregate event data could be useful, however we think that generating the aggregate values "on the fly" will provide more flexibility and be less of a load on the server by avoiding large, nightly batch jobs.

The response of this meta-designer came as a 10th reaction in this thread and led to among others the following response by a collaborator:

If not further work on the Aggregation query builder feature, please don't remove it. We actually find it very useful and is critical to our workflow. For example, we need to get Total patients seen in a facility. Now with queries the user can see total figures, plus when needed segregate them by age, gender, visit type (new, follow up etc.) and many more categories in Pivot tables which provides an easy interface to suffice all this.

In these examples, the email lists serve as a forum for designers and collaborators/contributors to articulate design choices and requirements and provide context to speak to the imagination of the other actor. In this case, the proposed change to the system would disturb work processes. However, these dialogues occur spontaneously in relation to specific requests for support, and are therefore unlikely to reach the awareness of most users of the list given that many support issues are raised on the list each day and searching the archive is not a straightforward process.

5.1.3 Regional and Expert Academies

The DHIS2 academies have an important role in enabling communication between members of the core development team and collaborators and contributors as well as among them. Dialogue is enabled by the ability to discuss and become familiar with various use-cases,

¹ Data retrieved on 25.08.2015

through which different users can identify shared practices. In addition, it is enabled in the form of feedback sessions and opportunities during an academy. During a regional academy, this session was guided by a Word-document that was put up on the screen while participants were asked to provide their feedback to the developers in the form of requirements for changes or new features. When participants proposed a requirement, the facilitator would take notes in the displayed document visibly to all participants. This furthermore enabled participants to make corrections as well as made them aware their feedback was being documented and therefore taken into consideration. However, during an expert academy, the use of this document created confusion and to some extent had an opposite effect, when this method made visible how during a feedback session the presenter only started taking notes half-way into the session, after a number of issues had already been raised without being given the same treatment. Consequently, participants started joking about how, when a requirement does not end up on the list, it will not be followed up on. Also, the following comment illustrates how a sense of being heard does not result from merely taking notice, as one participant commented:

'When we do have a chance to give feedback we need to know if what you write down on your list will be implemented.'

Participant expert academy (Donor community representative)

A similar observation was made during a regional academy, where a developer from a neighboring country expressed his frustration during the feedback session held because issues he flagged now he had already raised at a previous academy. This can create tensions between users and mediators, who may at times feel quite powerless in their position as the 'messenger' when they are both unable to address especially pressing issues with a local solution or see their requirement integrated in the core.

Compared to a regional academy, the expert academy hosts many more members of the core team which makes the process of giving feedback more efficient. Not only does this make them more accessible for feedback as a result of their physical presence, it also enables better communication (articulation) about the implementation of features, plans and prioritisation in general - which to some extent also provided input for discussions with the audience. These expert academies specifically target a selective group of collaborators.

DHIS2 academies serve an important value as physical meeting spaces for enabling participants to not only enter a dialogue with designers but also to formulate or voice collective concerns. During an expert academy, a session which walked members of the community through the latest developments surrounding DHIS2 (also referred to as the roadmap) illustrated how the interests of the present community may vary greatly. One announcement that sparked a diversity of reactions concerned efforts to develop GIS features in DHIS2 in such a way that data could be used to predict outbreaks of a certain disease and pro-actively inform decision-making. This pro-activity was a significant change compared to the way design had thus far always focussed on enabling re-active use of (health) data. For some members of the community, this raised questions about the stretching of resources in relation to the unlikely functionality of such a feature within the work environment they experienced, where 're-active' use of (health) data is already problematic and broadband issues do not allow for 'heavy' features of this kind. During this discussion, another member of the present community however expressed a different take on these developments, by saying:

'Most of us are professionals, we have a lot of ideas and most of the work you do is the simple stuff. It's acceptable to do some fun and interesting 'fancy' stuff, if only for the developers who do it to recharge their batteries.'

Participant DHIS2 expert academy (HISP node representative)

In this example a negotiation of interests takes place. Interests such as the allocation of resources in relation to functionality of the system are compared to a different interest, namely the allocation of time and resources which is considered to be a reasonable trade-off for an increase in work motivation.

Despite the advantages of these academies for enabling generification (as a by-product of the training itself), they are limited in size and occurrence and therefore limitedly accessible. Currently, there can be approximately 12 regional academies per year, whereas the expert academy and the NGO academy only happen once a year. Plus, although the participation fee is as low as possible, they furthermore pose a barrier and often mean certain users at lower levels (such as districts) are excluded from participation.

5.1.4 Informal Channels

As seen in previous sections, the user list is not a primary mechanism for collaborators or contributors to articulate their needs. In addition, the use of tools such as Launchpad offers limited transparency about the development process or prioritisation of requests. Nevertheless, as illustrated by the following quote, an important aspect of the generification process happens informally:

'Whoever [meta-designer] you are exposed to gives you an access so that you can even... exchange ideas before requests. (...) I might have a problem – let's say a client says he wants this (...) if I think I don't have the complete solution I can personally ask let's say [name lead developer], what is your suggestion? What can you... what is your input? He can give me his input and then I can work.'

HISP node representative 2 country D

This participant furthermore points out a need for capacity in order to be able to benefit from the platform approach whereby adaptation 'on' and 'to' may solve limitations experienced with the system ('of'):

'You need to be open - that is you have a problem, it can be implemented or if not: what can you do at the local level because sometimes the problems could be more specific to your environment and not 'global' so... you also need to have that ehm., intellectual [capacity] to see how you can resolve that problem while you are waiting on 'the global' to resolve it...'

HISP node representative 2 country D

Here, personal relations from a collaborator with a meta-designer give access to negotiate requests or support a mediator's capacity in solving problems through other forms of adaptation.

Some participants noted that the focus of the development roadmap seemed to correlate with big projects valued highly by the core team. When there was a lot of focus from the core team on the implementation in a certain country or a certain project, a lot of requirements for this project would be fed into the roadmap. One participant shared the perception that how to get an issue onto the roadmap has to do with the ability of collaborators and contributors to 'flag attention', stating '*obviously, you get attention with money*'.

5.2 Community Assignment

The previous findings are complemented with outcomes of a community assignment, in which the community present at an expert academy voiced where and how they would see

room for improvements in the open generification process. The left column summarises items raised whereas the column on the right zooms in on specific process aspects.

Table 3. Community Assignment

Assignment 1: Summary of community needs raised by the community	Assignment 2 : Prioritisation and actions as formulated by the community
1. Informing community about community procedures:	
1.1 Community engagement process	1.1.1 introduce templates for blueprints 1.1.2 openness on the process of how to do requests 1.1.3 teach how to file bugs 1.1.4 split expert academies into technical and non-technical 1.1.5 <i>establish clearing house (app store) for developed apps</i> 1.1.6 send out a list of academy attendees to all the participants
1.2 Where to find information	1.2.1 create structured list of profiles of community experts 1.2.2 develop Wikipedia type of dictionary for terms used in DHIS2 1.2.3 archiving requests better and create most frequently asked questions from user lists 1.2.4 videos for specific use cases or scenarios 1.2.5 establish QA/QC for developed apps
2. Enabling community engagement	
2.1 Development of the roadmap/ apps	2.1.1 distribute custodianship of components of the roadmap 2.1.2 develop collaborative development and user needs forum to develop apps (online, mailing list and face to face) 2.1.3 develop collaborative mechanisms (such as Launchpad, Github or Google groups) to synergize development and prioritize user needs 2.1.4 slow down release schedule (...) Need for implementers to plan. Feature- driven releases (as opposed to timed)
2.2 Transparency/ prioritisation (roadmap)	2.2.1 introduce voting process on blueprints and provide comments to the blueprints 2.2.3 need for more intentional collaboration with survey based tools for aggregating survey data. 2.2.4 communication of the features (roadmap) with community (open for discussion)
2.3 Introduce steering committee / member development	2.3.1 identify coordinator for managing community experts list 2.3.2 create a location for organisations to upload and submit documentation for review by community members 2.3.3 create special interest groups that take responsibility for translations in particular languages and develop review process 2.3.4 designate a bug manager – rotate responsibility between HISP nodes 2.3.5 designate release manager
2.4 Inclusion of developers from within and outside the ‘HISP’ community to contribute to the development of DHIS 2 and related processes	2.4.1. hire experts locally for translations 2.4.2 build development capacity in nodes to fix bugs 2.4.3 <i>accreditation of trainers and organisations</i> 2.4.4 <i>nodes to do level 1 academies</i> 2.4.5 create a reward mechanism for experts creating training videos for specific tasks or scenarios
3. Interaction between community members	
3.1 Sharing best practices	3.1.1 create community profiles which include documentation that highlights organisations, use cases and contact information 3.1.2 encourage community to share the problems solved and experiences in stack exchange or user list 3.1.3 Wikipedia for DHIS2 use-cases 3.1.4 create a sharing space for training resources 3.1.5 communities need to have something in common (...) need to create or make visible that the community is a community of communities.

In table 3, 11 out of 33 suggestions (highlighted in grey) concern improvements in the generification process at the level where requests are channeled from contributors and collaborators back to the meta-designer. These suggestions have to do with making the process to file requests (bug reports and feature requirements) easier as well as more transparent. Some suggestions indicate the community wants more influence in negotiations regarding their integration ('of'). Also, the suggestion of collaborative mechanisms to prioritize user needs (2.1.3) indicates that current mechanisms are inadequate (or inadequately used) for such purpose.

6. DISCUSSION

Generification is a process of an evolutionary and cyclic nature, which emerges from the bouncing back and forth between designer idea's interests and practical implementations with those of local stakeholders. Central to this process is how users or their representatives are *engaged* and *valued* in the process. Accordingly, this requires mechanisms for engagement as well as transparency. Based on the study's findings, we can understand this process as a dialogue between gain and loss that occurs at each information-processing step taking place across three interrelated circuits. Open generification, in our perspective, attempts democratic forms of engagement and validation of knowledge regarding what needs to be included in the core of design ('of' and 'in'), while enabling those aspects that fail to be included to be enabled at its periphery ('on' and 'to'). Through the development of a conceptual framework of the generification circuit (presented in figure 5) this paper contributes to an understanding of how these distinctions are made.

Moving away from perceiving generification processes to be either 'open' or 'closed', this paper proposes to look at them as circular. This way, one could envision them to be both open and closed at the same time as part of a balancing act that may furthermore vary as time passes. What such an understanding does not reveal is how different agents are valued, which especially in a developing country context is an important concern. What it can do however, is increase transparency where it is lacking in order to improve the mechanisms in place for a more equal and/or transparent validation process. Mapping out generification *circuits* is thus about making the commonly 'invisible' practices and mechanisms of processes of embedding and disembedding in generification, *visible*, and therefore may be used to combat power inequalities in line with an open generification ideology. In the DHIS2 case, such an understanding reveals that at the level of these software founders (meta-designers), mechanisms in place are lacking in offering such transparency which would be able to shed light on the democratic nature of the generification process. We argue this is necessary for determining how 'open' they truly are.

Accordingly, this paper expands on the conceptualization of 'open generification' as a cyclic and multi-dimensional approach. *Open*, we argue first of all, is about *closed loops* (no matter how short or long they are). This implies that, should these circuits be interrupted at any point, requests cease to be conveyed and the generification process is ended. In conceptualising this process, we are inspired by the conceptualisation of 'circulating references' used by Latour (1999) to designate among others the quality of understanding chains through which information is transferred and transformed in their entirety. We follow his description of such chains in our understanding of generification circuits in the sense that '*truth value circulates here like electricity through a wire, as long as the circuit is not interrupted*' (Latour 1999 p. 69). This was illustrated in figure 5. Similar to the concept of circulating references, generification circuits can help reveal what mechanisms enable an organisation to determine what is lost and what is gained as information is transferred as part of the generification process.

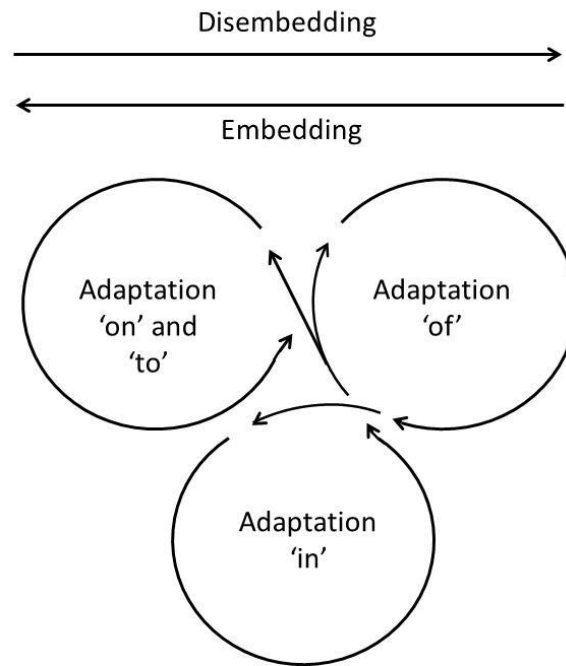


Figure 5. Generification Circuits

As seen in figure 5, adaptation ‘of’ the product is a mandatory passage for ‘on’ and ‘to’ forms of adaptation to become available for customisation ‘in’ the product. This also makes visible how the negotiation process this requires core to traditional generification processes remains present in so called open generification (Gizaw et al, forthcoming).

In addition, our data suggests *closed loops* to be both about *mediators* and *mechanisms*. We have referred to these mediators as *generification agents*; contributors and collaborators, described elsewhere in the literature as ‘power users’ (Volkoff et al. 2004) or ‘prosumers’ (Johnson et al. 2013) who, based on their capacity, represent user needs and speak the language needed for development in transferring these needs to meta-designers (Johannessen & Ellingsen 2009). As seen in the paper by Gizaw et al (forthcoming), the opening of generification processes requires a *transition* between (passively ‘organised’) user groups into (active and empowered) ‘prosumers’, ‘local developers’ or what we call generification agents. Data indicates making this transition calls for mechanisms that further enable actors to climb the ‘generification ladder’.

In FOSS communities, participation in the design process tends to be earned with expertise, time, passion and commitment. Open generification in FOSS is no exception from this practice (Gizaw et al forthcoming). However at the same time, Gizaw (ibid.) note that openness is constrained especially in developing countries where skills, infrastructure, funding and political commitment may be scarce. As noted by Gizaw et al. (ibid.), the generification process between collaborators and the meta-designers is prone to power discrepancies in favour of meta-designers and power users that have access to stable funding resources. However, it needs to be taken in to account that the capacity of meta-designers is limited that disembedding processes can be practically challenging (ibid.).

Accordingly, once mediators have acquired a position in the generification process their influence can vary (Pollock et al. 2007; Johnson et al. 2013). In comparison to the definition of ‘prosumers’ by Johnson et al (2013) as part of a top-down generification process, the DHIS2 case tells us that in open generification, local developers are also part of a collective fora; provided with the space for independent action and innovation by in this collaborators; in a collaborative relationship with ‘managers’; nevertheless ‘managed’ by a

coordinating entity (meta-designers) enabling (influential) relations as well as disables them for various reasons. What matters then, is to understand (and discuss) the *influence of various generification agents* on the generification process. For this, we need to draw the attention to the mechanisms made available to them. Specifically, the capacities of mechanisms in place to 1) draw in generification agents and 2) close the generification circuit between them and meta-designers.

7. RECOMMENDATIONS AND FUTURE RESEARCH

According to a free and open source approach, software development is opened up to a wider community in an attempt to employ its rich knowledge base. In using this approach to make a generic software product, how input from that community is retrieved defines how ‘open’ this ‘sourcing’ process is. In networked FOSS development, this requires putting in place mechanisms that benefit transparency, accountability and equality in design processes of a wider community of mediators and users. Such applications of mechanisms would need to fit into an overall ‘generification’ strategy. Tools and mechanisms supporting an open generification strategy need to be initiated by meta-designers who have the power, knowledge and legitimacy to shape the generic product.

In realizing such a strategy, future research could benefit from investigating the ‘epistemic stance’ of organisations or networks, which has been defined by Fayard et al (forthcoming p 9.) as follows:

‘a collectively enacted attitude toward the pursuit of knowledge, which reflects beliefs about reality and the “true” sources of novelty, and is expressed through certain modes of pursuing and evaluating knowledge. This concept enables us to unpack how an organization, for which the pursuit and creation of knowledge is crucial, responds to and enacts possibilities offered by new IT-enabled practices.’

Understanding the epistemic stance of an organisation could enable it to critically reflect on the IT tools and processes in place for enabling generification. This could help explain how knowledge flows of different agents are valued and why bottlenecks in generification circuits occur. However, in order to give organisations analytical tools to do so, the concept of epistemic stance requires further development.

In addition, and to some extent in relation to this, it is important to note that the collaborative development efforts by open source communities encompass two processes of a very different nature: collaboration and adaptation. These processes in turn place very different requirements on the generification process in terms of the desired level of convergence and divergence. In the DHIS2 case, an unequal representation of these mechanisms that focus more on technical aspects of development potentially limits the capacity of the core team and the wider network to absorb and process information provided by/or hidden in the community.

In this light, outcomes of the community assignment as well as its process furthermore indicate that the open generification process itself (and its mechanisms), not merely its generic products, are a fertile topic for negotiation by the community involved. The community assignment discussed in section 5.2 serves as an example of a generification exercise initiated by the authors, in which different stakeholders were grouped and asked to select and prioritise aspects of the generification cycle they would like to see improved. Outcomes of the community assignment furthermore suggest an interesting alternative research angle would be to look at mechanisms at other stages of the innovation circuit, for instance mechanisms surrounding the communication of usage and capacity building of mediators.

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Appendix 2

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Chapter 2

Action Research and Open Innovation: A Synergy?

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ABSTRACT

In today's world, 'global' problems increasingly require global solutions. In order to realize these solutions, innovation processes are 'opening up'. Both of these developments add a level of complexity to the Action Research process that is traditionally, and perhaps inherently local in nature. However, it also offers opportunities. This chapter explores the case of an Action Research innovation that reached a global scale beyond the initial Action Research process that started it, with the help of Open Innovation strategies. From this case we learn that Open Innovation has a significant potential for sustaining Action Research 'action' beyond its initiation and make them transferable across contexts. At the same time, such 'open' innovations can grow very complex, and therefore so can 'open' Action Research solutions – especially when they concern (free and open source) information systems. The concept of 'Action Research Systems' is introduced as one way in which Action Research can help ground Open Innovation processes in dealing with this complexity.

INTRODUCTION

Especially in the high-tech industry, there is a growing awareness that traditional organizations should be open to 'outside' innovation (Saint-Paul 2003) which furthermore stimulates external exploitation of innovation (Chesbrough & Crowther 2006). In this networking imperative (Enkel, Gassmann & Chesbrough 2009) blurring boundaries between organizations and between them and consumers has led to new ways of innovating, also discussed by Chesbrough (2003) as 'Open Innovation'.

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Open Source software development is generally perceived to be an example of Open Innovation in the IS field that has led to highly ‘fluid’ development processes. Unlike physical or biological matter, software innovation is made up of ‘code’; a language that can be accessed from computers from all over the world and is increasingly spoken beyond the traditional information technology domain. Users can access the source code, they can alter it and create their own local alternatives of the product or enter a dialogue about the ‘source code’ itself and therefore the way the product should function/exist. Building on a rich ‘hacker ethics’ tradition characterized by values of openness, sharing and collaboration, OSS is argued direct power transferred to corporations as a result of globalisation, back to the people (Bejoy 2010).

The previous example illustrates how consumers as part of more ‘open’ forms of innovating and co-creating are perceived to be “armed with new connective tools” and “want to interact and co-create value, not just with one firm but with whole communities of professionals, service providers and other consumers” (Prahalad & Ramaswamy 2004 p.14). There is an increasing understanding that design problems faced nowadays require stakeholders from different disciplines and need to include problem-owners (Fischer 2013). To action researchers of information systems (IS), who have specialized in including problem owners in design processes, this paradigm shift is exciting and full of opportunities. However, it is also one in which new challenges present themselves.

Action research (AR) can be generally captured as the collaborative production of scientifically and socially relevant knowledge through a participatory process. In the information systems domain, Action Research cycles often produce socio-technical constructs that combine technology and social intervention in order to address a ‘real world problem’ and produce scientific knowledge. At the same time, these (scientific process and) practical hands-on interventions also leave behind tangible design. We have imagined Action Research can take place in multiple cycles that spiral in a linear direction, with the advantage that the negotiation of participatory designs remains of a relatively simple nature, and the disadvantage that they are difficult to scale. But have we considered the scenario, partly made possible by open innovating techniques, whereby they fractal out across multiple dimensions?

As pointed out by Waddell et al. (2015), action researchers today like any other change agent are more likely to find their projects entangled in complex global constellations, even when they appear to be – or intend to remain - local. IS increasingly evolve from things into structures; from ‘finished’ products into customisable platforms. In these environments, platform-based services acquire characteristics of infrastructure¹, while both new and existing infrastructures are built or reorganized on the logic of platforms² (Plantin et al, 2016).

This chapter is written with the intention to prepare Action Research for such situations by picturing what this situation and its challenges look like in a particular case and domain which is especially likely to produce ‘high maintenance’ outputs. Though an Action Research process itself may discontinue to be part of the ‘life’ of its solution sooner or later, we also imagine how action researchers may still continue to play a valuable role in different chapters of the solutions ‘story’. The potential of Open Innovation is explored in an attempt to address the sustainability of such AR actions.

An interest in the growth and sustainability of action research solutions attempts to counter an over-emphasis on method and ‘first phase’ aspects of Action Research in the literature, in relation to a relatively limited understanding of the change that is created over time. There is a lot of emphasis on the role of Action Research for sustainability, but too little discussion on the sustainability of Action Research outputs. When Action Research generates actions with the potential to serve as a solution for

Action Research and Open Innovation

the problems of many, it is important to consider what happens to those actions. Do they need some form of maintenance; do they need to be transferred?

At the same time, researchers of Open Innovation phenomena are still searching for the mechanisms and best practices of this recent era (Enkel et al. 2009) and how ‘opening up’ innovation should gain shape is still a hot topic of discussion (Chiaroni, Chiesa & Frattini 2011). An important bottleneck for Open Innovation, as well as related participatory design and Action Research approaches, is managing the differences between collaborating partners in terms of organizations and cultures (Du Chatenier, Verstegen, Biemans, Mulder & Omta 2009). Understandings from the journey of Action Research ‘actions’ that entered this field can reveal the potential value that Action Research can have in addressing the challenges of the Open Innovation process.

The IS that will be explored in this chapter spiralled from an Action Research project that attempted to improve health information management in a particular development country. Over the course of 20 years, the actions that followed needed to be ‘opened up’ in order for the IS to for it to meet the demands of a diversity of users/ use cases. In other words, new opportunities of the Open Innovation paradigm were used to cope with issues related to scaling a solution and maintaining a scaled/scaling solution. By studying what happens to such a particular Action Research output as it ‘lives’ on in a time in which innovations are no longer the efforts of single firms but emerge from co-creative efforts of many stakeholders, this chapter aims to answer the question:

(Where) does a fusion between Action Research and Open Innovation lead to a synergy?

In exploring this question, this chapter encourages researchers and practitioners to glance forward and think about two things in particular:

1. The potential of Open Innovation for the scaling, ongoing development and maintenance of Action Research ‘action’ in ways that ensure the involvement of problem owners in line with Action Research philosophies.
2. The potential of Action Research for dealing with the complex challenges associated with Open Innovation processes – especially when reaching a global scale.

BACKGROUND

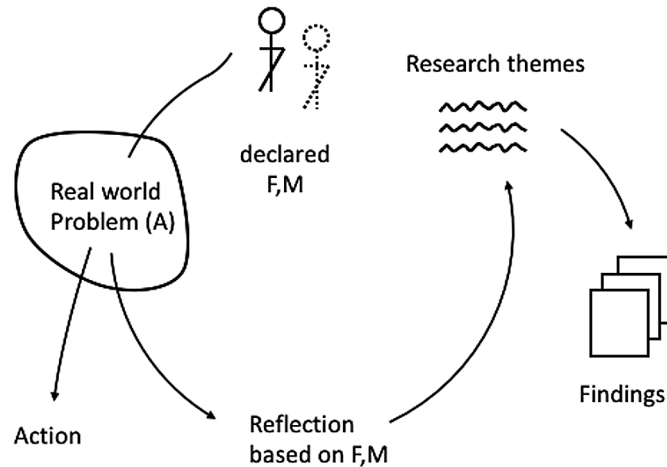
In order to meet the previously stated objectives of this chapter in understanding where Action Research and Open Innovation processes can potentially complement each other, this section will first attempt to shed light on the commonalities between these two approaches, their current shortcomings, challenges and potential.

Action Research and Its Challenges

Action research as a scientific method for social inquiry is somewhat caught between its objective to study human practices with the aim of improving them on the one hand, and its own historical attempts to suit the standards of scientific social research on the other (Carr 2006). Action research solutions are born in the midst of these two potentially conflicting forces. In an attempt to add structure to this

Figure 1. A systematic display of the Action Research process

Source: Adapted from Checkland & Holwell (1998).



conflict, Checkland and Holwell (1998) conceptualized the Action Research process as a number of phases in which researchers declare a framework of ideas (F), methodology (M), an area of application (A) and research themes in order to produce two types of research outcomes in the form of action and findings that are informed by reflection on the process. This chapter focuses specifically on this ‘action’, which is understood to be activity/ efforts in relation to the development of solutions for a ‘real problem situation’. Action can be related to Action Research as part of the cycle in Figure 1 (Action Research ‘action’) but also to the development of IS in general (IS ‘action’). In the case of Action Research in the IS domain, these actions may furthermore overlap.

The debate this chapter wishes to enter concerns ‘the real problem situation’ as the domain, or ‘living lab’, in which an important part of the Action Research process takes place. After all, it is here that social change needs to be established as a result of action taken. Zooming in on this domain there is one question which the current model for Action Research, designed around a local Action Research project, does not effectively address. In the current innovation climate, how local can we consider Action Research interventions to be, or, to remain?

Globalization, the internet and the deep and widespread integration of communication channels in our society have contributed to an environment in which solutions can be shared easily and extensively. From thinking about creating solutions for a specific setting, the current innovation climate is increasingly urging both practitioners and academics to look at ‘global problems’ (Gustavsen 2003; Waddell 2007). It has been already briefly mentioned that Action Research projects, even when intending to create a local solution, are bound to encounter global complexities in their surroundings (Waddell et al. 2015). In fact, in some cases, aiming to create a local solution can be problematic in this environment. So called ‘pilotitis’ in which there are too many small projects that do not scale, is a big problem in the IS field and in particular in low resource settings. Although Action Research can play an important role in transferring solutions across contexts because of its sensitivity for local conditions, this also adds a risk of contributing to this ‘pilotitis’.

Action Research and Open Innovation

In addition, like other research approaches, the Action Research process is constricted mostly by time and resources. However, unlike other research approaches, action researchers produce an ‘action’ in addition to their scientific findings, in the form of a solution for an established problem. It is the production of this solution that has led to theorizations of the Action Research cycle as endless in the sense that new cycles can start where previous cycles end. This is among others because the real life problem situation that triggered and/or justified the action taken in the first place, may change over time. Aiming for social change, this could mean that Action Research solutions are inherently temporarily in their ability to actually addressing especially complex problems.

Transforming solutions into generic solutions that can deal with diversity across contexts may deal with limited local capacities and resources to maintain solutions locally as well as combat ‘pilotitis’. However, making the jump from transferable to transformable solutions adds a whole new level of complexity. Does this complexity concern the action researcher? This chapter argues that it does. Especially in IS, where action researchers are bound to be faced with high interconnectivity in their surroundings, the aim to create social change comes with the responsibility to consider the sustainability of the ‘life’ of the solutions they co-create - especially when targeting problems of marginalized and vulnerable groups.

In the previously sketched scenario, the problem situation identified as part of the Action Research process has grown in complexity (from a local problem situation to a regional or even global one) that may furthermore change in nature over time. Ironically, the success of an Action Research solution (addressing the problems of many) may contribute to this growth as the solution is transferred. Transforming solutions to address this complexity requires a re-thinking of the current model through which action is produced.

Open Innovation and Its Challenges

Open Innovation offers such a model. Open and networked forms of innovation are emerging from changes in the landscape of software development that challenge notions that any given company can create value unilaterally and that value resides exclusively in the company’s or industries products and services (Prahalad and Ramaswamy 2004). Open source software development are often perceived as example of an Open Innovation approach in the IS field.

In some ways, Open Innovation is nothing new. As discussed by Huizingh (2011) the roots of Open Innovation go back far in history (Chesbrough 2003). A literature review conducted by Dahlander and Gann (2010) furthermore unravels how within the field of Open Innovation many ideas reflect concepts such as ‘absorptive capacity’ (Cohen & Levinthal 1990) in the innovation literature and the notion of ‘lead users’ (Von Hippel 1986) to name a few. And yet in other ways, the Open Innovation paradigm is unlike anything we have seen before. As stated by Badawy (2011 p.66):

The open innovation paradigm embraces the non-traditional activities relating to creativity, invention, innovativeness, and product/ service differentiation from the currently existing and accepted mold. As such, ‘newness’ is the name of the game.

What Action Research in IS and Open Innovation efforts have in common is a recognition of the value of user participation and ‘co-creation’. This understanding stems from the ontological assumption that knowledge is practice-based and accordingly equivocal, dynamic and context-dependent by nature (Newell et al 2009). In Action Research in the IS domain, action researchers often act as designers, or

on behalf of designers and or users. In Open Innovation, an organization will take the lead in organizing this mediation. In some forms of co-creation there may not be one organization, but several organizations that partake in the co-creation of solutions (Pralhad and Ramaswamy 2004).

In all the previous approaches, the innovation emerges as a compromise of these participatory processes. However, as the notion 'compromise' indicates, designer-user relationships can be challenging (Suchman 1988; Bødker, Ehn, Kammersgaard, Kyng & Sundblad 1987). In firms, negotiation processes are often 'top-down' in the sense that ultimately, the company decides how it groups, extracts and values input from its users (Pollock et al. 2007).

Though challenging the previous top-down approach with more 'bottom-up' strategies, this does not mean that the co-creation process surrounding Open Innovations is necessarily smooth. This becomes clear when we take Free and Open Source Software (FOSS) development as an example. The FOSS approach, whereby the so called 'source code' of a software product is made freely available, is highly suitable for development of software where participation by various users in the design is important. However, as it focuses on general use, this approach is also bound to addressing a selective range of user requirements, given its aim is to cover universal aspects of local requirements (Camara & Fonseca 2007).

In the terminology used in system development, tension occurs between the 'trunk' and its 'branches'. In short, creating a 'trunk' involves that networked development focuses on creating a generic technical solution for widespread use. A tension between these generic features and local requirements may lead to the creation of branches which offer local alternatives. However, for various reasons, the creation of branches (also referred to as forking of the core code) can be undesired. Problems occur when, in adapting the software for it to address a local problem, the 'forked' software solution may not be brought back into the generic core. The disadvantage of developing such software 'forks' is that the user eventually can no longer benefit from later versions of the system and the advantage of consulting the wider community. These disadvantages compete with the situation of the user that may require urgent adaptation. Consequently the open source software development process too requires a constant negotiation of conflicting interests in order to develop a generic product. Especially when an open source community involves many different stakeholders, interests may differ greatly. This is likely to be the case as solutions scale.

In addition, the required speed of developing and maintaining IS solutions adds further pressures on designer and user-relationships. The information system domain is characterized by the way technology and software in particular 'lives' or, perhaps even more specifically; lives *fast*. As pointed out by Kankanhalli et al. (2003), the production of software artefacts happens in an environment where the rate of innovation and the speed of new product development is crucial. At the same time, the production of support and the building of use capacity need to be tailored to local requirements and often in a timely fashion (ibid.) In comparison, we can imagine hardware to 'live' too; they are subjected to fashions, to the environment and technological improvements. However, these processes move slower and it takes more time adapt objects to changes in the physical environment that simply does not change as fast as virtual environments do. Software is highly dependent on this virtual environment that is furthermore highly competitive too: there are many that speak the language and information travels quickly. The tricky part hides in designing for such a fast life, especially if it is to be a long one, when design processes are complex collaboratives.

THE DHIS2 'NETWORK OF ACTION'

In previous sections we have identified a number of challenges that are new to the IS domain in which both action researchers and practitioners are grappling with enabling co-productive designer-user relationships as solutions increase in scale and complexity. This section will discuss an example of such an Action Research solution, the District Health Information System version 2 (DHIS2).

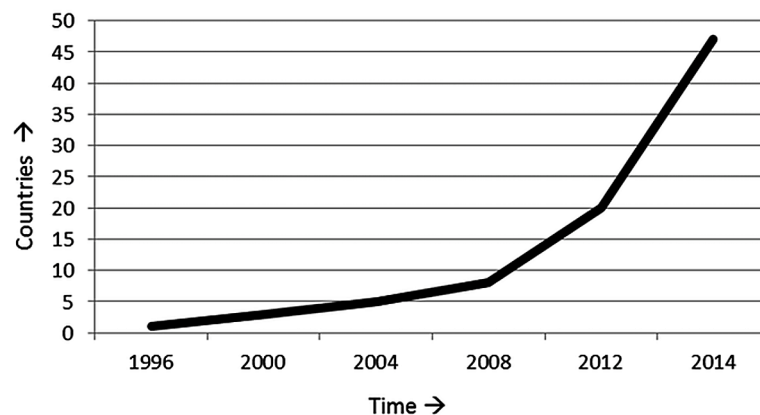
DHIS2 is a free and open source based software platform. It is widely used as a tool for collection, validation, analysis, and presentation of aggregate and transactional data, tailored (but not limited) to integrated health information management activities in low resource settings. Being a platform, it is highly configurable and customizable, and has extensive interfaces allowing for integration with other systems (Nielsen & Sæbø, 2016). It is also a platform for innovation, enabling the development of apps by a global network of software developers. While apps are developed to meet particular local needs, they can be made available for all users by being published in the DHIS2 app store. Apps may also be implemented in or result in changes in the generic software core (Gizaw et al, forthcoming).

Originating from Action Research efforts, the development of DHIS2 nowadays is the result of collaborations of a global network, the Health Information Systems Programme (HISP), which is established and coordinated by the Department of Informatics at the University of Oslo (UIO). The HISP network comprises of various entities, including Universities, Ministries of Health, non-government organizations (NGO's), international agencies like WHO and NORAD and many in-country implementing agencies commonly referred to as HISP nodes.

DHIS2 found its origins in South Africa as DHIS1, as collaboration between a PhD researcher from UIO who had received some funds and local members of a committee formed by the Ministry of Health with an interest in tackling weaknesses of the country's paper-based health information system. Following participatory Action Research approaches, whereby de-signers closely collaborated with ministry staff and health practitioners in the field, they aimed for the implementation of a digital district health information system. The success of their solution led to the export of the software to other countries that faced similar challenges, as illustrated in Figure 2.

Figure 2. DHIS expansion

Author: Ola Titlestad (2014) power point slide. Labels added.



Over the course of 20 years, the system scaled to use in over 60 countries (in 2016) with a majority of implementations in Africa and Asia. In this time, local developers have organized themselves as part of a network of ‘nodes’ that gradually emerged around the customization and implementation of DHIS. Currently, decentralizing design processes toward regional or local HISP nodes and other skilled users (and thereby diffuse the development of the software’s core) is considered to be of significant importance in order to cope with the growing user base.

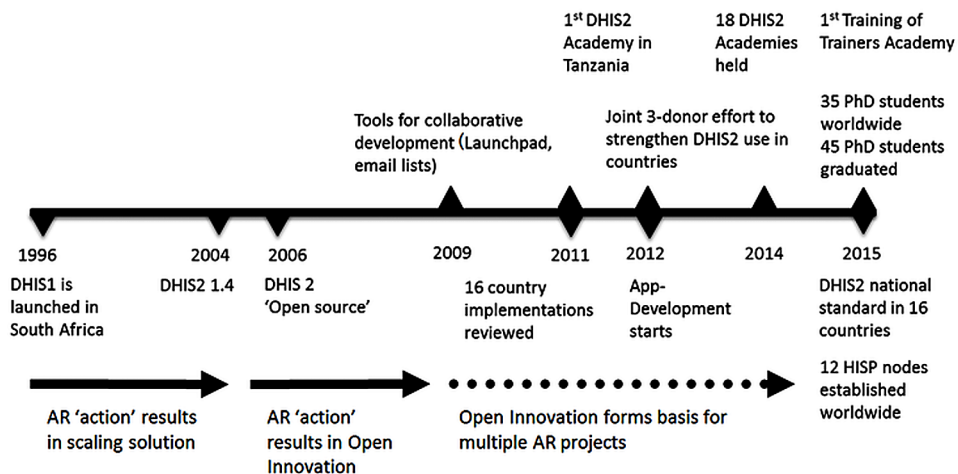
These developments will be discussed in more detail in the remaining of this section, which derives from the insights of the longitudinal involvement in the activities of the HISP UIO node within the network over a period of 1,5 year. Insights provided are based on interviews, observations, field conversations and document analysis was conducted during this period. In addition, frequent meetings (averagely held on a 2-week basis) with the community coordinator of the DHIS2 community (at the time also in charge of coordinating the academies) were used to reflect upon various elements of the research process.

Analysis aimed at developing a broad understanding of the distribution of development processes, mapping of key actors involved and their roles and regional activity over time. Part of the data was collated and used to create a timely reconstruction of key events (the development of the object, in this case DHIS2 and its support structures). This timeline, a summary of which is provided in Figure 3, enabled an overview of the various participatory activities in the network; provides an historic overview of the case and creates an image of the complexity and scale of the network as it develops over time. These developments will be discussed in more detail in the remainder of this section.

After developing a solution from scratch in South Africa in 1996, other Action Research projects followed in which participation took the form of the introduction of a pre-developed and flexible system that was then customized in collaboration with the developers. Following a highly intensive process, referred to as participatory customization (Kimaro & Titlestad 2008), developers and local health management worked together in setting up the overall structure of the database to collect health data at lower levels. Developers then needed to work together with the health workers to customize the system so it could be used in local contexts. Because this approach did not adapt well to the differences between countries

Figure 3. Timeline

Source: Author.



Action Research and Open Innovation

and use cases, an international version of DHIS was released in 2004 under the name DHIS 1.4. HISP UIO would take the lead in the development of the system from here onwards.

The following participant recalls how the system, inspired by the South African case, was piloted in his country. He became aware of DHIS during a course in another country where it was promoted as a solution for related issues, which he describes as follows:

Record people at the Health Unit would record at a monthly basis, then send that by taxi or whatever to the District level. Then the District HMIS focal person would get into a taxi or with bus or whatever and take the paper based reports to the Ministry of Health. It was very difficult to meet the time limit (...) so we thought the DHIS would improve on the reporting. – Actor local donor funded NGO

In this example, DHIS as a solution answers to a pre-existing local concern about the existing situation of health systems that transfers across contexts. In this case, the DHIS version 1.4 was piloted in one district by a local NGO as an alternative to the previously discussed existing paper-based system:

We piloted it at [district x] (...) and at that time it was only [district x] that had timely reporting. It was an eye-opener for the entire country, and that is how DHIS came to be [in country x]. Because [donor x], which supported the Ministry of Health to roll out DHIS, took an example of the DHIS 1.4 from one of the districts where we had installed it. So they came and looked at it, because at that time the Ministry representatives were bragging about how [name] district reports are always timely and they are always send to them by email, and all that kind of thing. So the [donor x] folks came over to that district, looked at how DHIS 1.4 worked, and then a few months later we were called for a training in DHIS. – Actor local donor funded NGO

In 2006, researchers at UIO changed the DHIS 1.4 architecture to a Java-based platform, which made the software free and open source. This version, now called DHIS2, introduced two important changes; 1) for the developers at UIO it required identifying generic needs across settings and stakeholders and 2) it allowed other developers to participate in contributing to this design by submitting ‘blueprints’ (code) that could then be integrated in to the software ‘core’ code, while for users it meant they have to update regularly to new versions that are released quarterly if they want to benefit from any of these improvements. In 2012, the platform approach furthermore enables those users who need customized requirements that cannot be integrated to the core to extend the software to develop their own applications (in 2012) with the opportunity to share them with the wider user community (Braa and Nielsen 2015).

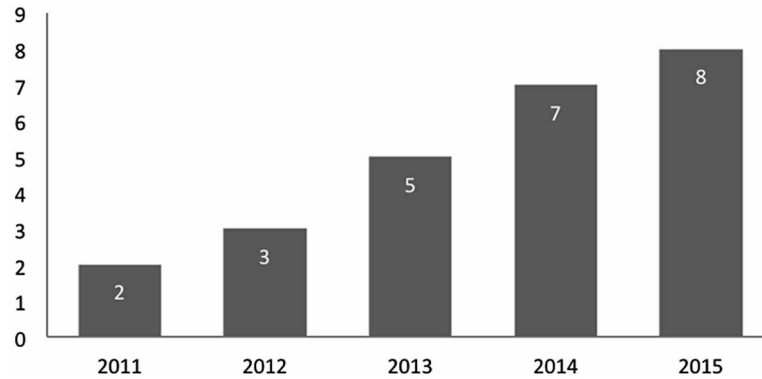
These changes furthermore required putting in place various technological tools and social interventions to enable collaboration and stimulate capacity building (Braa & Nielsen 2015). These capacity building efforts, which started in 2009, have gradually made the development process more interactive through development platforms (Launchpad and Github) and user- and developer email lists. In addition, regional training academies for basic and advanced users became structural events (see Figure 4).

The following excerpt from an email to the DHIS2 community illustrates the way DHIS2 academies are able to increase the capacity of users:

[Ministry of Health country x] has left the pilot phase since three months (...) with the integration of different programs [x y z] in a common DHIS2 database. This work has been done due to the skills we have acquired at the DHIS2 academy Level 2&3 at [country] (Thanks to [academy organizers]) and a

Figure 4. DHIS2 academies

Author: Matthieu Pinard.



tool that we developed for importing existing Excel and Access files in technical directions and health programs in DHIS2. – Email Ministry of Health representative

A network of HISP nodes, local organizations of varying nature, has emerged over time to provide in-country or regional support. In 2015, core researchers at the UIO state in a publication [(Braa & Nielsen 2015 p.10) that this network of nodes is increasingly being formed strategically for the purpose of decentralizing aspects of the development process; to make use of the expanded size and skills available in a ‘maturing’ community of developers as well as external knowledge beyond the health domain and limited resources of the core team. The importance of such nodes is also emphasized in the evaluation report (2011 p. 24; 27 and 28) stating:

The two strongest successes for HISP are the HISP [country x] and HISP [country y], the two oldest and most influential nodes within the network in terms of institutionalization of DHIS (referring to government linkages) and capacity to provide support.

While the new possibilities created by architectural changes instigated a rapid increase in the number of users, all DHIS2 solutions had (and still are required) to ‘speak’ to the core version of the software for other actors (users of the software) to benefit from the network, During a regional academy, one of the researchers from HISP UIO explains this to the participants as follows:

Whenever we learn something from you guys [audience of participants from mainly local NGOs and Ministries] from a new use case, it will be generalised and taken into the core, and become available in the next release for all the other countries. – Spokesperson HISP UIO at regional DHIS2 academy

Following this strategy, new innovations that appear when user-representatives solve a problem on the ground are integrated into the DHIS2 platform, making it available for other users through quarterly releases.

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This generalization process (also referred to as generification (Pollock et al. 2007) however is full of challenges, and only a selection of use cases make it into the core. These challenges result from a diversity of perspectives between users as well as between (South based) users and (North based) developers, and the way certain actors (among which those considered the software's 'founders') have much more influence on prioritizing proposed features than others (Gizaw et al, forthcoming p 28). For instance, funding sources tend to play an important part in the prioritization of new features (ibid.). At the same time, Gizaw (ibid.) reminds us that the open source development approach provides a permanent opportunity for users to 'fork out' and create parallel development processes, stressing that 'this creates a necessary tension convincing the community to remain open, collaborate and stay together.'

From a developers point of view, there is also a tension between allocating time and resources toward integrating use requirements to meet certain expectations versus keeping up with the latest technological requirements and developments to stay ahead of others. This is reflected in the following conclusion that was drawn in an evaluation report in 2011 (p. 39) as follows:

The need for developers to be flexible and independent for meeting their partner country needs and the reduction of development redundancy are at odds.

Maintaining this balance was an important motive to develop the system into a platform, enabling users to address local needs through developing apps and extensions, which are furthermore attempted to be made generic and available for others in an DHIS2 'app store'.

The initial approach which relied on Action Research efforts for the software's implementation and development remains to be an important drive within the network. Through Action Research, researchers at UIO secure their involvement and support in local implementations to either further develop or make improvements to the system. An evaluation report from 2011 (p. 19, 20, 45) underlines the way 'researchers have had direct impact on the technology development and the new deployments of DHIS and other HIS' and 'the important role of UIO graduates for example in HISP node [country x] as well as nearly all country deployments'. Nowadays, the latter is no longer the case as developers at UIO express there are now more DHIS2 deployments than they are even aware of.

Today, the overall aim of the program is formulated in a strategic document (2014- 2016 p.1) as follows:

The overall goal of the Health Information Systems Programme (HISP) at the University of Oslo is to enable and support countries to strengthen their health systems and their capacity to govern their Health Information Systems in a sustainable way to improve the management and delivery of health services.

Strategic aims of the program in achieving this overall aim involve the development and improvement of DHIS2 which followed the DHIS1; enabling the use of DHIS2 as a data warehouse to counter fragmentation, and providing training in the use of DHIS2 (strategy document 2014- 2016 p.1). In a research publication (Braa & Nielsen 2015) researchers at the UIO assign the following roles to various actors in the 'network of action' which are defined around the programs aims (see Table 1).

In addition, in the strategic document donor roles are described as follows (Strategy document 2014- 2016 p 2):

Table 1. Actors and their roles

Actors	Roles
University of Oslo	Academic research, strategizing, software development, prioritising requirements for generification, coordinating software development, demonstrations, piloting, engaging countries and donors, generating funding, facilitating Academies and related knowledge sharing, develop and participate in Master programs in the South, offer PhD program, provide API's, integrate with other software etc.
Developer nodes in the South	Software development, explore new domains
Software providers (e.g. openLMS)	Offer complementary functionality, integration with DHIS
Ministries of Health in the South and local NGO's	Training, implementation, knowledge sharing, data use in management
Regional health organisations	Facilitate the establishment of regional standards and regional implementers of DHIS
Universities in the South	Offer Master programs, participate in implementation projects
Independent consultants	Implementation and software development support, training
Academy trainers	Facilitating learning and knowledge sharing
Hosting partners	Virtual server provision or DHIS as software as a service
Health workers	Participate in training and use DHIS

Braa and Nielsen 2015 p 10.

- ...'Provide core funding for core development of the DHIS2 platform and staff for coordination and support of implementation in countries'
- ...'Supporting the implementation of DHIS 2 in countries'
- ...'Fund further development of DHIS 2 to support specific reporting requirements within the scope of country-owned health information systems.'

DISCUSSION

As pointed out by Walsham and Sahay (2006) scaling a system in scope and size requires growing diverse networks that surround a technical solution. In previous sections we have seen how experiences of developing the initial DHIS version '1.4' inspired a 'networks of actions' approach in previous work by Braa, Monteiro and Sahay (2004). In the DHIS2 case, the Researchers formed the beginning of this network with the aim to build knowledge on implementing health information systems while building systems on the ground and addressing local problems collaboratively.

According to this approach, researchers mediate between users and their institutions – in this case Ministries of Health and later NGO's– in several places. Put differently, the researchers apply Action Research in one place and then take their lessons learned to the next. They become a thread that spins between different organizations. This is also possible because they are the one building the solution in collaboration with different actors in various locations and at different moments in time. Where these 'threads' would be of a temporarily nature (in the sense that they are broken when the researcher leaves) these cases could be considered individual Action Research projects.

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However, in an alternative scenario that follows the networks of action approach, these threads between the researchers and their separate Action Research projects remain to exist over time (Braa & Nielsen 2015) due to the required efforts to sustain them. We could say that these ‘threads’ in a sense ‘institutionalized’ with the introduction of DHIS2, as all users now depend on a central product that ties them to each other and to the researchers. The response of the researchers to this new situation leads to a more ‘Open Innovation’ approach. The cornerstones of this approach are:

- A team of ‘core’ developers, established to coordinate and secure continuous and speedy development of the solution;
- A network of user-representatives, inspiring improvements, new use and innovation
- Open sourcing the software, enabling collaborative development of the solution together with user representatives in various countries and organizations that have employed the system. Although this also enables creating local ‘branches’ (that exists separately from the generic solution) the core aim of this strategy is to enable addressing of common needs shared by members within the network;
- Developing the DHIS2 into a generic platform, enabling flexible customization and extension of the solution to address individual needs within the network.
- Capacity building strategies in the form of as DHIS2 Academies become a prominent and formalized part of the networks activities and offer the network physical opportunities to meet.

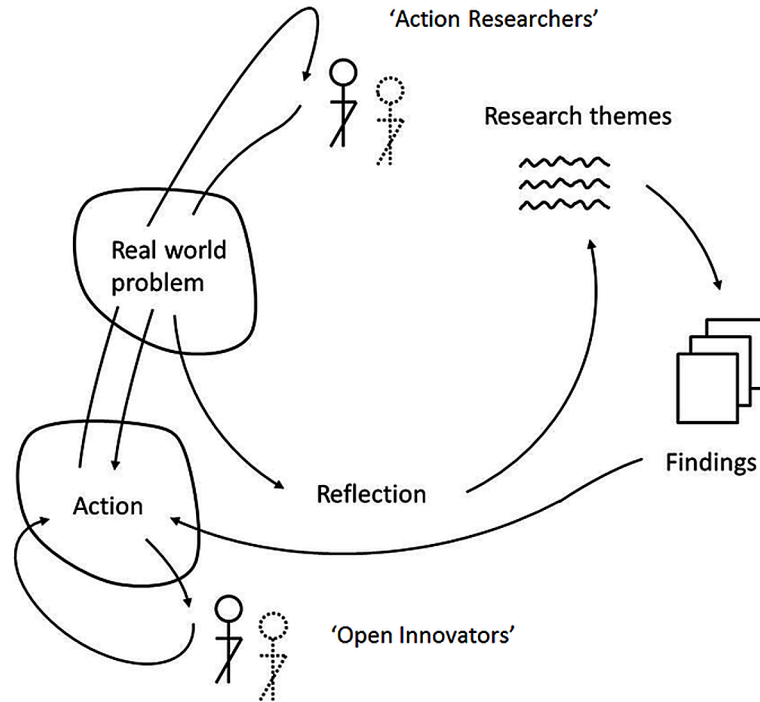
As the development of the solution becomes the effort of a team of developers and a network of practitioners, the role of the researcher changes. The initiating researchers are now supervising and introducing new action researchers and Action Research projects to support implementers and problem owners to improve the solution.

Action Research Systems

Looking back, we could say the traditional Action Research process ended when DHIS moved from South Africa onward to other countries, where the solution became part of new Action Research projects that started and ended. Once DHIS2 became a standard in the world of HMIS in low resource settings, more actors became involved in its development and funding. However, Action Research still had an important role to play as networked Open Innovation efforts continued to take shape. No longer emerging from one, the solution began to draw in new Action Research projects. One could say that from driving the solution, the solution now began driving research. The involvement of action researchers would contribute to informed action by participating in a wide array of design and implementation efforts (‘actions’) undertaken in different parts of the network.

As part of this new model, action researchers and practitioners are no longer working together from the initial phase of the AR cycle, but instead the action researcher enters an on-going ‘action’ process that is the combined effort of a variety of practitioners. This effort can be seen as an Open Innovation effort by an organization, in this case HISP UIO, that takes an Action Research solution forward, inviting action researchers to join a vast network of practitioners in their effort to tinker and improve aspects of it as problem owners are attempting to implement the solution to address real world challenges.

Figure 5. Action research system as part of Open Innovation models
Adapted from Checkland & Holwell 1998.



In Figure 5, this process is conceptualized as an Action Research System, in which (aspects of) Open Innovation processes are reflected upon by action research projects which, though temporarily in nature, are part of a permanent structure that informs the Open Innovation process as it attempts to negotiate a compromise between the needs and efforts of a variety of stakeholders. The following sections explore how Action Research Systems may contribute to current debates in relation to both Open Innovation and Action Research related domains.

Currently, these systems take the shape of individual Action Research projects that inform action in a specific part of the network involved in the Open Innovation process. For instance: AR researchers collaborate with Ministry X and HISP node Y to enable a new use of DHIS2 on mobile phones in country X. After a successful Action Research pilot, the solution can be made generic and available for everyone and action researchers share their lessons learned with others in the network. Such contributions certainly also emerge outside of these Action Research projects. However, with involvement of the Action Researcher, the innovation process is extensively studied and reflect upon inspired by theory and comparative cases. Being part of a 'system', the role of the action researcher makes it easier to consult AR research colleagues active in other projects within the network and research perceptions of the systems core designers as well as the perceptions of the end users who will be using it. In their role as a researcher, they furthermore document and share this knowledge. This way, AR research contributes to new innovations, collaborations and knowledge production in the network.

Action Research and Open Innovation

Action Research Systems have similarities to the ‘soft systems methodology’ (SSM). Checkland and Poulter (2010) developed this action-oriented method after studying the initial response to messy and complex situations that (among others) IS may find themselves subjected to / be designed to respond to. Action Research Systems are also developed for these situations, in which solutions required to respond to such complexities are dealt with continuously.

As part of the soft systems methodology, users find out about a complex problem situation through discussion or debate about the situation, identify how it might be changed in the form of models and take action to improve it (Checkland & Poulter 2010). Their conceptualization of SSM, which is the output of an Action Research process, focuses on the way participants of action oriented change processes have different world views of the problem situation. They base this approach on the assumption that ‘the complexity of problematical situations in real life stems from the fact that not only are they never static, they also contain multiple interacting perceptions of ‘reality’’ (ibid. p 192). Because the problem situation may change, the SSM process needs to be repeated with the aim of securing adaptive and holistic systems of *purposeful action*.

The concept of Action Research Systems stems from the same assumptions, however focuses on the way the solutions that follow from these non-static problem situations are required to ‘shape-shift’ along. The assumption is therefore not so much that problem situations change (and also world views themselves) but that the solution also changes as a result. Whereas Checkland and Poulter (2010) focuses on the process that went before this solution, Action Research Systems in some sense could be seen to emerge ‘after it’ to ground (changing) models used and emerging from these or other processes in research. It pictures an active role for researchers as part of holistic change systems such as Open Innovation initiatives / networks. As such, the aim is to contribute to *informed action* as part of these systems. Grounding innovation processes in research is considered important given the fast developing nature of both IS and knowledge in this area. The involvement of action researchers can enable dialogue and actions to be informed by knowledge of best practices both in and outside the network.

The Relevance of Action Research Systems for Action Research and Action Oriented Approaches

The previous conceptualization of Action Research Systems not only offers an alternative interpretation of the notion that scaling efforts of action researchers are unique in that they have the potential to transcend ‘roll-outs’ (of solutions) in terms of replication and generalizability (Gearty et al. 2015). It also has implications for the role of action researchers.

In early studies of Action Research in information systems (such as Braa, Bratteteig & Øgrim 1996 and Bødker et al. 1987), action researchers would take on the role of mediators between firms (their managers) and workers or users of a technological solution (for instance for the workplace) in the negotiation of purposeful design. Their Action Research solutions, though developed as much as possible together with users, are adopted by the firm. As mediators, action researchers tend to act as coordinators in bringing together various stakeholders and fine-tuning aspects of the design cycle.

In some aspects this traditional role of the action researcher is left unchanged in Action Research Systems. They still mediate for the needs of individual ‘parts’ of the network in order to enabling improved design for the network as a ‘whole’. However in other aspects, the role of the action researcher changes significantly. Whereas practitioners in the network become ‘mediators’ in the sense that they act as coordinators in bringing together various stakeholders and fine-tuning aspects of the design cycle,

the action researcher becomes a mediator between the practitioner and the scientific community. The Action Research targets specific parts of the network, as a result of which both the knowledge about the network as well as the knowledge within the network grows.

This conceptualization of Action Research systems furthermore requires a renegotiation of the role of the action researcher, who is no longer seen to engage participants and stakeholders as ‘co-researchers’ (Gearty et al. 2015 p. 46) but is engaged by stakeholders in ‘action’ instead. This new role has a potential of addressing what are considered weaknesses of the action research process. What Greenwood (2002 p. 130) points out as one of the most ‘unsettling’ features of AR literature is the way the term action research is used without attaching ‘any serious meaning to the concept of research’, adding that “throughout these [research] processes the collaborative process of reflection is the guiding thread that integrates the work.” This critique is perhaps especially valid in the IS domain.

Following Greenwoods perception that the collaborative process (unique to Action Research) is *guiding*, Action Research Systems have a potential to restore this ‘unsettling’ feature into one of the strongest assets of action researchers. Being engaged by practitioners in a collaborative intervention rather than driving it frees up the hands of the action researcher to reflect on knowledge gained from being deeply embedded in the change process. In a way, we could say that as part of Action Research Systems, the action research process ‘opens up’ as the actual ‘action’ becomes the main responsibility of a collaborative in which the action researcher takes on the role of a mediator and a counsellor based on his knowledge of both worlds – theory and practice.

In fact, perhaps the greatest benefit of Action Research Systems hides in a challenge pointed out by Greenwood (2002 p 133) which is very central in the case examined, namely: who owns action research products? This is where differentiations between Action Research within the IS domain and Action Research elsewhere becomes even more visible. Whereas Greenwood (2002) writes mostly about reports and documentation being created, in the IS field, these products concern technical solutions that require future development. Yet, as Greenwood (ibid.) suggests, ‘a collaborative project belongs to the collaborators’.

In the case of DHIS2, researchers and developers at UIO claim responsibility for the software’s development. Nevertheless, others are and remain free to fork out, maintain their own instance and remain part of the collaborative development process when they desire to. At the same time however, the negative consequences of not being able to benefit from later versions are likely to outweigh the positive for most actors involved. This is why the ability to stay part of collaborative development of the solution is so important, and where Open Innovation strategies offer the most potential. In the case of Open Source products, the answer to Greenwoods question about who owns the AR product is: no-one, and everybody does. And that answer is potentially the closest solution to solving the issue raised.

The Relevance of Action Research Systems for Open Innovation and Social Innovation Approaches

In an attempt to deal with scale and retain (local) participatory processes, action researchers at UIO have searched for solutions in Open Innovation strategies. These solutions in turn gave life to a new role for action researchers in studying them while contributing to them in line with the overall Open Innovation approach. As seen in the case discussed in this chapter, Open Innovation strategies have a great potential in dealing with complexity; however these approaches come with their own challenges.

Action Research and Open Innovation

Action Research Systems may complement the Open Innovation process that characterizes as spontaneous, free-wheeling, and organic (Badawy 2011) by making sure its processes continue to serve the needs of problem owners and subjecting solutions and practices to a vast body of research. Depending on the context, Action Research may further continue to infuse the Open Innovation process with creativity and novelty as well as share such cases with a wider network of scholars. As we have already established, Open Innovation and Action Research have many common grounds, and Action Research could take forward values of Open Innovation in relation to the sharing of knowledge in bridging activities of research and practice. In addition, Open Innovation is not merely enabled by developments in technology. For instance, as seen in the case discussed in this chapter, physical meetings and capacity building efforts may be an important part of its processes. Action researchers as part of Action Research Systems can stimulate and/or support networks or organizations in setting up such community-structures.

In doing so, Action Research Systems could furthermore help address two key areas in the Open Innovation literature that struggles to 1) understand the relevance of Open Innovation beyond high-tech industries and 2) study how firms implement Open Innovation in practice (Gassmann 2006).

Although this chapter has focused on Open Innovations as a wide spread and increasingly known phenomena, it must be said that Action Research Systems would perhaps in fact be most beneficial to the (sub-)domain of 'Digital Social Innovation'. This domain has risen along with developments in the area of Open Innovation and is referred to in a report about this approach for the European Committee (2015 p.9) as:

A type of social and collaborative innovation in which innovators, users and communities collaborate using digital technologies to co-create knowledge and solutions for a wide range of social needs and at a scale and speed that was unimagined before the rise of the internet.

As hinted at in this definition, the field of Digital Social Innovation is a relatively new field with 'little existing knowledge on who the digital social innovators are, what types of actions they are involved in and how they are using digital tools to achieve a social impact' (European Union, 2015 p. 23). Accordingly, Digital Social Innovation presents an almost entirely untouched area in both IS, Open Innovation as well as Action Research literature.

According to the current Action Research Systems approach, the ability of the action researcher to contribute to social change is limited to (multiple) local AR projects. By triggering and studying action in the networks' 'parts', these projects together contribute to a greater understanding of the bigger 'whole'. However, the concept of Digital Social Innovation in which co-creative Open Innovation processes that steer toward social change inspires a possible expansion of the relevance of Action Research Systems in this domain. Action Research Systems could potentially carve out a role for action researchers in enabling structured dialogues as part of (often unstructured) Open Innovation efforts about its social purpose. As explored by the SSM approach, this could lead to the development of shared models with the intention of enabling *purposeful action* – something which aligns with the intention of Action Research to contribute to meaningful change while learning from the process. Future research is encouraged to explore further how these two approaches can complement each other in realizing Digital Social Innovations and understanding how this is practised.

CONCLUSION

In the current innovation climate, Action Research interventions are no longer ‘local’ by default. However, our Action Research methods are currently limited in designing for solutions that address more complex problem situations. Open Innovations appreciate and increase opportunities for personalizing and customizing them to our own individual needs and tastes, and as such offer important opportunities for Action Research solutions to scale. Nevertheless, action research ‘action’, as one DHIS2 expert referred to it, is ‘a bit like building a mud house; when you are busy trying to hold one part together somewhere else another part is slipping away’. This metaphor illustrates well how Action Research solutions are not well-defined objects with a beginning and an ending and clear boundaries; they gather an array of often unpredictable processes and actors.

Given that ‘co-creation’ is key in both Open Innovation and Action Research approaches, this chapter has looked at their challenges as well as the way they can complement each other in overcoming their individual weaknesses; Action Research solutions are difficult to scale as part of the research process, and the chaos of the Open Innovation process may compromise the ability of innovators to reflect on its processes. Nonetheless, when Open Innovation initiatives gain the ability to span across over a dozen countries and trickle into ministries and multinational organizations of resource-poor countries there is no room for short sightedness. Scenarios such as the case discussed in this chapter enable us to think beyond local Action Research cycles toward Action Research Systems that can create and or/become part of the on-going development of real world solutions as they increasingly open up to the involvement of problem owners.

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ENDNOTES

- ¹ Infrastructures are essential, widely shared socio-technical systems ranging from electric power grids to communication networks (Plantin et al., 2016).
- ² Platforms are computing devices and software environments that are extended with application software built upon them, ranging from game design to content-sharing websites and social media applications (Plantin et al., 2016).

Appendix 3

Fruijtier, E., Sæbø, J. The Role of Action Research in Making ICT4D Sustainable (unpublished).

Making ICT4D Sustainable with Action Research: Re-conceptualising Client System Infrastructure

Action Research (AR) has been recognised as a viable approach in low resource settings to realise development outcomes. However, few studies have sought to understand the structures through which AR initiatives are sustained beyond the research project. Such structures have been conceptualised as ‘client system infrastructure’. In low resource environments where conditions surrounding AR projects are especially challenging, understanding how local AR solutions may be taken forward after AR researchers leave is of importance. It is therefore remarkable that, up until today, the Networks of Action approach (Braa et al. 2004) remains unique among few efforts to address this void, arguing that (global) scaling is needed for (local) AR-based processes to be continued. In this paper, we took advantage of the unique opportunity to, more than 10 years later, follow up on this approach in an effort to understand the previous dynamic. We explore how a ‘network’ developed around a particular ICT4D solution evolved, and simultaneously zoom in on how one of these client systems locally manages to sustain an AR-based solution over time. Our findings shed light on the complexity of change processes generated by AR efforts in low resource environments in developing sustainable ICT4D. Based on these findings, we propose Action research may be used to kickstart ICT4D solutions and give rise to networked infrastructures that function as a safety net in environments where the development and maintenance of local capacity may be challenging. These findings are relevant for both Action Researchers as well as practitioners who wish to gain insights in the sustainability of their efforts in empowering local clients and understand the advantages as well as disadvantages of scaling strategies.

Keywords: ICT4D, Action Research; Client Systems; Infrastructure; Sustainability; Low Resource Settings

1. Introduction

The field of Information and Communications Technologies for Development (ICT4D) has long grappled with the problem of sustainability (Walsham and Sahay 2006), which has been attributed to various challenges, from design-specific factors (Heeks 2002) to a host of financial, technological, informational, and institutional factors (Best and Kumar 2008). The persistence of technological solutions in low resources environments over time does not denote a static system but the capacity to adapt to changing technologies and needs (Kimaro and Nhampossa 2007). Sustainability is thus about being adaptive over time, rather than to perpetuate a certain technology or system as is. This is especially clear in a key area of development, namely health provision. The health sector is extremely complex due to the inherent nature of the field itself, the dependency of multiple sectors to achieve health outcomes, and the large number and diverse nature of development partners involved (Lane and Glassman, 2007). At the same time, it is dynamic in terms of changing priorities, emerging disease patterns, and adoption of technology. Reflecting both its importance and its complexity, health has been a recurrent theme in the ICT4D literature (Walsham 2017). Accordingly, in this article, we follow up on the challenge of creating sustainable public-sector health information systems (HIS) in developing countries, which we see as crucial components to improve health service provision and equity (Sahay et al 2016; Qureshi 2016). Specifically, we do this with an Action Research (AR) perspective, based on two observations. First, AR has been promoted as an approach for developing sustainable health information systems

in these environments (Braa et al. 2004, Burns et al 2012). Second, the AR process is a combined effort of action researchers and so called ‘client systems’ which consist of (a group of) stakeholders who actively participate in the process and are meant to take the process forward in sustaining the intervention. The researcher-client relationship is mediated by a ‘client system infrastructure’ (Susman and Evered 1978, Baskerville and Wood-Harper 1989), which can be understood as the research environment around the AR process. If the client system infrastructure plays a role in achieving the aims of the AR processes, what role does it play in the sustainability beyond the AR project? Whereas much has been written about the role of the client system in enabling a research environment, we know remarkably little about what happens when the action researcher leaves.

This study is motivated by an interest in understanding the long-term sustainability of AR solutions in ICT4D. Looking at the role of client systems, and the client system infrastructures, our study is guided by the following research questions:

RQ1: What client system infrastructures do AR based ICT4D projects generate to enable clients in taking AR solutions forward?

RQ2: How does scaling AR efforts as part of networks affect the creation of client system infrastructure around AR interventions in low resource environments?

Empirically, we look at the HISP case which inspired the Networks of Action (NoA) approach (Braa et al. 2004), which aimed at creating sustainable AR projects by scaling across organizational boundaries. Having been part of the HISP project for one and a half decade, we have the opportunity to both revisit the international endeavours so integral in the NoA approach, and to examine the waxing and waning of a specific client system in one country. Given that the NoA approach was developed over a decade ago and that technological solutions change rapidly, insight into the current activities of HISP in developing sustainable ICT4D today is relevant. Specifically, we focus on the period that followed the formulation of the NoA approach.

This paper is structured as follows. The following section provides a re-capture of the nature and history of the AR method, in which we also discuss how more recent ideas about the potential of networks in sustaining AR efforts have emerged. In section 3 we reflect on our methods, as we empirically engage with the same case which was used to develop the NoA approach. We structure our case findings in section 4 around the independent and yet interlinked development of client system infrastructure and the wider ‘network of action’, based on expert interviews, document analysis and extensive research involvement within the HISP project. We offer insights in our analysis process in section 5. In section 6, we reflect on these findings and the importance of growing ‘inter-client infrastructures’ around action research-based (ICT4D) solutions in ways that are attune to the needs of low resourced local client systems over time.

2. Action Research

The term 'Action Research' is usually traced back to the work of the social psychologist Kurt Lewin in the 1940's (see Lewin 1946; Adelman, 1993) as a method that enabled scientists to deal with critical social problems through understanding and changing human actions. Since then, his method has been subject to many revisions, and broad application.

2.1 Action Research and Information System Development

Kurt Lewin's ideas on AR found their way into the information system domain via a group which later formed the Tavistock Institute of Human Relations, who further developed them into a 'socio-technical' approach toward IS design as a strategy to generate scientific knowledge as well as a way to address social problems (Neumann, 2005). AR was thus applied in the information systems domain to help make industries that wanted to change production processes become more aware of how for instance automating processes impacted work processes of the individual workers. Traces from this work found their way to Scandinavia (Karlsen 1991; Sandberg, 1985) where the Norwegian Industrial Democracy Project gave rise to a strong participatory Action Research tradition in organisational work.

The project underwent three important stages, as discussed by Elden (1979). The first 'sleeping bag stage' (1964-1976) involved researchers, considered experts whose presence was essential to the project's success, intensely engaged on site for extended periods. What followed was a 'tool kit' period (1968-1970), in which previously developed concepts and instruments were applied under the guidance of the researcher in the role of a consultant. Finally, the project entered a 'do it yourself' period, where the aim was to 'de-mystify relevant knowledge sufficiently' (Elden 1979 p. 232) in which the role of the researcher was slowly diminished, and workers and their employees were trained to develop their own concepts and widen ownership further by setting up a broader social system within the enterprise or community.

This awareness of local ownership and knowledge was a crucial focus in a new generation of AR projects that focused on the means of production and the form, content of the working condition and the development of technological alternatives. An example of such an AR project is the Norwegian Iron and Metal Workers project initiated by Nygaard (Nygaard and Bergo 1974, Nygaard 1979) and the Utopia project.

2.2 Client System Infrastructure in Action Research

In this study, we will rely on the work from Susman and Evered (1978) which furthermore informed later works on Networks of Action by Braa et al (2004). Susman and Evered supplement earlier developments of the AR method with a consideration for cultivating sustainability in the following AR cycle (figure 1):

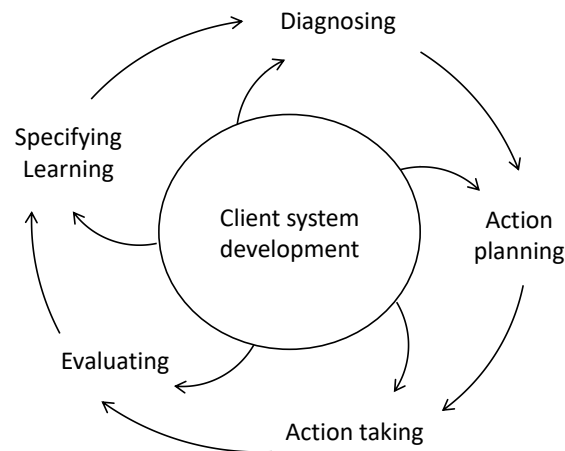


Figure 1. AR cycle. Adapted from Susman and Evered (1978 p.588)

In addition to previous aims of action researchers to contribute to both the practical concerns of people and to the goals of social science, Susman and Evered (ibid.) add the aim to develop the *self-help competencies* of people facing problems. They carve out an identity of AR that is future oriented; collaborative; generates theory grounded in action; is agnostic and situational and implies (client) system development. Notably, the word ‘system’ in this context has a social rather than a technical interpretation. Susman and Evered (1978) define a client system as the social system in which the members face problems to be solved by AR. Client system development refers to capacity building of a system to facilitate, maintain, and regulate the cyclical process (Ibid.)

At the same time, the notion that there is a single ‘client’ in a client system wrongly raises the image of unity. Client systems may involve face-to-face groups, an organisation or a network of organisations or a community (Trist, 1977; Susman and Evered 1978). Studying AR in complex organisational settings, Johnsen et al. (2014 p. 240) find a defined group of actors may not necessarily come to mutual understandings based on their own work experience. These settings are a meeting place between ‘*actors with very different institutional relations, very different agenda’s and very different time perspectives*’. Despite this complexity, Fox (1995 p.100) notes that in socio-technical system design processes AR should ideally be iterative or never ending:

The question ‘how can we improve upon the way we operate?’ should always remain open. To a large extent, maintenance of this AR-based process is more important than any given design solution.

This implies that client systems created in AR processes are required to re-arrange and forge new relationships in a way that generates a long-term relationships and problem-solving capacity between different actors. In fact, this may well be the most important aspect of the AR process.

In spite of this, our understanding of ‘client system’ development at present is currently tied to research involvement. In the literature, the client system *infrastructure* has been referred to as a social entity with whom researcher-client relationships are negotiated and agreed upon. It consists of both an ad hoc and permanent groups developed within a client system to conduct research (Susman and Evered 1978 p.588). However, this understanding of client system infrastructure does not reach beyond the research process, and perhaps, as a result, does not elaborate on how these elements are to be balanced in maintaining action research solutions. Such a notion of client system infrastructure is reinforced by Baskerville and Wood-Harper (1989) who define the client-system infrastructure as the specification and agreement that constitutes the research environment. These relationships are similar to the researcher-client relationship discussed by Davison et al (2004; 2012) in which a client system infrastructure is interchangeably understood as a ‘research environment’ that is being created at the start of the research as a vehicle for the research process (Baskerville and Wood-Harper, 2016).

2.3 The problem of growing Client System Infrastructure in Development

In the previous sections it has become clear that the historical roots of AR and its potential in developing information systems, in particular, were largely shaped by North American and Northern European experiences. Since then, AR has been explored globally (Bruce et al 2017) including low resourced environments in which ARs focus on social betterment has found fertile ground. According to Burns et al. (2012 p. 5):

Action research can be helpful in these situations because it assumes that participants should not only act but learn their way forward – this better prepares them to make sense out of complex situations than does pure action or supposed neutral observational research.

However, AR efforts in these environments may also have to deal with their own particular challenges. For instance, many AR projects in developing country contexts will be donor driven. A bulletin on AR by the Institute of Development Studies (IDS) notes that all contributions report on donor-supported projects (Burns et al 2012). The editors (ibid. p3) point out that such relationships can have an impact on the research, for instance, because donors may hold different expectations from either researchers or participants. They give the following example:

Good work may need to develop more slowly than the donor requires; emerging issues may not stick to the core of what the donor wants to focus on; communities may want to work on issues which are not easy to measure; monitoring and evaluation systems may undermine trust and impact on what is done, and so on. Similarly, participation can be distorted by a donor–facilitator–participant relationship: expectations may be formed which cannot be met; payment may be anticipated, participants may frame their inquiry or provide information that they think is expected of them by outsiders.

Such views are reflected also in other studies, pointing to the potential distorting role of funders of AR projects (Moxley et al 2017).

Similarly, the positions of researchers may equally invite multiple, and possibly competing, motivations for engaging in AR projects. Researchers are required to write publications and attract funds as part of their job descriptions at their institution, and doctoral students are expected to produce a thesis (Burns et al 2012). This can be problematic because, as facilitators, they also need something from the process in return. All of the previous relationships can contribute to situations in which projects are entangled with highly unbalanced power relationships from the onset. As a result, Burns et al (2012) note that communities in low resource environments may invest a great deal of time into processes which have little or no impact – but are hugely beneficial to the researchers or students who’s professional gain is driven from the process rather than the anticipated outcome (in the form of social, political or economic change). Indeed, the unbalanced power relationships may be interpreted as a form of cultural and epistemological imperialism (McNiff 2017). However, there are also cases where the previous issues are unproblematic, and that *‘people live in the real world and are aware of what others have to do in order to make things happen’* (Burns et al 2012, p. 4).

It is in the previous challenges that the limitations of the logic of ‘a client system infrastructure that serves a research process begin to appear. What is missing in this equation is a long-term perspective that enables researchers to approach client system infrastructure (and therefore its development) as an effort to enable maintenance of action research interventions beyond research processes, in line with the aim to develop the self-help competencies of people facing problems (Susman and Evered 1978).

This limitation was recognised by Braa et al (2004) when they applied action research methods under the HISP project, which started in 1997 aimed at developing health information systems that could address management challenges prevalent in developing country contexts (see section 4 for more details). In order to sustain AR based processes, researchers focused on putting in place both vertical processes of appropriation and horizontal processes of “replication” and sharing. These processes are discussed as the creation of a network of sites; enabling local learning processes; bringing together a variety of actors around shared goals and interests and aligning interventions with environmental structures (existing institutions, competing projects, and efforts as well as every-day practices). This network mainly consisted of researchers who took roles of supervising,

training, systems design, mobilising support and generating funding (Braa et al. 2004) in alignment with Ministries of Health in countries of implementation. Scaling, as a mechanism for sustainability, was achieved as researchers travelled along with the solution they continued to re-create in different settings, giving rise to a networked environment, while rooting their efforts in local continuous action at the same time.

This became conceptualised as the ‘Networks of Action’ approach, which argues that sustainability in terms of continuous learning (in the form of a network) is required for the sustainable creation of client system infrastructures around AR solutions in developing country contexts. However, acknowledging that not all local client systems may achieve the development of such infrastructures successfully, a case seems to be made for sustaining the overall activities of the network in creating sustainability *beyond* individual cases in coping with these tensions. For instance, in cases mentioned in the paper (Cuba, Ethiopia and Mongolia) the networks created fell apart after initial efforts discussed by Braa et al. for a diversity of reasons (see for instance Saebo and Titlestad (2004)) while others (Tanzania and Mozambique) experienced significant set-backs.

We are inspired by the development of what we will refer to as an ‘inter-client system infrastructure’ to sustain local client systems in the midst of challenging settings. At the same time, we are also concerned that, in line with the papers’ theoretical framework, we can detect the presence of an actor-network-theory logic here in that once a network enrolls enough actors, its survival becomes less dependent on individual linkages. This dilemma raises the question: what exactly is the role of scale in developing client system infrastructure that is able to sustain AR induced processes?

3. Methodology

This paper is the result of a case study of the HISP project to research the networked development of a free and open source software called DHIS2 over a period of 13 and 3,5 years.

A naturalistic inquiry is founded on the primary belief that phenomena should be studied in context (Frey et al. 1999). Following this approach, both authors have been involved longitudinally with various activities of the larger HISP network during which relationships were built with developers and researchers.

3.1 Data collection

Data collection for this study can be divided into three modalities. The first denotes the general participation of both authors in HISP. Data collection on multiple occasions over time contributed to a thorough understanding of the inner workings of the HISP network and its main processes, from the perspectives of HISP experts, researchers, as well as members of HISP nodes and local users within Ministries of Health and further down the chain. This was used to develop an understanding of how a ‘global’ inter-client system evolved around DHIS2. The development of DHIS2 is the result of collaborations of a global network, the Health Information Systems Programme (HISP), which is coordinated by the Department of Informatics at the University of Oslo (which we here call HISP UoO).

Data was collected during HISP UoO activities which involved attending various presentations within HISP UoO by both researchers and management; meetings with stakeholders; developer team meetings; strategic meeting with members of HISP nodes, and a series of conference calls with external experts and/or HISP node members. Both authors attended several expert and

regional academies in multiple regions for both advanced and basic users, which would sometimes lead to field visits which generated insights in local practices of community health workers and local NGO's or those of local HISP nodes and Ministry staff. In addition to regional academies, annual 'expert' academies were attended which hosted users, co-developers and members of the core team and further expanded access to various actors at different levels of the network, to take note of interactions between actors as well as use the opportunity to intermingle and interact.

Engagement in the previous activities led to a collection of interviews with various actors on a variety of topics concerning their involvement, practices and experiences within the network, and many observations were documented. This data was combined with a bulk of internal documentation which was gathered over time including training material, process reports and evaluations, as well as a large volume of publications (including MSc and PhD theses) on the formation and development of DHIS2. In addition, authors access to designer and user interactions/ issues on DHIS2-user and developer lists.

The second modality concerns direct involvement of the second author in specific developments around a particular client system in Sierra Leone during an AR project. This project took place between 2007 and 2011, where a total of 13 weeks over 6 visits were spent in Sierra Leone. The data collection methods applied were varied, but mostly of a qualitative nature and focusing on understanding and improving health information systems in Sierra Leone (see Sæbø 2013). Given the nature of the involvement, with 6 weeks being intensive training in DHIS for 26 people and the rest of the time variously spent on the road between district offices, health clinics, and different departments at the Ministry of Health and Sanitation (MoH) as meetings were arranged in a pragmatic fashion based on availability, it is impossible to give an accurate account of the number of interviews and length of observations and the like. For here it would suffice to say that the author worked closely in a team consisting of three Sierra Leone nationals at the MoH as well as other action researchers and practitioners in the field of health informatics, which engaged in a participatory development process with health programs, district staff, and numerous NGOs to completely revamp the Sierra Leone health management information system. As such, a multiplicity of methods, including informal and semi-structured interviews, observations, group discussion, and document (especially health data collection forms) analysis, that is typical of AR projects, was applied.

The first author was not involved in research activities that happened during this stage, however, was able to relate some of these experiences to ethnographic study of work practices conducted in a country in Asia. Here, the author spent a period of 5 weeks observing the practices of 4 DHIS2 experts and 2 DHIS2 user groups (NGO and Ministry) amid an effort to integrate and implement several DHIS2 instances and provide training.

Finally, both authors attempted to piece together developments of the client system in Sierra Leone and its interaction with elements of the networked infrastructure surrounding DHIS2 after the researchers had left. The second author has at four later occasions (2014 and 2016-2018) visited the country for one week during this time, related to the earlier work but not directly linked to it (crucial in this regard is the typical situation of a different funder/budget). Furthermore, several colleagues of the authors have been working with health information systems in Sierra Leone occasionally since the closure of the AR project.

3.2 Data analysis

Our data analysis was led by the interactive process described by (Miles and Huberman, 1994) comprising of a mixture of data-reduction (during which we selected focused, simplified, abstracted and transformed ‘raw’ data), data display (during which we created organised assemblies of information) and conclusion drawing and verification efforts (during which we had to decide what things meant, noticed regularities, patterns, explanations, possible configurations, causal flows, and propositions) Analysis was aimed at developing a broad understanding of the development of both a local client system and its infrastructure as well as a ‘inter-client system’ and its infrastructure over time.

We developed this broad understanding by mapping of key actors involved in both processes, their roles and involvement over time, as well as key events that had a shaping effect. Actors and events were identified during interviews with informants and field note analysis and complemented with information from internal documentation and publications. Data was collated and summarised to create a chronological reconstruction of both processes. This time-line provided an historic overview of the case and creates an image of the complexity and scale of the network as it develops over time.

The second author furthermore was able to draw from previous experiences of working with WHO on health information systems strengthening for a period of two years. Given the involved nature of the research as well as the meta-levelled nature of the analysis, triangulation was applied in analysing these findings with two HISP UOO informants that were familiar with events within both cases. Finally, we focused on investigating these insights in the light of present knowledge.

4. Case findings

The empirical data presented in this paper draws on the development and implementation of the District Health Information System version 2 (DHIS2). DHIS2 is a free and open source-based software platform, widely used as a tool for collection, validation, analysis, and presentation of aggregate and transactional data, tailored (but not limited) to integrated health information management activities in low resource settings. Being a platform, it is highly configurable and customisable and has extensive interfaces allowing for integration with other systems (Nielsen & Sæbø, 2016). The HISP network that surrounds DHIS2 is comprised of various entities, including Universities, Ministries of Health, non-governmental organisations (NGO’s), international agencies and many country-implementing agencies commonly referred to- as ‘HISP nodes’.

4.1 Introduction of DHIS2

DHIS2 was heavily influenced by the earlier DHIS version 1, which had been developed after the fall of the apartheid system in South Africa as a joint Action Research project between UoO, University of Western Cape, University of Cape Town and the Ministry of Health in South Africa. This collaboration was motivated by a shared goal to turn the fragmented and centrally governed health services inherited from the apartheid into integrated and to some extent locally governed health services that would serve a new South Africa. Following participatory approaches whereby designers closely collaborated with health practitioners in the field, a desktop based DHIS was developed and, over time, successfully implemented. This success led to the formation of a South-Africa based NGO to support the implementation.

Our point of departure is the situation described by Braa et al. in 2004 who describe the growth of the HISP project, starting from an action research project in South Africa, to a loosely connected network of similar activities in Mozambique, Ethiopia, Mongolia, among other countries, which is the basis for their formulation of a NoA approach (ibid.). Of the countries described as part of the Network of Action, the projects in Cuba, Mongolia, and Ethiopia had by then come to an end, while lingering on in Malawi, Tanzania, Mozambique, and only going strong in South Africa and India.

In 2006, development of DHIS2 was initiated at the University of Oslo, to only use open source technologies, and to be generic based on the requirements from multiple countries. Now, attention of researchers had to be divided between building the capacity of local client systems to make a generic solution work locally; *and* developing a network around the global development of the generic solution.

DHIS2 was first implemented in the Indian state of Kerala in 2006 when it was still in its infancy. This success opened the door for a second implementation of DHIS2 in 2007 in Sierra Leone, which would be the first country to roll out DHIS2 nationally. Sierra Leone had been selected by the global advocacy organisation and WHO-partner Health Metrics Network (HMN) as a “first wave country” of improved health information systems. The University of Oslo, being the developer of DHIS2, was tasked with assisting Sierra Leone through an AR project funded by HMN. This would be the beginning of two important aspects which we concentrate on in this paper. From here, we follow two client systems developing in relation to each other; one global client system is built around the ongoing development of DHIS2 and its subsequent implementation in a range of countries, and another local client system is being built in Sierra Leone around this concrete implementation.

To examine the role of client system infrastructures in sustaining action research solutions more deeply, we now first turn to the “local” case of Sierra Leone, before looking at the concurrent and later growth of the inter-client system infrastructure from a global perspective. They are not independent of each other, as will be highlighted when we revisit Sierra Leone later in the chapter.

4.2 Implementing DHIS2 in Sierra Leone (2007-2011)

The project in Sierra Leone has been extensively covered in other publications (see for instance Sæbø et al. 2011 and Kossi et al 2012) in line with the tenets of the action research project carried out there. We will not reiterate the details, but here rather focus on the composition, role, and evolution of the client system infrastructure. This was created in 2007 when HMN approached HISP UoO to help implement the strategic plan for health information system strengthening that Sierra Leone and HMN had developed. HMN, being a partner of World Health Organisation and funding the project, carried both the legitimacy and resources to bring about broad consensus for revising the existing system and implement DHIS2.

Specifically, HISP UoO was approached to help revise the health data collection forms that are used to report on activities in all health facilities, set up the DHIS2 to support the electronic reporting and analysis of the data, and to build capacity locally to use the new system. The Sierra Leone counterpart was the Directorate of Policy, Planning, and Information (DPPI) under the Ministry of Health and Sanitation, which was in charge of the current monitoring and evaluation structure at facility, district, and national levels.

While from HMN and DPPIs point of view this was a project with consultancy needs only, it was agreed that a professor and several PhD students from UoO would be involved in a periodic and cyclical manner and that they would carry out research. The research would inform the development of the DHIS2 software, which was still very new and quite immature, generate knowledge on appropriate implementation strategies, and more concretely focus on the identified challenges in Sierra Leone such as improving the use of data for decision making in the health sector, find appropriate and sustainable use of technologies in an extremely resource poor environment, and build capacity locally to make any solution implemented sustainable.

DPPI was the main problem owner, the *client*, and was responsible for revamping the health information system after the civil war which had just ended a few years earlier. They had around 15 staff, but only two technical staff were involved in the project on a full-time basis, with some involvement from the director and the lead Monitoring and Evaluation (M&E) officer. Moreover, DPPI staffed two M&E officers in each of the 13 districts in the country, which would be the key persons using the DHIS2-supported information system.

The HMN's main role was to fund the implementation. However, they also added substantial time of one senior staff to drive the project, and he was frequently in the country to organise meetings, training sessions, and actively engage in the implementation efforts. In addition to financing the involvement of HISP UoO, HMN also directly funded the two technical staff at DPPI, as well as a driver and a car and the necessary hardware and money for training workshops for the district staff. The car and computers would continue to be in use after the end of the funding, initially not to go beyond 2012.

The project staff funded by HMN had several responsibilities within the project. First and foremost, they were responsible for the information system, making sure DHIS2 was running, data was collected from health facilities to national level, and that relevant stakeholders would get access to the data they would need for decision making. They were also responsible for the project locally, such as organising and distributing hardware to districts, organise training workshops for all relevant staff, and facilitating the involvement of HISP UoO by means of organising visits to districts, calling in meetings with partners, and reporting to both HMN and HISP UoO on the progress and challenges they faced.

Lastly, HISP UoO was responsible for the development and implementation of DHIS2, capacity building, and providing, through research, input into the further improvement of the overall health information system. HISP UoO action researchers together spent several months in the country customising the DHIS2 application, making training material and conduct training workshops, and visiting district offices and health clinics to provide on-the-job training and collect feedback on both the system and the software application. All this was done together with the project staff at DPPI, with the aim of building their capacity to conduct similar tasks. In addition, the lead DHIS2 developer (and only non-research staff at the time) visited the country and maintained close communication with DPPI and HMN, which was natural given the very few real implementations of DHIS2 at the time and the need to gather requirements for further development.

This collaboration was set up to work towards one specific goal; the implementation of an integrated health information systems as per a globally acknowledged standard (the "HMN Framework"), with one specific technical solution; the DHIS2 software and associated practices of data collection, processing, and analysis. Within this broad goal, the specific actions had to be both research- and opportunity-driven.

Action research efforts, for instance, led to the development and introduction of “league tables”; simple tables that were ad-hoc created in Excel to rank health facilities’ performance based on a small set of important health indicators. It came about as one approach to remedy a concurrent problem throughout Sierra Leone, namely the limited use of data for decision making. The strategy was to develop tools that were both simple, yet powerful, to improve the incentives of the districts to critically reflect on the data they were putting so much effort into collecting from the health facilities.

During the years 2007-2011 the client system which facilitated an environment for action research, consisting of DPPI, HMN, and the University of Oslo, remained relatively stable. It succeeded in reaching national scale of the system, improving data quality, achieving some effect on improved information use for health management, and publication of several academic papers. Notably, two PhD theses were based on the project, with many more individual papers published. On the software side, Staring and Titlestad (2008) speak of a ‘dramatic improvement of the code through the Norwegian team’s hands-on work in Sierra Leone’.

Sierra Leone remained to play an important part of the rapidly growing inter-client system infrastructure until HMN re-focused its agenda and stopped funding the project in 2011. When funding discontinued, HISP UoO involvement was significantly reduced, and over the next years was limited to sporadic visits in relation to other projects. At this point, HMN had closely documented the DHIS2 implementation in Sierra Leone and published this outcome in various outlets.

HMN thus highlighted the Sierra Leone project as one of their successes, and it received broad coverage in various reports and conferences at the global level. UoO used the Sierra Leone project similarly and adopted it for their online demo of DHIS2 which became the showcase for other countries considering it.

With these previous developments in mind, we now turn to the inter-client system, which continued to expand rapidly in the following years, before we again look at Sierra Leone to see how the two systems related to each other.

4.3 The globalisation of HISP (2006 – present)

The inner workings of the global inter-client system around DHIS2 were very similar to the NoA approach described by Braa et al. (2004). However, the main hub in the network shifted from South Africa to HISP UoO, who led the development of DHIS2 and secured funding for both action research and more implementing-oriented activities. The new DHIS2 software represented another big difference: It was web-based as compared to the desktop-based DHIS1, and no longer primarily developed with one particular country in mind, but sought to take in innovation and requirements from all implementing countries. In line with the NoA approach, HISP UoO continued to develop a global network of action comprised of different countries and their institutions and government agencies that played different roles in the establishment of the network.

The rapid growth of DHIS2 implementations began after Kenya implemented the first online instance about the same time as the project in Sierra Leone ended. Kenya had also received funding from HMN for an HIS assessment and planning process. Researchers from HISP UoO who had

worked in Sierra Leone saw the potential for utilising the good nation-wide mobile internet in Kenya to set up DHIS2 as a “cloud” instance. Contrary to the Sierra Leone implementation, which faced many logistical challenges in synchronising offline district-implementations of DHIS2, Kenya could reach the whole country with one centrally installed instance. The Kenya-requirements pushed UoO researchers to make a new transition, from a desktop-based to a cloud-based system, which became the norm for all DHIS2 implementations hereafter.

This shift from desktop-based to cloud-based significantly improved scalability (Manya et al 2016), which kick-started a rapid growth of implementing countries. In addition, this growth was also a result of the way DHIS2 (and HISP UoO) at this stage had become firmly established at the international level. This was in part due to the implementation in Sierra Leone, which for instance played an important role in convincing the West African Health Organisation (WAHO) to promote the replication of this success across its 15 member states.

While responsible for its scaling and success thus far, the NoA could not accommodate the changes required to cope with the rapid scaling of DHIS2. This led to a change in strategies which will be elaborated on further in the following sections.

4.3.1 From local to regional support

As part of the NoA approach, local implementations and capacity building processes were conducted by researchers in implementing countries, in collaboration with staff at the ministries (this was for instance done in Sierra Leone through the HMN-funded project) or local developers – for instance through University collaborations. This was possible as a number of local MSc programs had also been established during this period to contribute to the overall capacity around health informatics in the countries. However, the introduction of DHIS2 – and especially its scale – required that the network of local developer teams would also rapidly expand. Here, the role of action-research as the engine of the network changed.

While PhD scholarships and MSc research remained a strategic tool in the implementation of DHIS2 and the strengthening of client systems, they have perhaps been most effective when graduates¹ have returned to their countries. This development has contributed to the strengthening of implementations, institutional capacities and potentially support local Master’s programs (as evident in the ‘HISP UoO Business Plan for DHIS2 Core Resources 2016-2021 p. 5’). Doing so, they furthermore become both advocates and users of DHIS2 and, in many instances, will occupy key decision-making positions within Ministries or establish social enterprises in support of DHIS2.

In part, the previous PhD scholarships and MSc programs would contribute to creating a network of ‘HISP nodes’; typically, a few people organised in a legal entity, so that they can take on consultancy projects in their home country and abroad. These nodes vary in size and capacity, experience, (formal) relationships with their local Ministry of Health, and the extent to which they engage in technical work locally or internationally. Over time, these nodes became both more formalised and internationally oriented, with more or less specified roles in the wider HISP network.

¹To date, 45 PhD candidates have graduated (5 a year on average between 2006-2016) with 3 or 4-year scholarships each.

One example is HISP West Africa, which was started by one of the PhD students who was initially involved in the Sierra Leone case described above. Extending the team, this entity is now active in West Africa in general, facilitating standardised training programs and collaborating at the international arena together with HISP UoO and large international NGOs. The legal entity formalized with HISP UoO what up until now had been informal practices on open source software development of DHIS2, national, regional and global capacity building activities including hosting and arranging DHIS2 Academies, and implementation support to Ministries of Health and others.

Rather than focussing on local capacity building, this enabled the team of researchers and implementers at UoO to focus on holding regional trainings starting 2011. During these trainings, representatives from various countries would learn from each other and meet with global developers and international trainers, and then go on to conduct in-country training themselves with the support of local developers. These trainings became known as DHIS2 Academies. Today, there are approximately 20 DHIS2 academies held annually all over the world, covering an ever-expanding portfolio of topics and levels of experience. The HISP nodes are responsible for holding the majority of these. In addition, an on-line DHIS2 academy was launched recently (academy.dhis2.org) which is used to help users prepare for on-site academies as well as reach users who may not be able to attend them.

4.3.2 From research funding to donor funding

Concurrently, an assessment conducted in 2016 notes decreased funding for research and scholarships. Whereas funding structures supporting the NoA approach primarily came from a Norwegian programme for development, research and education, later the main funding comes from development agencies whose interest is predominantly in the solution/ change created by the network, rather than its research aspect (HISP UoO Business Plan for DHIS2 Core Resources 2016-2021 p.21). As part of this development, academic pursuits received less funding than previously.

As the clientele of the network shifted towards international agencies and NGOs (“donors”), several of these organisations have increasingly become advocacies for the software in terms of support and implementation for their own use. Many of these donors implement DHIS2 as their system for internal reporting and accordingly provide funding to HISP UoO for the development of the DHIS2 software. Others allocate resources for the strengthening of health information systems and capacity in developing countries more generally; others offer small scale support to individual country DHIS2 projects or the development of specific modules.

4.4 Sierra Leone (2011 – present)

As the global network around DHIS2 was expanding, HISP UoO direct involvement in Sierra Leone diminished. HMN increasingly shifted its focus away from HMIS-projects from 2011 and was finally dissolved in 2013. Funding to carry out the strategic plan of HIS strengthening in Sierra Leone was in any case limited in time, but the exit of HMN came at a point in time where few new resources had been secured to continue what was regarded as a success.

One immediate consequences of the ending of HMN was that the two staff in Sierra Leone lost their salary. Having knowledge of IT, they managed to stay in DPPI for a while, but eventually drifted away into other posts, in other ministries. Another immediate consequence was the end of funding for technical support from HISP UoO. This would at normal times not be too crucial as

several students were involved and their scholarships and need for empirical material would justify continued involvement. However, in 2012 it coincided with the rapid growth of the global activity level, drawing available resources to other (funded) activities.

In addition to the end of the HMN-funded project, two other shocks would seriously challenge the remains of the client system infrastructure. First, due to political reasons, the whole leadership of DPPI changed shortly after 2012. This removed an important part of the institutional memory, as well as the crucial capacity that had been built at central level in the Ministry. An important factor that kept the system going nevertheless was the ‘disadvantage’ discussed earlier, in which DHIS2 was not deployed as an online system, but instead as independent installations in each district as well as a synchronised national database. Thus, when the national system collapsed, the districts were relatively shielded, and they could continue using their local instance. DHIS2 was thus still in use, but with no support from the top, the districts would find it hard to maintain the system over time.

Second, the Ebola virus epidemic that ravaged West Africa in 2014-16 had a profound impact on the workings of the health information system. Normal functioning of the health services was severely disrupted, and several districts were locked down completely for weeks. The Ebola epidemic would eventually lead to increased efforts by the international community, and an influx of funding has supported several initiatives specifically focusing on disease surveillance and response. However, by 2018 the funding triggered by the Ebola epidemic has all but dried up.

Throughout this period the client remained the same, but the people changed. Both the political situation and the inability of the Ministry to compete with international agencies for qualified staff, would lead to frequent changes of key staff over the years. While new staff would occasionally attend DHIS2 academies, this would only contribute to their ability to get more secure positions in other places, such as with NGOs.

HISP UoO would sporadically engage with DPPI during this period too. Some of this work was covered as part of regular HISP UoO activities such as the provision of online support through user-lists and answering direct request by emails. Some visits to Sierra Leone were also carried out as part of a new project led by the West African Health Organisation (WAHO), which was taking up a lead role in the region concerning health information systems. This project was eventually focusing on disease surveillance, but while in Sierra Leone researchers from HISP UoO would also check up on DPPI and provide small-scale support and capacity building. Lastly, HISP UoO would put in its own resources occasionally to assist DPPI, for instance, related to assisting in making the shift from desktop-based to online-based DHIS2 implementation in 2015.

In addition to the “original members” of the client system, additional consultants and NGOs have been active in the wider space of the Sierra Leone health information system. Notably, individual consultants with DHIS2 experience (previous PhD students at UoO) have been engaged through various seemingly uncoordinated means. This has led to a lot of short-term design decisions in the system, typically made with only a limited view of the system as a whole, which has accumulated over the years. One DHIS2 expert recalls how, when they first came to Sierra Leone, they found there was no data in their system prior to 2011. There had been no back up process in place, and they perceived the fragmented work as a result of sporadic involvement of consultants to try get something going without knowledge of the ‘bigger picture’. The database had been set up, but with a serious lack of standardisation and design that would enable its sustainable maintenance. This expert noted:

'You need someone for long term care (...) it is like trying to fix your garden, but you have to weed the garden, cut the trees... you need someone who comes back and looks after your garden.'

Despite serious problems, DHIS2 is still in use, and the Global Fund has become a main funding partner in the overall inter-client system, allowing HISP UoO to become a technical partner yet again.

5. Case analysis

In the previous sections, we have described two parallel developments: the emergence and evolution of Sierra Leone's client system, and the global network surrounding DHIS2 which developed *after* the NoA approach. To understand the role of the wider network in sustaining the Sierra Leone implementation, our analysis process broadly covered four phases which we will discuss in more detail in this section.

First, we identified the 'client system and 'client system infrastructure' out in place in support of research activities. In the Sierra Leone case the client system consisted of the Ministry of Health who was interested in a sustainable solution for their health information management; HMN who wished to pilot DHIS2 as an integrated health information system solution as part of their HIS Framework; who were joined by HISP UoO who was interested in researching and improving the HIS solution they develop and expand it to more countries and different use contexts. These actors were joined temporarily in what was an AR project for HISP UoO, a pilot project for HMN, and a drastic re-organisation for the Ministry. Notably, our client system is not a stable entity. Actors were temporarily united by a shared interest in an (AR) solution. However, their agendas were different, and their relationships were likely to disperse again over time. To better understand this dynamic, we chronologically organised our case data about the DHIS2 implementation in Sierra Leone.

The second stage covers the initial process of implementing DHIS2 in Sierra Leone (2007-2010) and was funded by a single donor, HMN. This actor furthermore created strong legitimacy for the project, being a partner of WHO. HMN established partnership with HISP UoO who brought in an early version of DHIS2. These actors together provided most of the capacity for the project, in the form of HMN-funded technical staff, HMN and UoO funded researchers and developers; and they furthermore developed the capacity within the Ministry. The DHIS2 software at this time was still very much in its infancy. The client system infrastructure that was built in Sierra Leone during the action research intervention thus relied on highly unstable elements.

The third stage can be seen as the period 'after' the Sierra Leone implementation, during which a global network begins to develop around DHIS2 based on the global activities action researchers are engaged in elsewhere. The foundations of this network were already put in place by the NoA approach and the network established around DHIS1. The partnership with HMN in Sierra Leone and its success then added to the legitimacy of DHIS2 as a credible solution - and the interests of new parties were raised. At this stage, the spotlight of the network moved toward Kenya which because of its enabling environment became a test case for a web-based implementation of DHIS2. This became another key factor in the spread of the solution and growth of the inter-client system. As part of this 'chain-reaction' more donor funding was attracted; more core staff was hired, and more features were added to the solution which in turn gained more attraction.

These developments also benefitted the establishment of local HISP nodes; entities of one or more local DHIS experts, often trained to support the ministry, some of whom are able to extend their

support to other countries in their region as they partner up with other HISP UoO activities. DHIS2 academies became a key vehicle for training new actors and create arenas for knowledge exchange, learning and networking. In addition to HISP nodes, many NGOs also acquired good skills in DHIS2. As a result, we see a drastic change in funding; research funding went down and was replaced by an increase in funding from international donor agencies who paid for software development and implementations.

Finally, we then turned back to the situation in Sierra Leone. Although our data is less rich on the period in between 2011 and 2018, we were able to trace important developments during this period in which various actors of the global network that emerged around DHIS2 implementation were sporadically involved.

As it turns out, many things had happened in the meantime. DHIS2 had been deployed online in contrast to the desktop-deployment. However, it was this desk-top deployment that kept most of the systems infrastructure in place as it enabled the districts to keep using the system when the consolidated national database was lost when. Efforts had been made to patch the system together again at national level - however, once HMN funding stopped, the capacity to maintain the system was also reduced dramatically. Some Ministry staff went to DHIS2 academies in the region, but staff turnover continued to be high. As a result, the system had relied on the occasional support of HISP UoO consultants and regional HISP nodes drawn to the country as part of other projects. At this point, the growth of the global client system infrastructure (with DHIS2 academies and deployments in more and more countries) actually placed Sierra Leone at a disadvantage as direct collaboration with key UoO staff became harder due to increased scale of global activities.

In explaining the previous changes, we can identify several trends. First, both the implementation in Sierra Leone as well as the development of a global network around DHIS2 are subject to what we refer to here as a moving ‘spotlight’ attention of international donors. Crucial elements of the client system in Sierra Leone falls into place when this spotlight is on them. However, it may move away and move back again without much certainty. Secondly, we see a successful client system infrastructure may significantly contribute to the development of a wider global network; aiding its legitimacy, its intervention (in our case technology); its capacity and funding, that are magnified as more client systems (in the form of country implementations) are added. The other way around, we see such global networks may be able to provide ‘life-line’ support when country client system infrastructure crumbles. At the same time, this ability is compromised by two of the previously mentioned trends, namely: 1) joining of more client systems (which disentangle the risk and dependency of infrastructural elements to require a single client system to remain successful) and 2) moving ‘spotlights’ of donors which can direct support of a global infrastructure toward or away from individual client systems.

The global network around DHIS2 was unsuccessful in providing such support on a consistent basis. Nevertheless, although this was not the case in Sierra Leone, there are examples in the HISP network in India, South Africa and Tanzania where strong local HISP nodes have been established to support client systems over time (see for instance Fruijtjer and Senyoni, forthcoming). Here, the initial AR projects created institutions that became part of the national health information infrastructures. In addition, HISP nodes may provide regional support for several client systems that do not have such a support structure but did manage to gain some ‘spotlight attention’. When these HISP nodes also are connected to a local Ministry, such activities generated by being part of

the global network may at times enable them to support local implementations in between funding contracts.

However, in absence of such local capacity, our case illustrates how support from the wider network may not provide solutions for the periods of ‘darkness’ that may fall on client systems - especially as they grow in size. In addition, our data also shows risks of short-term involvement of non-HISP consultants who operate without a ‘bigger picture’ in mind.

6. Implications

The situation in Sierra Leone discussed in the previous sections is illustrative for the problem being addressed in this paper, namely: what happens when the action researcher leaves? Action researchers recognise that maintenance of AR based processes may be more important than any given design solution and that maintaining AR based processes requires a client system infrastructure. However, developing such client system infrastructure may be particularly challenging in developing country contexts and ICT4D projects in particular, which are known to be complex evolutionary endeavours.

Especially in the health sector, aid effectiveness has suffered from inefficiencies in the global aid architecture and inherent complexities of the health sector. There are more major global stakeholders in health than any other sector with often overlapping and unclear mandates (Lane and Glassman, 2007). These dynamics affect AR efforts that operate in these environments and bring together a large and diverse number of partners. In line with findings from Burns et al (2012), we find that funding agencies’ agendas’ play a key role in funding and shaping action research solutions. However, as illustrated in the Sierra Leone case, donor funding is often not well coordinated. In addition, fragmented and earmarked for specific purposes, Lane and Glassman (2007 p. 941-945) find that most health aid is still ‘short term, volatile, unpredictable, often geographically or technologically tied’ and that ‘donors explicitly or implicitly assume that countries will be able to finance the supported health services at the termination of the grant’.

6.1 Implications for the sustainability of AR-based ICT4D solutions

Local action research may benefit the scaling of global action research efforts, as conceptualised in Braa et al. (2004) as the Network of Action approach. This is also evident in the Sierra Leone case, where the temporary success of developing client system infrastructure around an AR solution creates opportunities to continue the process elsewhere. However, our findings challenge that this scaling process in itself is sufficient in contributing to the sustainable application of such solutions by the *local* client systems that helped them scale.

What is missing thus far in the DHIS2 case, is a way to connect global with local client systems. In other words, how the creation of inter-client system infrastructure can strengthen and sustain local client system infrastructures. We firmly believe in the notion by Susman and Evered (1978) that client system infrastructure is in the first place about *enhancing the self-help competencies of client systems*. Our findings indicate this equally applies to inter-client systems. In the end, the purpose of developing inter-client infrastructure in AR is to make up for a lack of client system infrastructure and self-help competencies of client systems.

There remains a risk that transferring a focus from local ‘self-help’ competencies to those of a wider collective, makes that scaling becomes an end in itself (rather than a means to an end). In this case, the very purpose of AR to create social change becomes lost and a situation arises in

which the most marginalised end up benefitting the least from AR solutions – in exact contrast with the AR philosophy. Importantly, this would make the NoA approach subject to the very same weakness central to AR efforts in general (and especially in developing country contexts) in which attention toward the development of client system infrastructure is limited.

In the case we discussed, the benefit of the network for the local client system is merely a life-line that offers sporadic, elementary, support. This does not align well with key action research values. It is important that networks remain ‘aware’ of their purpose; to contribute to the self-help competencies of client systems to maintain action research solutions – specifically not to maintain the network per se. As also illustrated in our case, this line may become blurred as the network becomes occupied with sustaining itself and managing its own growth and processes. This *network-generating nature* of AR does not necessarily contribute to the development of local client system infrastructures. The role of action researchers needs to go beyond the mere creation of a network. In the following section, we will conceptualise this role in more detail.

6.2 Conceptualising inter-client system infrastructure in AR

In this paper, we propose a recognition that scaling of action research efforts is important for their sustainability also requires an expansion of the role of the action researcher concerned with creating local social change. Specifically, we propose that action researchers add an extra dimension to their ability to retrieve learning as a critical aspect of the action research methodology to strategically support client systems over time. In figure 4, we illustrate this process. The left-hand side of this figure draws attention to the fact that ‘inter-client system infrastructure’ (outer band) emerges from client systems (on the left). The right-hand side of the figure visualises the role of this external infrastructure development to aid client systems (inner band) that fail to develop client system infrastructure of their own.

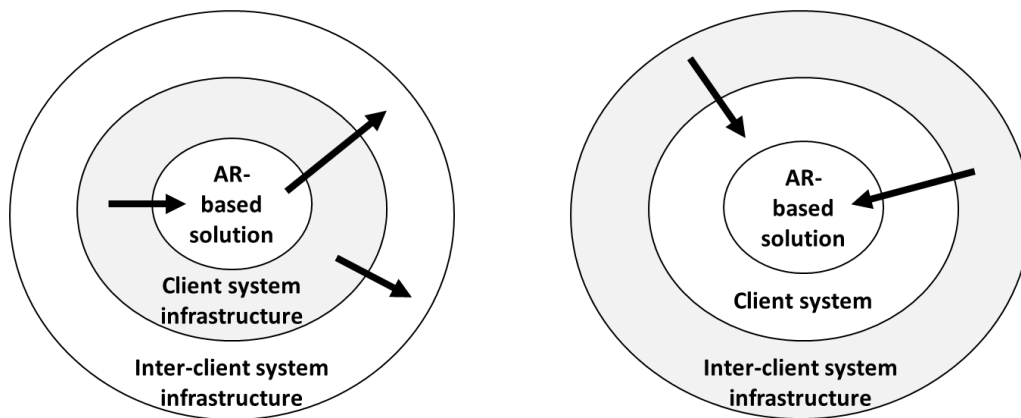


Figure 4. Client system infrastructure as a combination of client systems and inter-client system infrastructure

This role is significantly different from more common roles attributed to action researchers in which the development of client system infrastructure as part of the AR process is of temporary nature. Inter-client system infrastructures are bridges; the function of the road is realised in its ability to make a connection on either side. The role of the action researcher as part of these

infrastructures is not to sustain the solution over time, but to make sure temporary successes (and failures) can be nurtured as part of a wider network. The establishment of this network then enables researchers to engage with client systems that struggle to maintain action research interventions in hopes that circumstances around the system become more sustainable for local infrastructure development. This process may be sped up through the previous strategy, as inter-client system infrastructure processes enrol members with resources and power (for instance in the donor community) to make a lasting impact and re-structure client system environments.

This conceptualisation of inter-client-system infrastructure shows similarities with the Network of Action approach, in that both share a belief that developing a network or ‘critical mass’ of users is important in making ICT4D solutions sustainable in environments where client system infrastructure development can be challenging. However, the NoA approach argues action research activities need to scale in order for local client-infrastructures to become sustainable. In contrast, we argue scaling action research activities (such as following a NoA approach) contributes to the development and sustainability of a global (cross-case) infrastructure. Importantly, our findings problematise how a focus on generating such global infrastructure actually hinders the development of the local client system in such a way that local actors are able to take over the wheel (marked by Elden (1979) as a do-it-yourself’ period). In addition, it does not equally empower all client systems involved– especially those where local capacity was lost. This was illustrated in figure 5.

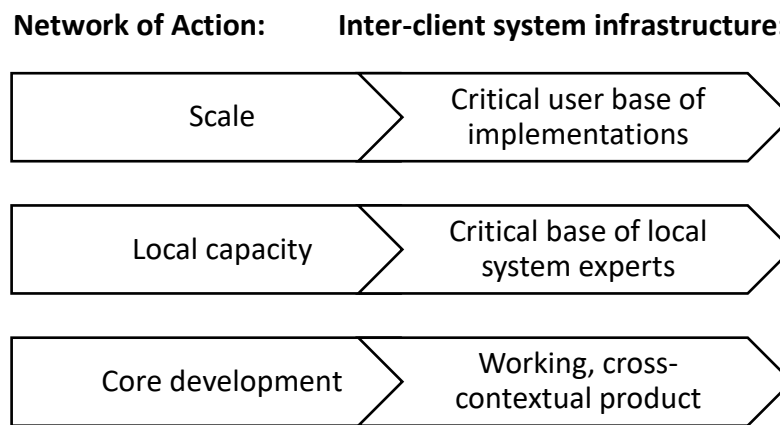


Figure 5. Role of AR in sustainability of ICT4D

In the DHIS2 case, we propose the NoA approach successfully managed to lift certain AR processes out of what Elden (1979) has termed a ‘sleeping bag’ period, and into a ‘toolkit-period’. The Sierra Leone case is an example of a case where a sleeping bag period failed to be followed up by tool-kit and ultimately do-it your-self stages. Instead, the client system in Sierra Leone had to depend on others in the network to reach tool-kit stages, to make sure the AR intervention that was started did not collapse completely. Inter-client system infrastructure in this paper is proposed to target the interfaces between such stages in enabling the transit of client systems. Accordingly, we propose that the development of such inter-client system infrastructure is only the first step in this process. Next, the different elements of inter-client system infrastructure created need to be orchestrated in ways that benefit local client systems. In the next and final section, we will conclude this paper with some practical recommendations to aid the previous process.

6.3 Practical implications

In our nuancing of the understanding of global and networked AR projects, such as the NoA approach earlier described, we see some practical implications for how global scaling of AR can more consciously be used to support the local AR. The growth and consolidation of inter-client infrastructure around global AR needs to be tightly linked to the client system infrastructures in the individual projects that made such developments possible.

First, we suggest that ‘spotlight’ natured funding opportunities such as those evident in our case are countered by more long-term commitments. Here the inter-client system infrastructure can leverage on their knowledge of the network and relationships with the donor community to advocate resource allocation towards unstable client systems. There may be a role of action researchers to educate the donor community about how funding can make the greatest social impact.

In order to realise the previous role, it is furthermore important that inter-client systems don’t come to rely on donor funding alone for their own sustainability but continue to attract research funding. Notably, research funding and donor funding does not have to be separated in the sense that research funding should come from research bodies and donor funding from donors. However, it is important that inter-client systems remain a level of independence that allows them to allocate resources to engage in action research with those client systems that fail to move into ‘spotlights’.

Finally, we suggest that local universities are included when local client systems are formed as part of action research projects, due to the strong role they play in countries where they form part of the client system infrastructures such as Tanzania (see Fruijtier and Senyoni, forthcoming). They are not only the core recipients and sources of research funding, but also contribute more long term with the training of critical staff, such as software developers with domain knowledge. Such local support is considered especially important in enhancing the ‘self-help’ ability of client systems.

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Appendix 4

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The Role of Local *Bricoleurs* in Sustaining Changing ICT4D Solutions

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Abstract. This paper problematises the way ICT4D projects are rarely equipped to anticipate for the longitudinal and organic nature of ICT4D processes. As such, it aims to explore how these ever-evolving processes may be met with adaptive solutions that are responsive to their changing environments. Our analysis concentrated on uncovering the change processes of a particularly successful ICT4D implementation over time. Based on these findings, we develop a process perspective of bricolage-driven change in ICT4D in which bricolage practices move through 3 different stages we identify to be ‘opportunity based’, ‘locally owned’ and ‘locally driven’ in nature. These insights are aimed at aiding researchers as well as practitioners in the ICT4D domain in the implementation of long term ICT4D solutions.

Keywords: ICT4D, Bricolage, Sustainability, Change.

1 Introduction

While the field of ICT4D has been occupied with making ICT solutions work in the most challenging contexts for over two decades, it continues to grapple with making ICTs sustainable in these environments [1]. Accordingly, the sustainability of ICT4D solutions has been subject of a significant body of research and a whole spectrum and combination of factors have emerged that explain either failure or success.

Success in ICT4D projects is generally associated with a situation in which ‘*stakeholders attain their goals and do not experience significant undesirable outcome*’ [2, p.102]. As pointed out by Sanner & Sæbø [3] failure may be attributed to factors such as lack of alignment of interests and responsibilities among stakeholders [4], the often-limited duration of donors’ financial support and technical bias of projects [5] and a “pilot project” orientation [6,7]. In addition, Kimaro & Nhampossa [4] perceive the main challenge to be the (often lacking) development of local capacity to adapt to changing technologies and needs.

While insightful, such accounts of success (and by extension its antonym failure) in studies are often problematic in understanding how to create sustainable solutions, due to the implication success and failure can be measured in a series of (predefined) factors in relation to the outcome [8]. In this regard, Nijhia & Merali [9] note that initiatives may be judged prematurely as having failed (or succeeded) in the absence of a longitudinal understanding of change processes which may be required for the ‘right’ confluence of conditions and pressures. Andreassen [8] has a similar perspective of the organic nature of ICT4D processes, arguing that in some ways, any effects and achievements that could be labelled failures or successes are side-effects. In addition, Walton and Heeks [10] advocate process approaches that avoid using ‘successes’ and ‘failures’ as single, cross-sectional, final judgements but rather treat them as multiple, contingent and passing in nature; and as a basis for learning.

However, ICT4D projects are rarely equipped to anticipate for the longitudinal and organic nature of ICT4D processes that was previously outlined. As noted by Meyer et al. [11], ICT4D projects tend to be especially thin on describing methods of achieving ‘embeddedness’ and focusing on the developing of local capacity to integrate ICT4D solutions into the environment where it should reside [11].

This paper contributes to the previous knowledge gap by proposing how organic processes may be met with organic solutions; both of which evolve and mature alongside of each other as time passes on and circumstances change. This way, side-effects can nevertheless be nurtured, manipulated, grown and deflected based on adaptive, reflexive and interactive intervention. To achieve this, we expand on the role of local developer teams as ‘bricoleurs’ (as coined by Ciborra [12]) in planning for changing ICT4D projects. We propose the seeding of bricoleurs as part of ICT4D projects in the form of stable agencies that nest in between ICT4D solutions and their environment, upon which they act and react over time as solutions and environmental factors change. We perceive these bricoleurs, while in some ways entangled with the solution’s (potentially hostile) environment, to become essential points of reference for development intervention.

Empirically, we draw on experiences of local developers in Tanzania in the development and implementation of a health information system called ‘District Health Information System’ (DHIS). DHIS is developed as part of the Health Information Systems Programme (HISP) under the coordination of the Department of Informatics at the University of Oslo (UiO) and in collaboration with a vast global network of local developer teams, consultants and development partners.

2 Related Literature

Planning for change processes is perhaps one of the most difficult challenges both researchers and practitioners are faced with in developing ICT solutions that are sustainable and appropriate in the complex context of developing countries as part of

development strategies. While the ICT4D field would benefit from understanding change processes in ICT4D [13] to require flexible and long-term endeavours in a changing context [10], Andreassen reminds us that, while any design may be an interpretation of an intentional future, development is a ‘world in the making’ and that anticipating outcomes for interventions as dynamic as those found under the ICT4D label is ‘extremely difficult if not impossible.’ [8, p 251).

When we understand ICT4D projects to be side-effect-driven and ‘worlds-in-the-making’ [5, 8], sustainability becomes a moving target. The previous image strokes with a metaphor used by Star and Ruhleder [14, p. 112] who compare scaling IS solutions in general with *‘building a boat you’re on while designing the navigation system and being in a highly competitive boat race with a constantly shifting finish line’*. This would imply that we should not plan to install ICT4D solutions, but to breed and raise living organisms; responsive constellations that can interact with changing resources, capacity, infrastructure, politics, if we are to have any realistic expectations about their maturing. Is this truly a mission impossible? Taking on the previous quest, this study started with the following research question:

What design approaches may enable the long term, organic and evolutionary development ICT4D projects?

The closest we have come to identifying an approach that attempts at ‘building the boat while sailing’ is known as *bricolage*. Ciborra [12] introduced this concept in response to his search for the development of ‘true’ information systems that avoid ‘easy imitation’. With a focus on creating sustainable competitive advantage, Ciborra conceptualised bricolage as a grassroot approach in which IS emerged from the grassroots of the organization. Ciborra’s preferred English translation of the French word ‘bricolage’ was ‘tinkering’, to contrast the importance of strategy and expert-roles with the importance of improvisation in dealing with challenging designs. This approach builds on the perspective that limitation is a driving force behind success [15].

The same way ICT4D researchers question that success or failure can be measured from setting goals in advance, Ciborra questioned the managerial habit of engaging in purely cognitive processes of strategy formulation in planning out the implementation of IS. Instead, he argued strategy formulation should follow the continuous acquisition of knowledge in various forms. Especially in volatile environments, Ciborra perceived effective solutions needed to be embedded in everyday practices which formed the ‘petri dish for tinkering’ [12, p. 288]. This furthermore required environments that allow for serendipity; open experimentation; unskilled learning; recognise failures as the stepping-stones for success; are receptive to ‘raw material for innovation’ being produced and that enables collaborations on unfamiliar territory or even involving competitors in order to ‘learn by intrusion’ [16]. Ciborra [12, p 289] referred to the previous principles as the oxymorons that could

represent a new "systematic" approach *'precisely because they are paradoxical [could] unfreeze existing routines, cognitive frames and behaviors'* guided by traditional, managerial forms of strategic framing responsible for project failure.

However, the role assigned to the bricoleur in ICT4D literature so far has been somewhat disappointing. While bricolage is cited occasionally to refer to the importance of local fixes and creative grassroots solutions [17], these practices are seldom linked to the long-term ability of projects to adapt to changing conditions, let alone has it led to discussions on the embedding and even institutionalising of bricoleurs in ICT4D project environments. Ali and Bailur [5] take a rare stance in arguing bricolage could in fact be an answer to the development of sustainable ICT4D. However, they also question the likelihood that implementing agencies for ICT for development projects would allow for bricolage. In contrast, Da Silva and Fernandez [18, p. 3] argue that the bricolage approach of Ciborra is *'likely to be less relevant for [the sustainability of] ICT4D initiatives, due to the more problematic context of developing countries'*.

Like Ali and Bailur [5], we see in the bricolage approach a potential to provide the systematic and yet organic process approach ICT4D researchers have been looking for in designing for 'worlds in the making' that ICT4D projects are perceived to be. To us, the low resourced context of developing countries makes an understanding of how a bricolage could be applied systematically in ICT4D all the more relevant. In line with notions from Ciborra [12], we understand bricolage to concern a grassroots process of 'tinkering' and improvisation by developers based on resources available that thrives in serendipitous over controlled environments. Importantly, we do not approach bricolage as an individualistic undertaking, but as a mode of operation that can include teams and external stakeholders (the same way more traditional project management approaches are not the strategy of a single manager).

3 Methodology

This case was developed as part of an ongoing research effort to study the networked innovation around DHIS2 as part of the Health Information System Program. The authors are both researchers involved in studying various aspects of this networked innovation and bundled their knowledge to understand how organic and changing ICT4D processes can be made more sustainable. As a result of their individual engagement with practices within the HISP Network, they developed a particular interest in the role of local developer teams, that are also informally referred to in the network as 'HISP nodes'.

The first author, in the role of a researcher, has been extensively exposed to various perspectives from different HISP nodes over a period of 3 years. The second author had been exposed to the practices within the HISP network over a period of 10 years before joining the research community while participating in various strategies

deployed by one HISP node at the University of Dar es Salaam (UDSM) (from here onwards referred to as the UDSM TZ node).

What makes the Tanzanian case particularly valuable is the way it is generally considered a best practice example by others in the HISP network. First, the deployment of DHIS2 is one of the oldest in the network and its successful national scale up continues to be well embedded. Second, the team has developed a strong relationship with the Ministry of Health (MoH) and its stakeholders as in its role as the sole provider of technical support as stipulated in the national health strategic plan. Third, the UDSM TZ team stands out because of the way it has been actively extending DHIS2 with innovative ‘work arounds’ in addressing needs emerging from local use cases that the ‘core’ of the system failed to facilitate in time. While such work arounds are typical for the practices of (most) other nodes in the network, UDSM TZ is at present for instance the leading HISP node that is contributing to the ‘DHIS2 app store’ in creating generic apps that can be used elsewhere in the network. The following study is a result of a shared interest in understanding how the UDSM TZ node came to be where it is now and what we can learn from these efforts about the long term sustaining of ICT4D projects in general.

3.1 Data Collection

Data collection was done during a 3 week field visit to the UDSM TZ node in February 2018. During the visit, the study met with strong support from the rest of the team, which resulted in a team effort to map out all the projects that the node had been engaged with over time; identification of the stakeholders it had worked with and reflection on the outcomes of the projects as well as lessons learned. This was done over an intensive 2-day exercise which involved four senior members of the team and combined workshop elements (recalling the various projects and listing them) with focus group discussions (recalling project progress related aspects and the linkages among them). The second author was part of these discussions as part of it being a team-effort, however he was engaged as little as possible to keep interference with the data collection process at a minimum and give the other team members space to present their perspective of events.

A total of 11 interviews were conducted (an overview is provided in table 1 Appendix 1). One interview had been conducted with the second author prior to the visit in February 2015, regarding his role as a Senior Implementer at UDSM TZ. Although data from this interview proved an important point of departure for the study and the creation of an initial timeline when the authors began their collaboration on this study in late 2017, additional interviews were structured around open questions designed to allow the surfacing of contrasting views.

Interviewees were selected based on their knowledge of specific periods as well as various aspects of the organisations’ processes. For one of these interviews, the first author conducted a one day-field visit to one of the first pilot sites, Kibaha district in Pwani region. Both authors furthermore attended a (1 hour) presentation at

MoHSW on how the Malaria program currently used a DHIS2 interactive dashboard application. Documents analysed included MESI documentation; the MoU; an evaluation report by the MoH reflecting on 5 years of DHIS2, and various theses and research publications that emerged from UDSM TZ activities at various points in time.

3.2 Data Analysis

The analysis process featured a grounded theory approach [19] as adapted by Charmaz [20,21]. This approach emphasises the examining of processes, making the study of action central, and creating abstract interpretive understandings of the data in order to move from data to a contextualised theory. Central to the previous process was the creation of a timeline in which progress and challenges in the implementation of DHIS2 were separated from alliances that were formed and formalised. The next step involved the grouping together of instances (events, processes, occurrences) that had central features or characteristics in common. Characteristic for this process was a continuous comparative analysis of the research interests held that motivated the study, a growing body of emerging data, and efforts to conceptualise patterns observed; and the creation of various memo's and visual displays.

4 Findings

4.1 Promoting a New Health Information System (2002 - 2010)

This study centres on the story of DHIS development and implementation in Tanzania and what we will refer to as the 'UDSM Tanzania node'¹, a team of DHIS2 developers, instructors, supervisors and academics hosted by the Department of Computer Science and Engineering (DoCSE) at the University of Dar Es Salaam (UDSM). The early foundations of UDSM TZ can be traced back to the efforts of UDSM staff in 2003 who piloted a health information system co-founded by researcher at the University of Oslo (UiO), then DHIS 1.3. The pilots took place in Bagamoyo and Kibaha districts in Pwani Region as part of their PhD studies at UiO and involved implementation of the system, training and conducting research of the data flows and use at the national and local level.

The pilots aimed to demonstrate the advantages of the system to the MoH, in particular the Health Management Information System (HMIS) section, in hopes of its nationwide implementation. However, the MoH at the time already had a national system in place, named MTUHA. MTUHA had been implemented by external consultants in 1992, which meant that at present, changes to the system could not be locally accommodated when the consultants were no longer available. This resulted in system crashes and data loss at district levels. However, because it has worked well

¹ not the organisation's official name.

for a long time, it was known as a success story in the region, and the MoH was reluctant to change it despite its challenges.

At this point, researchers from UIO graduated and activities in the mainland were stalled for some time. Nevertheless, the UDSM Tanzania node was involved in another research project in Zanzibar with support from DANIDA to implement DHIS 1.4, which had just been developed in South Africa in 2005. During this implementation, attempts to convince the MoH to adopt DHIS 1.4 on the mainland continued. Several lengthy discussions and system demonstrations were held in negotiations between researchers from UiO, the UDSM Tanzania node and MoH officials in the mainland.

Eventually, DHIS was endorsed by MoH as the standard tool for implementation countrywide in 2007. At this stage, the pilots had demonstrated how DHIS could flexibly manage multiple programs and datasets in an integrated manner, something that was lacking in the MTUHA software.

'We could show things, we could demonstrate. You see? Just take these facilities, by 3 clicks, you just move them from here to there. Whenever we wanted to go to a presentation, we would put as much data in the system as possible.'

Furthermore, the UDSM TZ node had gained experience from the pilots and the Zanzibar project, and could show it had the capacity to customise the software and provide user support locally.

'One of the things that gave UDSM Tanzania node an upper hand, was that – we are coming from the University. We are not somebody's pocket, but local team with people who do research....(...) The university is there to stay.'

The adoption of DHIS instigated the signing of a Memorandum of Understanding (MoU) in 2007 between MoH, UDSM and UiO which included the development of a 5-year national HIS strengthening plan. The initial idea for the HIS strengthening plan was conceived by UDSM TZ with support from UiO and was first presented to MoH and other stakeholders such as NORAD, the Dutch embassy and JICA later that year. The plan however took a long time to materialize, as it required lengthy negotiations, several revisions of the plan and the need to include interests and demands from several partners, health programs and donors. While the HMIS section of the MoH was convinced to use DHIS countrywide, persuading the higher management, partners and donor continued to pose challenges. Some partners were not much in favour of the use of DHIS2 with others pushed for their own interests.

While the MoH was pursuing partners and donors to support the HIS strengthening plan, the previous pilots had generated the interest of a number of development partners who requested immediate implementation in their respective sites. For example, in 2008 JICA supporting National AIDS Control Programme (NACP) approached UDSM TZ to conduct a similar pilot of DHIS for their programs

in Pwani region. During this time, UiO was in the early stages of developing DHIS2, an advanced version of DHIS1 capable of being configured and deployed online that was developed by researchers in UiO based on research experiences elsewhere in the network (in countries like India and Sierra Leone). DHIS2 was implemented as part of the JICA pilot (funded by NACP). Around the same time, CHAI and IHI also implemented DHIS2 based on the existing HMIS data collection tools in Mtwara, Lindi and 27 Sentinel Panel of Districts (SPD).

During this time, a Master program in health informatics was successfully launched at UDSM in 2007 through NOMA funding and was able to source local capacity for the project (a total of 8 students received scholarships from UiO). The programme was conducted in collaboration with UiO staff to enable knowledge transmission and strengthen the cooperation between UDSM and UiO and increase capacity within the UDSM team and the MoH. In addition, the programme raised awareness of the activities UDSM was engaged in supporting the HIS in Tanzania. The university environment also had the advantage that excellent students could be easily picked up by the technical team (UDSM TZ).

4.2 Alignment of Donor Interests (2010-2013)

In 2010, the HIS strengthening plan was endorsed by MOHSW and donors and renamed the “M&E strengthening initiative” (or MESI). The formulation of MESI was a cornerstone that paved the way for the digitalisation of the health system using DHIS2. The MoH worked hard in soliciting funds and aligning donors and implementing partners in shared outcomes. In 2009, donors had started to pledge support to the MESI initiative as its plans were being finalised; thereafter in 2010 the first funds from the Dutch embassy was received which was later followed by funding from Global Funds. Other support from donors and implementing partners gradually followed over the next 5 years.

The MESI included a consortium of partners, which included the MoH and all relevant development partners and donors. Different committees were formed to foresee and support implementation of various work packages as part of the agreed MESI. One of the subcommittees in this consortium is the Monitoring and Evaluation (M&E) committee, which is responsible for directly supporting and managing activities related to HMIS. This involved revision and defining standards for integrated data collection tools and indicators. Importantly, as part of this committee, UDSM Tanzania node became the sole technical support of the MoH in terms of supporting DHIS2 and later also of some other systems such as the Human Resource system (HRHIS).

As agreed to in the formalisation of MESI, the roll out of DHIS2 would be preceded by a total ‘revamping’ of the existing paper tools. This meant that indicators needed to be defined and harmonised across various health programs as much as possible. Pwani was selected again in 2011 as pilot site to test the implementation of DHIS2 with the new HMIS data collection tools. Based on the experiences and the

results from the evaluation conducted in Pwani, DHIS2 was scaled to another 6 regions in 2012. Throughout the roll out, UDSM TZ was an important point of contact for DHIS2 users who needed support.

In 2013, the DHIS2 rollout was completed nationwide. This meant all public and private health facilities in the country (around 7000 facilities) were able to report data to the district level where DHIS2 data entry is done. While UDSM TZ had been important in steering the process of the roll out, they were (and still are) cautious to make sure the MoH had ownership throughout the process. Close collaborations between UDSM TZ and the MoH during trainings resulted in the formulating a national 'DHIS2 implementers team', which included members from MoH, UDSM and other implementing partners to provide user support.

4.3 Integrated Information Accessibility (2013 - onwards)

Overall, the national DHIS2 rollout was considered a vast success. The system could be accessed online (see: www.dhis.moh.go.tz) and was capable of capturing and processing all the nations routine health aggregate data on a monthly basis. This meant a massive flow of information was pouring in from over 7000 health facilities across the country to a centralised DHIS2 owned by the MoH. In addition, the MoH in collaboration with UDSM TZ started efforts to integrate health programs that were not accommodated in the initial national roll out in 2014 such as Tuberculosis and Leprosy (TB&LP) and Human Resource data.

The integration of all major health programs created a staggering demand among development partners to access data in DHIS2, which validated the success of the roll out. This was an important change, because previously this data could only be accessed by approaching health facilities directly or via the district councils they supported. It also led to an increased interest among development partner programs to use DHIS2 for own use with the support of UDSM. The MoH would have an important role to play in redirecting developing partners toward UDSM TZ. The other way around, UDSM Tanzania node also became a medium for NGO's and donors to initiate new projects with the support of the MoH.

As a result, the existing user base expanded dramatically. Today, there are over 15,000 users across over 40 programs. For UDSM TZ, facilitating this new 'wave' of users while still handling all previous issues from the initial user base can be challenging. One of the ways in which UDSM TZ tried to lift pressure on the team was by extending the capacity and size of the national DHIS2 implementers team by also including members from other MoH sections, development partners and DHIS2 champions.

4.4 Local Capacity Dependency (2015 - onwards)

The majority of functionalities that were requested by the development partners from the projects that 'mushroomed' out of roll out were quite advanced and to some extent also very specific to the Tanzanian context. Because the team could not

completely rely on the core team at UiO to address them for various reasons, this required a lot of ‘work arounds’. For instance, when requirements were put on the ‘global’ DHIS2 roadmap of the core team at UiO, they would be pushed forward endlessly because they were too specific and not needed in many other countries at the time. In addition, the nature of these projects would often be very short and surrounded by financial insecurities, as explained by one interviewee:

‘They [donors] need to show results (...) They have maybe a 5 year project but there are some deliverables they have to produce to sustain it. So if they give you a long term project and you don’t deliver you kill that project. So they want to monitor you: give you 6 months project, good results? Let me extend one year. Good results? Ok, then we can commit.’

What makes things more challenging is that many requirements would come at an ad hoc fashion and always with priority status. While at the same time, the client himself would not always fully grasp the complexity of what they request and how much time and money is required to deliver. In addition, support from UDSM TZ to the MoH would continue even during funding gaps:

‘Between one contract to another there is always a gap, maybe 6 months maybe a year, but what do you do, how do you sustain? (...) We [assistant director within the ministry] were talking one day and he was telling me: you know what? I think we have a marriage between the ministry and the University of Dar Es Salaam, and once you are married, off course you are not supposed to break up that marriage... for better or worse.’

‘That is the beauty and burden of the university of Dar es Salaam,(...) Sometimes you just have to take one for the team.’

The previous situation required a lot of additional ‘in house’ investment on the side of UDSM TZ that would never be contracted. In order to deliver quickly and in the face of extremely limited resources, UDSM TZ developed an innovation strategy that attempted the re-use of innovations as much as possible. This was not only due to the experience that requests would often be similar in nature across projects; but also because there was a need to re-use the capacities and skills of a limited team. Despite the growing demand for support, expanding the team at times of high demand was risky given its unpredictable nature. An interviewee explains:

‘Instead of waiting for international support that may never come, we proactively start to do something and then people can see ‘ah we can do that’ and then we continue chipping away at it. (...) So sometimes you compromise and say ‘ok, lets first deliver this, then come back and redraft it to make sure that going forward most of the code and the initiative can be re-used.’

Being able to deliver is also important for UDSM TZ to build relationships with development partners. For instance, in 2009 the team was contracted by JICA again

for 6 months to create a work-around for a dysfunctional HR system in order to preserve the data while the delivery of a new solution, developed by another company, faced delays. Rather than to create a temporary fix, the team saw opportunity to create a more durable solution by rebuilding a completely new HRHIS system. Because UDSM TZ had showed all this could be done in 6 months, JICA decided to go forward with this solution instead and the team still finds themselves supporting this system 8 years later. Based on these experiences, JICA reached out to the team again in 2014 to develop a web based portal for the Ministry of Agriculture and again, the team took on the challenge and delivered. In this case, they build on applications developed during earlier projects and by making radical adjustments were able to meet the clients demands in timely fashion.

Expanding activities to different sectors and ministries (presently health, agriculture, water, aggregation, sanitation, and social welfare) meant exposure to a high variety of requirements. This continues to force the team to push the boundaries in developing generic ‘cross-cutting’ applications. Pushing these boundaries is important because a large user base is needed to make sure others have a stake in the upkeep, on-going development and maintenance of applications and are willing to contribute.

‘What people don’t fully understand is how open source works. Most people are tied to money, and it doesn’t usually work when you say: ‘we have done this, it has taken us a lot of time, resources, energy and research to do it, you can have it for free but can you pay something back?’ So you try to work around that (..) You give it to them but you know demand is always expanding and they will reach the limit of what you give them. It is not enough but we believe in the long term perspective [this approach] will eventually become sustainable, it will break even in the far future.’

In an effort to make generic applications sustainable, the team also tries to communicate with the core team at UiO for support. Presently an estimated 20 % of the DHIS2 application developed by UDSM TZ has been absorbed in the ‘global’ DHIS2.

5. Analysis

The previous case describes a grass-root process that started with a single pilot, limited funds and capacity, and resulted in a sustainable nationwide solution that could be adapted to changing local requirements over time in the presence of local technical support. In the previous low resourced environment, creating local capacity to sustain the initial pilot was not planned for in advance. Rather, it followed a chain reaction of opportunities, both created and identified, that were successfully solidified into either achievements or alliances that would pave the way for increased levels of

adhesion. Here, alliances either followed from previous achievements, put them into motion and/ or were strengthened by them.

During this process, the role of the local developers changed. At first, they were able to somewhat lift along with a series of opportunities and circumstances in a highly improvised manner. The pilots, enabled by PhD scholarships, offered an important opportunity for learning (both on the mainland as well as offshore), while technical advancements elsewhere contributed to an attractive solution that proved to be customisable to the local context. Here, a basis was created for a series of achievements and alliances that gave way to a more systematic approach.

Initially, this approach was about rooting the local development team and solidifying its relationships with the MoH, its development partners and users at different levels of the health system. Investing in a lengthy participatory processes bought the team the time to deliver during the roll out. The previous process made that not only a single actor (the MoH) but a wide range of stakeholders had a stake in the roll out. As a result, its success triggered a much broader demand for innovations among partners that could fan out of the nationwide implementation.

This increase in demand was important for the team to remain a functional and reliable support to the MoH amidst funding gaps, however also added new pressure on the teams limited capacity. The team responded to this challenge with a generic innovation strategy through which technological features could be re-used. This approach leveraged on strong ties with the MoH and various partners, which increased exposure to a diverse range of user requirements and enabled UDSM TZ to actively sow demand for new innovations.

As a result, the team could keep support of previous activities ongoing while affording itself the ability to, every now and then, bite off a bit more than it could chew. This enabled the developers at UDSM TZ to break with a somewhat passive dependency on ad hoc funding opportunities, and to proactively start cultivating a serendipic environment instead. The previous process was illustrated in (Fig. 1). In the following section, these developments are theorised as three different stages of 'bricolage', which emerge as a result of the stepwise accumulation of achievements and the expansion and strengthening of stakeholder alliances discussed.

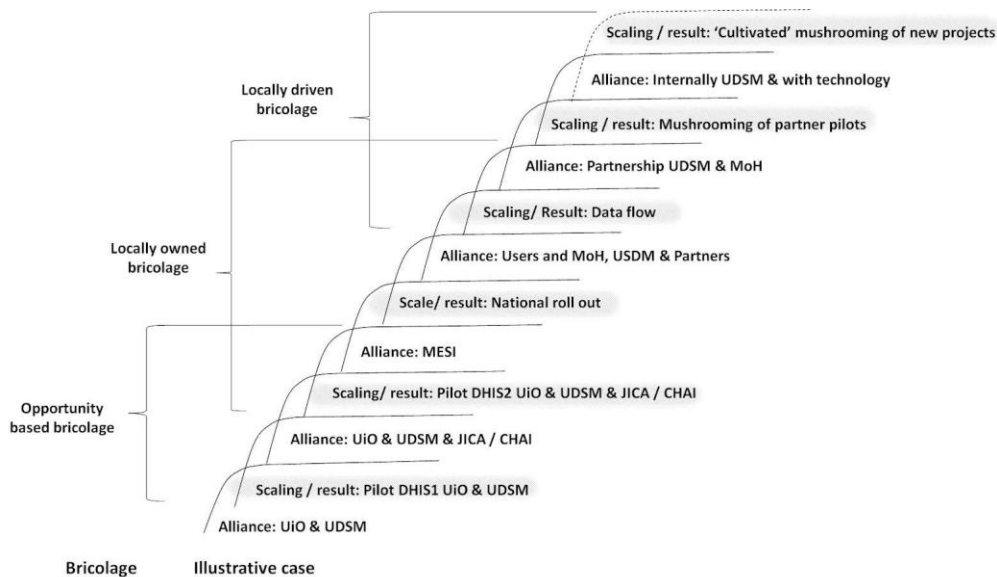


Fig. 1. Analysis

6. Bricolage-driven Change in ICT4D

The UDSM TZ case illustrates the role of local developers in ICT4D environment matches that of a ‘bricoleur’; action oriented-improvisors who, operating in the midst of scarcity and chaos with limited resources, are pushed to draw on their own creativity, move boundaries and develop strategic collaborations with others. Doing so, they pave the way for an evolution of their mode of operation which becomes connected with their ability to sustain the previous processes. Based on the previous findings, the bricolage process can be segmented out into three stages:

Bricolage begins with ‘*opportunity based bricolage*’ which may be externally driven. During this stage, the role of the bricoleur is external; new, fresh alliances need to be forged and while potential solutions may be shipped in from elsewhere, they need to be ‘piloted’ locally and customised along the way. This stage also comes with a risk that bricolage is not nested in follow up phases. When bricoleurs tinker with a rather short-term goal in mind, this may keep them from forging alliances needed or recognising their importance for a next stage in the bricolage process that will secure the first one which is still fragile at this point.

The next stage involves ‘*locally owned bricolage*’. During this stage, bricoleurs will have to both nurture and nourish the previous process in traditional bricolage fashion that requires workarounds and improvisation. While the bricolage process is still opportunity based, the role of the bricoleur is nested in existing

routines and practices. During this phase, these alliances need to involve (or be handed over to) local bricoleurs and extended to (new) stakeholders that occupy spaces in which initiatives can grow. Words like nurturing and nourishing don't do justice to the volatile nature of this process in which bricoleurs are pushed to its limits. This stage is all about survival for the bricoleurs as well as that of previous achievements.

Finally, a stage of '*locally driven bricolage*' is entered when efforts from the previous processes start to pay off. At this point, bricoleurs are able to turn workarounds created as they tinkered their way through unpredictable forces into opportunities that make the bricolage process itself easier. When done successfully, bricolage is no longer based on ad hoc improvisation in response to limitations encountered; the bricoleur has made the limitations of his environment his own and is now able to pro-actively manipulate it to make it more harmonious and cooperative. Nevertheless, this stage does not represent a final destination; the bricoleurs are likely to shapeshift further in an attempt to settle processes initiated in the most recent stage that are simply not known yet. It is through the accumulation of alliances in which the actors embed themselves that it becomes easier to adapt to new roles and forms of bricolage as well as accelerate its process.

Alliances act somewhat like intervertebral discs in the backbone of the previous bricolage process, that give it the flexibility necessary for its own evolution needed to adapt to a changing system and environment. Achievements then are the bones that carry the process forward. In addition, we borrow from Actor Network Theory [22] the idea that *alliances can include technology*, in the sense that achieving locally driven bricolage relies on the ability bricoleurs to get the technology on their side. The ability to tinker, hack, improvise and work around in a way that is not responsive and reactive but orchestrated and where possible strategic, requires a certain level of mastery, creativity capacity and skills.

Our case illustrates how developing alliances with technology needed for more systematic forms of (locally driven) bricolage can be a difficult and risky undertaking. It reveals the true nature of bricolage, which comes with the major limitation that it happens outside of project agreements and is excluded from funding arrangements which can (at times stubbornly as well as ignorantly) rely on the engineers in their traditional 'expert' roles. In contrast to other alliances which rely on the commitment of other stakeholders, generic innovation strategies of locally driven bricoleurs are to a large extent developed separately from other alliances. The next key ally at this stage of the process is the technology, that needs to be tamed and mastered with the right set of skills and dedication.

This will often involve hefty innovation processes that are started without knowing where they will lead or if they will lead anywhere, based on the mere intuition of the bricoleur that innovations tend to come back across projects, and especially across contexts. And therefore, the hope that the investment made will save the bricoleurs time in the future and provide a lifeline when faced with unrealistic

project deliverables. Other times, the bricoleurs will have to wait patiently, develop a short-term fix, and return to it later when more time and resources are freed up.

These findings generate insights in the generation of a serendipic environment that allows bricoleurs to ‘climb’ from opportunity based to more systematic, locally driven bricolage. It is only at this stage, that we can begin to discuss the local sustainability of ICT4D. Importantly, these findings imply that bricolage in ICT4D should be recognized as a social process as much as a technical one, in which piecing together alliances in adapting volatile environments is crucial for the ability to be creative, innovative and novel. In reflecting upon this process, we found ourselves imagining this aspect of bricolage to relate to the way a spider builds a web – but then within an ICT4D environment that is designed to count the flies it catches. We perceive the dominant focus on visible achievements to be as much a risk factor to the sustainability of ICT4D projects as the individual factors that can be analysed to contribute to their momentary successes and failures (and this includes an emphasis on these aspects in the literature). In this regard, this study identifies an important role for universities in hosting bricoleurs and counterbalancing the previous risks, given their climates can be more facilitative of timely processes as a result of their learning-oriented objectives.

7. Conclusion

This paper has illustrated how bricolage, as an approach to create novel innovations with limited resources, may benefit the sustainability of ICT4D solutions in the face of numerous challenges in relation to unaligned stakeholder interests; funding limitations; pilot-orientations; technical biases and limited local capacity. The paper argues that ICT4D projects become more sustainable as the ability of the bricoleur increases to shape their environment in ways that enable bricolage to thrive. In explaining these achievements, a three-stage process of bricolage-driven change is formulated that expands our current understandings of bricolage and the role of local bricoleurs in ICT4D projects. Practically, these findings offer practitioners insights in the significant role of bricolage in sustaining changing ICT4D solutions. Theoretically, they generate novel insights into the nature of bricolage and its role in the sustainability of ICT4D projects.

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Appendix 1

Table 1. Interviews

Participant	Organisation	Duration:	Location	Recorded:
Senior Implementer	UDSM	1 hour	Oslo	yes
Head of Department of Computer Science	UDSM	1,5 hours	UDSM	yes
Lead developer at UDSM TZ	UDSM	2,5 hours	UDSM	yes
Head of RCH	MoHSW	1,5 hours	UDSM	yes
Head of Malaria program and M&E officers	MoHSW	40 mins	MOHSW	yes
Head of the TB and Leprosy program and two M&E officers	TB and Leprosy program	1 hour	TB and Leprosy program	yes
M&E Director, Assistant directors and head of HMIS	MoHSW	1 hour	MoHSW	no (on request)
District Health Management Information System Coordinator	Kibaha Health Centre, Pwani Region	1 hour	UDSM	yes
Senior Implementer at UDSM TZ	UDSM	1 hour	UDSM	yes
Researcher 1 UiO Involved in TZ case from 2003 onwards	UiO	20 minutes	UiO	no
Researcher 2 UiO Involved in TZ case from 2007 onwards	UiO	20 minutes	UiO	no

Appendix 5

Fruijtier, E. (in review) Open Development: Game-changer or Sugar-coat? In review for ITD special issue on 'ICTs for promoting sustainable information society and harmony'.

Information Technology
for Development



Open Development: Game-changer or Sugar-coat?

Journal:	<i>Information Technology for Development</i>
Manuscript ID	01-18-0022-ITD-SI.R1
Manuscript type:	Special Issue
Keywords:	IT and the global community < Development Issues, Open sourcing, Online Communities < IT Business, IT and the emergence of the knowledge society < Development Issues, Health information systems < Health Informatics

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Open Development: Game-changer or Sugar-coat?

On the Challenges of Practising ICT-Enabled Collective Action

The potentials of open innovation strategies for crowd sourcing have raised discussions on the transformative effect new ICT enabled open models can have on processes and structures of development and even society at large. However, the practical aspects of the transfer of collective action approaches that underpin these more collaborative ways to ICT4D projects also discussed as ‘Open Development’, are under-researched. This study adopts a case-study approach to analyse the complex dynamics and challenges of a collective action initiative in the collaborative development of an ICT4D solution with the help of Hess and Ostrom’s (2005) Institutional Analysis and Development Framework. In contrast to common perceptions about the horizontal and grass-root nature of ICT-enabled open practices, findings reveal that collective action in Open Development requires top-down intervention at the level of institutions to assure the inclusiveness of different stakeholders in the open practices through which ICT4D solutions are created. These findings expose the nesting of collective action in ICT-enabled open practices as a coordination matter that transcends the individual institution and suggest a key role for major global stakeholders and legislative bodies.

Keywords: Open Development, ICT4D, Collective Action, IAD Framework, Information Commons, Commons-Based Peer Production

1. Introduction

Advancements in ICTs and Web 2.0 nowadays have radically changed how and from where innovations might emerge (Heeks, 2008; Von Hippel, 2005; Smith et al., 2011). These developments are often addressed as a movement toward ‘openness’, which Smith et al. (2011 p. 4) explain in terms of ‘*information-networked activities that have, relatively speaking, more information that is freely accessible and/or modifiable and more people who can actively participate and/or collaborate*’. These developments have sparked interest among researchers and practitioners in the ICT4D domain, who are driven by a challenge captured by Walsham (2012) as an effort to ‘make a better world’ with the help of ICTs. Phrases such as ‘Open Development’ (Reilly and Smith, 2013) and ‘Development 2.0’ (Thompson, 2008; Heeks, 2010), have been used to discuss ways in which new systems of knowledge and production and spaces of interaction can be applied to improve how development is delivered through its digitalisation.

This paper will use the term ‘Open Development’ as coined by Reilly and Smith (2013) to refer to so called ‘ICT-enabled open practices’ (Smith, 2014) that involve accessing, remixing, re-using, repurposing and re-distributing content for development purposes. Open development is perceived to change the face of current development practices in that greater flexibility may be generated and resources may become accessible to large audiences to change the face of current development practices (Reilly and Smith 2013). Heeks (2010) foresees a similar effect ICT-enabled open practices may have on development, listing ‘Connecting the Excluded’, ‘Disintermediating’, ‘Digital Production and Innovation’ and ‘Collective Power’. This envisioned transformation of development is not merely attributed to the availability of ICT’s to engage in ICT-enabled open practices, but the new ways in which those practices are able to change

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3 decision-making processes for the benefit of collective action¹ in which groups engage
4 in joint problem solving. Understanding openness as enabling ICT-enabled open
5 practices encourages researchers and practitioners to perceive ICTs a vehicle through
6 which openness practiced rather than a tool to drive openness (De Beer, 2017).
7 However, the practical aspects of how these new more collaborative ways of working
8 come into effect in ICT4D projects and their benefits to development objectives are
9 under-researched.
10

11
12 The previous perspective of openness in Open Development is reflective of a common
13 understanding of open source (or other open models) products as global public goods
14 that are non-rivalry and non-exclusive in nature. This makes them seemingly ideal in
15 realising collaborative processes in achieving development goals. However, as noted
16 by Sahay (2017 p. 2) such normative ideals *'can never be perfectly reached, as there*
17 *are various knowledge, power and resource asymmetries between and across developer*
18 *and use teams'*. Accordingly, Benkler (2006) argues that for open source models to
19 enhance the capacity of people or organisations to do more in loose commonality with
20 others, they need to enable collective action processes he also refers to as 'commons-
21 based peer production' (CBPP). However, while open models are pre-requisites for
22 commons-based-peer production, it is unclear how collective action problems are
23 resolved as part of their practical application. Accordingly, this research responds to a
24 vacuum in present knowledge on how collective action is orchestrated as part of ICT-
25 enabled open practices in ICT4D projects in realising development objectives.
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30 This research is motivated by an interest in the potential of what I will summarise here
31 as 'Open Development' practices to generate more harmonious collaborations in terms
32 of how by whom and for who ICT4D solutions are developed. However, if we are to
33 move beyond concepts and hypotheticals, it is important to separate the mere adoption
34 of open models and open practices from any collective action processes they may (or
35 may not) facilitate. It is only by enhancing our knowledge of this collaborative aspect,
36 that we can understand how Open Development may be applied to achieve greater
37 development outcomes. Accordingly, the research question underpinning this study is:
38
39

40 *What challenges do ICT4D projects face in applying ICT-enabled open practices that*
41 *enable collective action?*
42

43 Empirically, I conducted a case-study (Stake, 1995, 2006) of the ICT-enabled open
44 practices in the ongoing development of an open source ICT4D solution called DHIS2
45 (District Health Information System 2). Stake (2006) emphasises the discovering of
46 meaning through engagement in experiences within a particular setting. DHIS2 has
47 been developed as health information system following open source software strategies,
48 with the aim of supporting Ministries and NGO's in developing countries in achieving
49 global health targets. This paper makes the following contributions: First, it contributes
50 to a detailed understanding of the complex dynamics that constitute or hinder the
51 application of open practices for collective action in the development of ICT4D
52 solutions. Second, it illustrates the use of Hess and Ostrom's (2005) Institutional
53 Analysis and Development Framework as a tool for conducting similar examinations
54 in revealing these dynamics.
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59 ¹ Collective action is defined in this paper as a social dilemma in which actions that are individually rational can
60 lead to outcomes that are collectively irrational (Olson 1965).

2. Related Literature and Theoretical Framework

2.1 ICT-enabled Open Practices for Development

Now that Web 2.0 is increasingly reaching low resource environments, Reilly and Smith (2013) argue it is time for the ICT4D domain to move beyond thinking about Castells (2010) 'digital divide' as the principal barrier to development. Instead, they propose a focus on participation in the new culture of cooperation that Benkler (2006 p.8) has ascribed with potentials to improve human development across the following three core dimensions:

1. it improves the capacity of individuals to do more for and by themselves;
2. it enhances the capacity of individuals to do more in loose commonality with others, without being constrained to organise their relationship through a price system or in traditional hierarchical models of social and economic organisation; and
3. it improves the capacity of individuals to do more in formal organisations that operate outside the market sphere.

Importantly, to realise these potentials, ICT-enabled open practices should be based on a 'commons-based peer production' process (Benkler and Nissenbaum, 2006). Benkler and Nissenbaum (2006 p. 400) describe CBPP as a model of social production, that emerges alongside the production processes within the market as well as traditional forms of well-funded nonmarket action (such as state and organised philanthropy) out of the appearance of digital networks. This form of production has two characteristics typically found in open models and their open applications; 1) production is decentralised 2) collective action is driven by social cues and motivations in contrast to prices or commands. Table 1 outlines the structural attributes of commons-based-peer-production relations.

Table 1. Structural attributes of CBPP

Attribute:	Explanation:
Modularity <ul style="list-style-type: none"> • Independent modules 	The potential objects of peer production must be modular (divisible into components, or modules, each of which can be produced independently of the production of the others). According to Benkler and Nissenbaum, (2006 p. 401), this is a requirement for ' <i>pooling the individual discrete efforts of different people, with different capabilities, who are available at different times</i> '.
Granularity <ul style="list-style-type: none"> • Fine-grained • Larger grained 	CBPP needs to accommodate both fine-grained (bite-size) as well as larger grained projects that are able to challenge and motivate contributions from different individuals. Fine-grained projects are important to capture contributions from large numbers of contributors with limited capacity or motivation levels.
Integration <ul style="list-style-type: none"> • Low-cost • Quality control • Classic Collective action 	The mechanisms by which the previous modules are integrated into a whole end product should be low-cost and include quality controls against low quality contributions. Benkler and Nissebaum (2006 p. 401) further hint that especially this last stage is likely to involve ' <i>a variety of approaches towards solving collective action problems that are relatively familiar from the offline commons literature.</i> '

Open Development proponents envision ICT-enabled open practices will lead to more

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3 inclusion and greater digital equality, in which open models and their open applications
4 have a central role. At the same time, as noted by Smith et al., (2011), the full extent of
5 the proposed changes toward the digitalisation of development is yet to be realised and
6 understood. Importantly, we do not know how well CBPP processes transfer to ICT4D
7 processes as part of Open Development practices.
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10 **2.2 The Compatibility of Collective Action Models with ICT4D practices**

11
12 There are two assumptions inherent to the common-peer-production model that are
13 likely to make its transfer to Open Development practices especially problematic: 1)
14 the assumption that integration of both fine-grained and larger grained projects is likely
15 to involve collective action approaches such as found in the offline commons literature
16 and 2) the assumption that such models emerge alongside market-based and well-
17 funded nonmarket-based action such as found in the development sector. In this section,
18 I will address the problematic nature of the previous line of thought.
19
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21 *2.2.1 Applying collective action approaches such as found in the offline commons* 22 *literature for the integration of both fine-grained and larger grained projects in ICT4D* 23 *is likely to be extremely complicated.*

24
25 Collective action dilemmas encompass two problems (Ostrom et al., 1994);
26 appropriation problems (when the overconsumption by an individual of a shared
27 resource comes at the expense of the wider community and/ or possibly the condition
28 of the resource) and provision problems (when the infrastructure needed in order for a
29 resource to be consumed is lacking, for instance because individuals consuming the
30 resource are not contributing to its upkeep (Ostrom et al.,1994), also referred to as a
31 ‘free-rider’ problem². Collective action models for ‘offline’ commons (often natural
32 commons) tend to focus on limiting consumption levels and boosting provision levels
33 of individuals as part of a self-organising collective and in the absence of a higher
34 authority. In addition, these models will attempt to achieve that members (are enabled
35 to) correct each other in their own interest, which is crucial for such models to be
36 sustained (Ostrom et al., 1994).
37
38

39
40 Transferring these models to online commons (information commons such as internet-
41 based commons) is likely to be extremely challenging. First, because groups that are
42 large, heterogeneous, and/or geographically dispersed (common for open source
43 operations) are known to find it much harder to organise for collective action compared
44 to small, homogeneous, and concentrated interest groups. In information system (IS)
45 development, this may be especially challenging because orchestrating collective action
46 requires aligning interests and dealing with differences in ideologies of various
47 stakeholders who will apply various framing strategies to shape collective action
48 processes (Constantinides and Barrett, 2014). As noted by McGinnis (2016), such
49 groups are furthermore at serious risk of developing an overall bias in favour of certain
50 groups. In open source communities, initiating developers tend to obtain a special status
51 in maintaining the authorised code and manage contributions written by contributors
52 without such status. Shaikh and Vaast (2016) find that the previous heterogeneity
53 among software developers helps deal with the challenge to filter and prioritise what is
54
55

56
57 ² There are exceptions. For instance, Klandermans (1988 p.89) argues it is not as much free-riding but the
58 expectation that collective action will fail that may lead to non-participation. Others such as Fireman and Gamson
59 (1979) have also pointed out situations in which free-riding is not a problem but may increase the expected value
60 of a collective action initiatives goal and reduce the cost of participation.

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3 integrated in open source software production.
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6 In their case, they observe more skilled developers were able to work in so called
7 'digital folds' to temporarily escape the cacophony created by the participation of large
8 groups of less skilled developers. Their work suggests that the challenge of 'balancing'
9 openness requires participants to leave collective action efforts and that releasing
10 (unfolding) their efforts back in to the collective action 'space' generates momentum
11 and further discussion. Von Krogh et al. (2003) describe a similar role for core
12 developers as 'gatekeepers' which is largely based on a widely shared trust from the
13 larger community in which they operate that was gained over time. These findings are
14 illustrative of two risks that can cripple collective action attempts (McGinnis 2016 p.
15 1) that high levels of complexity make participation in collective initiatives
16 overwhelming and difficult to coordinate and 2) that long reaching transformation is
17 compromised by the inability of new members to entering inner circles of 'elites' (for
18 instance because gatekeeper positions are obtained meritocratically or through
19 initiators-trust).
20
21

22 23 *2.2.2 Commons peer production models (in ICT4D) are likely to merge with contract-* 24 *and market-based, managerial-firm based and state-based production.*

25 After studying the open source model as it is applied in organisations nowadays, Von
26 Krogh and Von Hippel (2003) conclude that only part of its production process is
27 enabled by collective action models, in that a public good (or information commons) is
28 created that is free for anyone to enjoy. Its production process, however, tends to be
29 privatised and therefore controlled by those who contribute most to its upkeep.
30 Accordingly, they argue, open source models are mixes of public and private models,
31 despite opportunities available to the public for sharing and contributing. As such,
32 developers not only create 'digital folds' but 'private folds' as well. Importantly, it is
33 this public-private dynamic that according to Von Krogh and Von Hippel (2003)
34 explains the major cultural and economic impact open source development has had on
35 production processes and their organisational structures. These public-private
36 mechanisms are however in contrast with the notion that integration processes are likely
37 to follow collective action approaches. At present, it is unclear how these dynamics
38 play out in ICT4D projects and to what extent we can expect them to be any different.
39
40
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42 The previous literature reveals a clear need to improve present knowledge on how
43 collective action may be applied as part of Open Development practices. In addition,
44 findings from the literature illustrate such insights are best informed by a perspective
45 of information commons that moves away from dichotomies of public or private
46 (Monge et al., 1998) and instead perceives these commons socio-technically
47 interdependent on the heterogeneity of interests and resources of a distributed user base
48 (Markus et al., 2006).
49

50 51 **2.3 Theoretical Framework**

52
53 To generate the previous insights, the complex dynamics of ICT4D processes need to
54 be unpacked in ways that shed light on their collective action potentials. To achieve
55 this, this paper applies the Institutional Analysis and Development Framework (IAD)
56 framework which was developed by Hess and Ostrom (2005) for the purpose of
57 understanding the creation of common goods and collective action situations (figure 1).
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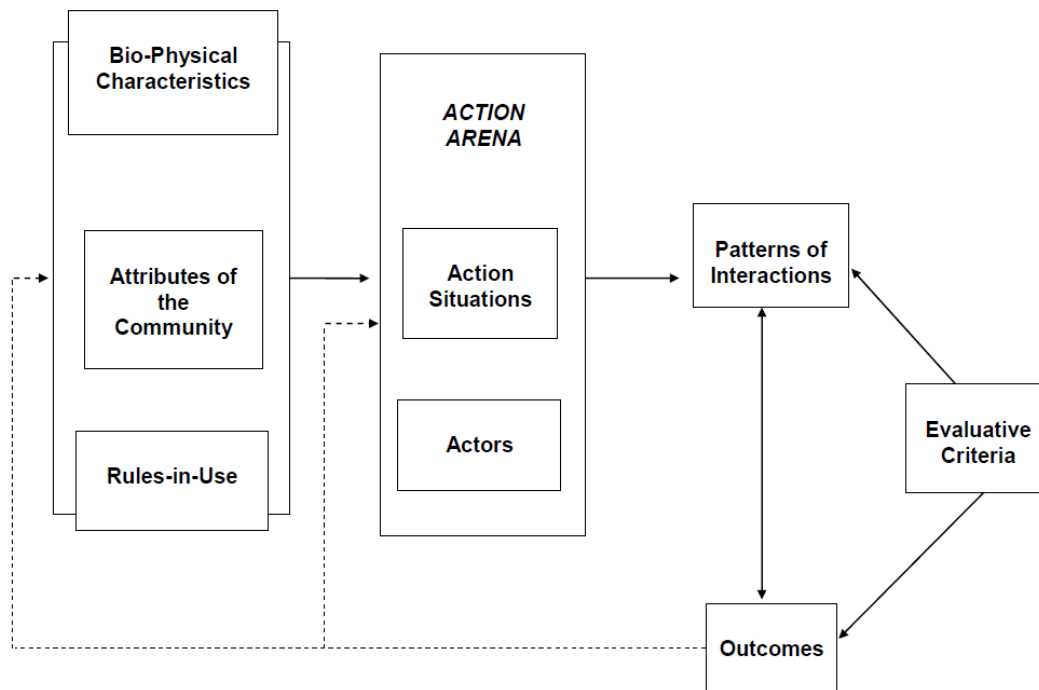


Figure 1. Institutional Analysis and Development Framework. Source: Hess and Ostrom (2005 p.6)

There are three ways to enter the framework when studying a question: on the left, in the middle, or on the right side of the framework. The left side of the framework considers exogenous aspects: underlying factors that influence the middle actions taken and the outcomes of the situation (on the right). These underlying factors reveal more about the nature of a resource being shared (physical, biological, and technical constraints and capacities of the resource) as well as other characteristics such as boundaries, size, communities of users and producers, and the relevant rules-in-use affecting the decisions of participants (such as policies and procedures enacted through practice). Action is described in the middle section of the framework, in an action arena consisting of the action taken and actors involved in it. Actions identified in this section, in combination with external factors listed on the left side of the framework, result in 'patterns of interaction' that will strongly affect the outcome. Finally, outcomes reveal more about why and how information is being enclosed and why actors contribute or do not contribute to a shared repository.

3. Methodology

A case-study approach by Stake (1995; 2006) was adopted to understand the organisation of a collective action initiative which aimed to improve the representation of a particular user group, Ministries of Health in developing countries in the integration stage of the development process of a free and open source-based software platform called 'DHIS2'. DHIS is designed to increase health information management in these countries, and the development of DHIS2 is the result of collaborations of a global network, the Health Information Systems Programme (HISP), which was established and coordinated by the Department of Informatics at the University of Oslo (UIO). In April 2017, UIO established an initiative called 'Roadmap Advisory Team'. The RCAT-case was selected because it aimed at increasing transparency and participation in the development process of an open source ICT4D solution. As I will elaborate in

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3 section 4, this initiative was piloted to ensure that software requirements from
4 Ministries of Health and Health Programmes in developing countries would be
5 considered in the design of DHIS2 in a time when donors and NGOs directly fund
6 DHIS2 software development activities and thus defining parts of its design at a
7 potential cost of country-requirements. The study followed this pilot from May 2017
8 when it had just been launched until its pilot phase ended in October 2017.
9

10 11 **3.1 Data Collection**

12
13 Following Stake's (2006) case-study methodology, the interpretive role of the
14 researchers is crucial in producing knowledge and '*requires experiencing the activity*
15 *of the case as it occurs in its context and in its particular situation*' (Stake 2006 p. 2).
16 Access was negotiated through the RCAT secretary, and permission was sought from
17 all members via email. I had minimal one briefing meeting with the RCAT secretary
18 during each of the initiative's different stages (elaborated on in section 3), during which
19 the progress of the initiative was discussed. In addition, I followed digital
20 communication, discussions and activities undertaken by RCAT members; activities
21 undertaken in relation to RCAT requirements on Jira (a software development tool used
22 to coordinate the DHIS2 design process); participated in 2 events attended by RCAT
23 members since the introduction of the RCAT; attended 2 RCAT meetings and 1 skype-
24 call between the RCAT secretary and the lead developer of DHIS2.
25
26

27
28 This study furthermore significantly benefitted from my research involvement within
29 HISP before the introduction of the RCAT. I attended 2 previous so called 'DHIS2
30 Expert Academies', which occur yearly and gather core developers, development
31 partners and national node coordinators. I also studied practices of designers at UIO in
32 interaction with researchers elsewhere in the network and closely studied the work
33 practices of 3 RCAT members during 2 separate DHIS2 training academies hosted in
34 Africa and Asia and during a one-month field visit. During this field visit (June-July
35 2016), I studied the practices of one RCAT member more intensely; I visited the
36 organisation of this particular RCAT member and shadowed (Czarniawska, 2014) three
37 of its staff members on a work-trip to implement DHIS2 with a NGO and the Ministry
38 of Health of a country in Asia.
39
40

41
42 Multiple sources and methods of data collection and analysis were used, with an
43 emphasis on informal interviews and observations. Informal interviews were held with
44 one or more representatives from each (South-based) RCAT member organisation (see
45 table 2) during 2 (North-based) training events (in June and August). Informal
46 interviews were preferred over formal interviews for various reasons. First of all, 7 of
47 the 10 interviewees were familiar with my role as a researcher from previous field
48 encounters within the HISP project and were also aware I was familiar with the informal
49 and open culture of the community. Second, it was more appropriate given the high
50 workload and work ethic of RCAT members, known to me from previous research
51 engagements. Informal interviews allowed me a level of flexibility needed to adjust to
52 the availability of participants, whose time was scarce and costly, in ways that would
53 not hinder their ability to participate optimally in activities related to the purpose of
54 their visit. Interviews would last approximately 20 minutes and covered their current
55 experience and motivations during the RCAT process, in which approximately half of
56 the informants was asked of their experience at stage 3 (when a long list with priorities
57 was created and voted on) and during an evaluation when stage 5 was yet to be finalised
58
59
60

(see section 3 for stages). This selection depended on the attendance of RCAT members to 2 Oslo based events during stage 3 and 5 of the RCAT process.

Table 2. Interviews

HISP node:	A	B	C	D	E	F	G	H	Total:
Nr. of informants	1	2	1	2	1	2	1	1	11

These interviews were semi-structured in nature, and questions focused on challenges encountered in participating and adhering to process requirements; communication with other members and stakeholders; how participants felt about outcomes achieved; the governance of the initiative and their reflections on their ability to influence the process. The relatively small number of interviews resulted from challenges of engaging with a predominantly virtual and geographically distributed community. Nevertheless, the overall quality of the interviews was assured because report was already established with many of the informants, and the researcher was familiar with practices that underpinned RCAT activities. In addition, most of the initiative's activities and interactions occurred digitally and therefore could be studied in detail.

3.2 Data Analysis

In seeking understanding and meaning, both direct interpretations and categorical or thematic grouping of findings were used. For the first part of the analysis, I relied on thick descriptions of the characteristics of the development process, community attributes and rules in use. Second, I kept a timely record of RCAT-related actions and events; documented participation of RCAT members, as well as informal interviews, conducted; combined with an interpretive account of interactions and situational factors. During this process, I also kept a record of requirements as proposed by different RCAT members, and when possible their follow up. Finally, I documented and tracked both promised outcomes and outcomes achieved.

In the last stage of the analysis, I categorically themed field notes that emerged from the previous process with guidance of the Institutional Analysis and Development Framework (IAD) developed by Hess and Ostrom (2005) for the purpose of understanding the creation of common goods and collective action situations (figure 2). This paper follows the example of Schweik and Kitsing (2010) who illustrate this framework may be applied to understand how internet-based and often transnational collaborations in software operate, are governed and evolve over time. Accordingly, this framework was used to understand factors that enable and hinder collective action in the collaborative open source innovation of a development solution.

In line with my analytical process, the discussion of the case in section 4 will start in the 'action arena' (section 4.2), as it is considered a particularly useful point of departure in analysing specific problems or dilemmas in processes of institutional change (Hess and Ostrom 2005). I first labelled different events in the action arena, which led to the emergence of different themes that could be categorised under various sections of the framework, in which a single event in the action arena could lead to a number of themes in each category. I then went through multiple rounds of eliciting patterns from the various themes that emerged. This was displayed in figure 2.

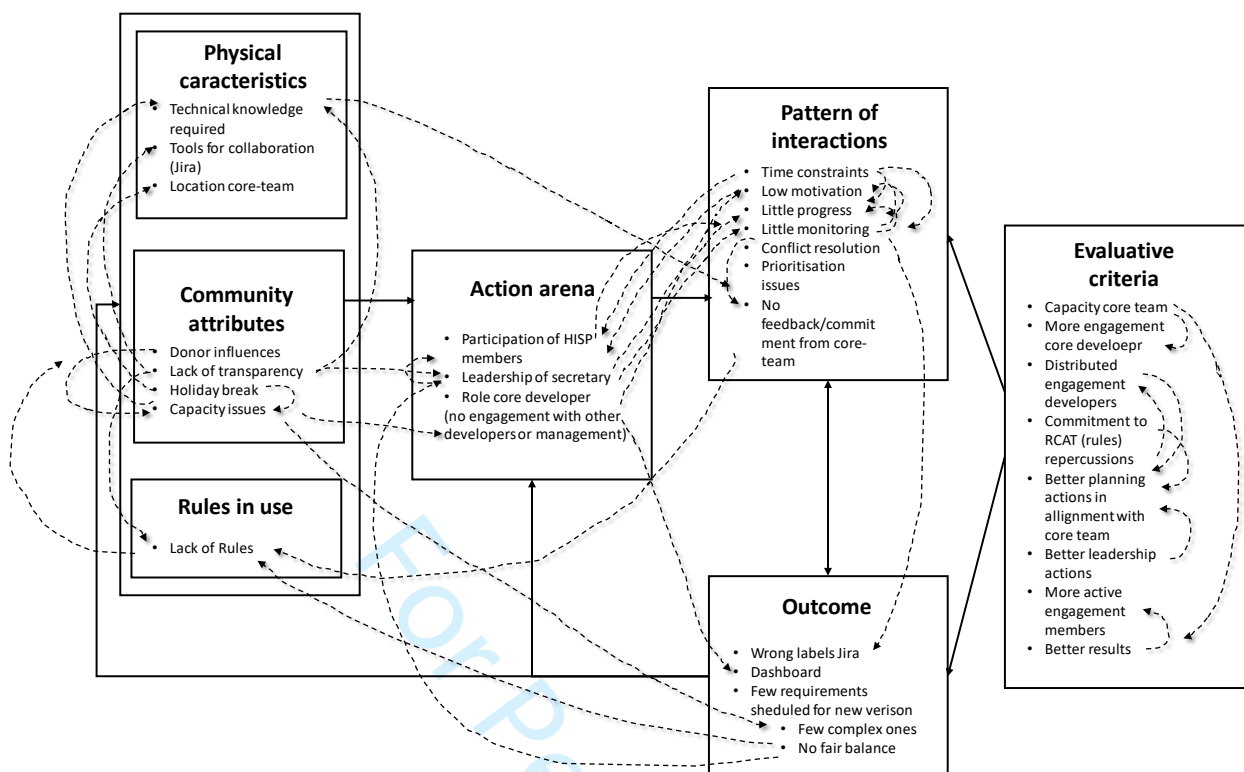


Figure 2. Analysis following IAD framework

4. Case Findings

DHIS2 is a free and open source-based software platform. Its development started in 2006, and today it is widely used as a tool for collection, validation, analysis, and presentation of aggregate and transactional data, tailored to integrated health information management activities in low resource settings. Being a platform, it is highly configurable and customisable and has extensive interfaces allowing for integration with other systems. The HISP network surrounding DHIS2 comprises of various entities, including Universities, Ministries of Health, non-government organisations (NGO's), international agencies and implementing agencies commonly referred to as HISP nodes. A new version of DHIS2 is released trice yearly and users have to update regularly if they want to benefit from the latest improvements and bug-fixes.

Each DHIS2 release is the outcome of primarily two compromises: First, it is a compromise in terms of giving priority to addressing the functional needs from a range of different stakeholders active in the Global Health arena. The different stakeholders can be categorised as countries (Ministries of Health represented by HISP nodes), international NGOs and donors. These different groups of stakeholders have different requirements; different priorities and different abilities in influencing how compromises are made. Donors and INGOs have the capacity to fund the software development that solves requirements. While these requirements primarily reflect the needs of their individual programs, solving these requirements will usually also be to the advantage of the other stakeholders. Funding from the donors and INGOs will be based on projects with specific deliverables and a process where the status of each

requirement is followed up closely. These stakeholders will typically also have a high capacity to understand the software and the ability specify new requirements. There are also donors that offer support to the development of the software core without specifying requirements. Ministries of Health in countries using DHIS2 will typically not have the money to fund new requirements nor the capacity to specify them. HISP-nodes representing the countries can define requirements. While many of them have deep knowledge of DHIS2, the lack of funding challenge persists. At the same time, HISP-nodes will typically have strong relations to the core DHIS2 development team and will also be present at an annual training event, the ‘DHIS2 Expert Academy’, where they can promote their requirements. These dynamics are illustrated in figure 3. In relation to section 2.2.2., this figure furthermore depicts DHIS2 as a public good that nevertheless relies on a specific group of funders for its upkeep.

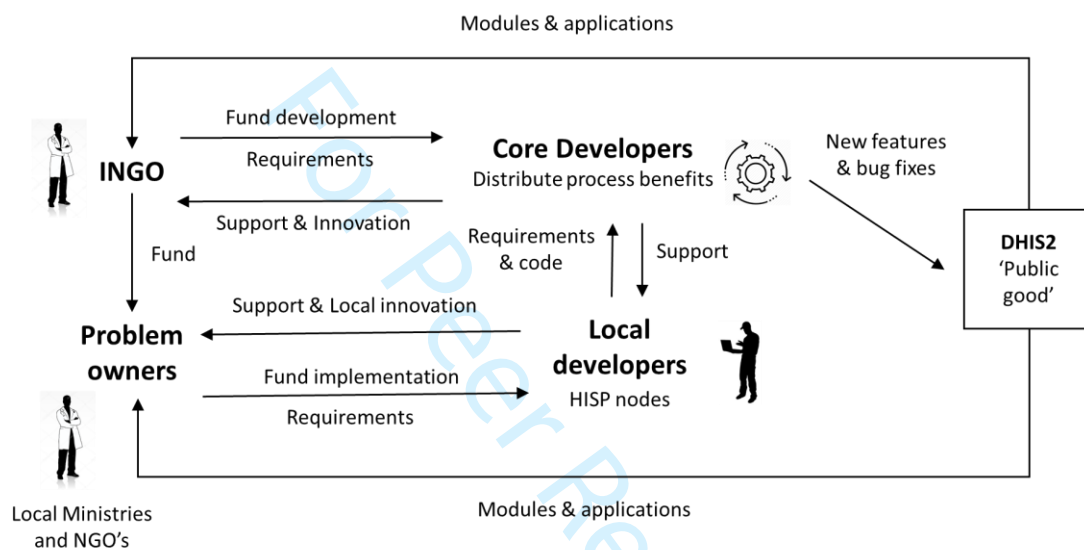


Figure 3. Stakeholder dynamics

Second, each DHIS2 release is the outcome of a compromise between the need for maintaining a generic software on the one hand, and the availability of contextual, local solutions on the other. For the core development team facing design decisions such as these, prioritising between many requests can be challenging. It can be observed that the basis for this compromise has changed over time as the ‘rhetoric’ of DHIS2 has changed from being positioned as a ‘software’ to a ‘software platform’. As a software platform, the focus is on being even more generic, and thus less country- or use case specific. With advanced APIs, apps and extensions can be used to develop new features. It becomes an architectural question where to put new features – in the core or elsewhere.

In 2015, a community assignment held during an Expert Academy revealed that the current way of dealing with these compromises is creating tensions within the community and those contributing to (or seeking to) the systems development and implementation, because it is not transparent (Fruijtier and Pinard 2016). An evaluation of the HISP activities in 2016 also highlights the challenge of ensuring representation of the wider community on the roadmap. Recommendations from this assessment among others include the establishment of an external advisory board, representing various stakeholder roles (including country and NGO users, donors, developers, and implementers) to increase community input, visibility, and usability of the DHIS 2

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2
3 product roadmap. In recognition of these issues, a need has arisen among HISP UIO to
4 understand the previous challenges in relation to the development of the DHIS2
5 roadmap more deeply, as well as to understand how action can be taken for
6 improvement.
7

8
9 The previous collective action challenges have led to the recent development of a
10 'Roadmap Country Advisory Team' (RCAT). The mandate of RCAT is to advise the
11 management team on country requirements that should be on the roadmap for the
12 following DHIS2 release. RCAT members are not the only ones accessing the roadmap,
13 however, it is the first initiative that attempts to collectively distribute 'space' on the
14 roadmap among a specific group of roadmap-appropriators.
15

16 17 ***4.1 Action Arena and Patterns of Interaction: Roadmap Advisory Country Team Pilot*** 18

19 During the time of this research, participation in the RCAT was reserved for those HISP
20 nodes that have entered or are in the process of entering a memorandum of
21 understanding with HISP UIO based on a series of specific commitments to actively
22 promote, develop, implement DHIS2 and facilitate research activities. The first meeting
23 of the DHIS2 Roadmap Advisory Team in the form of a conference call was joined by
24 representative from all HISP nodes and the RCAT secretary who was appointment by
25 and also part of the UIO management team to facilitate the process. Participants pointed
26 out that for the RCAT to increase roadmap transparency and accountability,
27 mechanisms for prioritisation needed to be put in place and a form of 'assurance' that
28 promised action is taken, expressing that issues that are ignored by core developers
29 should have repercussions. In order to do this, participants suggested closer monitoring
30 on how the different requirements in Jira are handled in terms of what is resolved and
31 what is not, which should include an overview of the different requirements from
32 NGOs, donors and countries.
33
34

35
36 Feedback from the RCAT meeting was discussed with the developer team at UiO based
37 on which a process and approach to work with the roadmap was suggested. The
38 proposed process included 7 stages, which are discussed in more detail in table 3
39 (appendix A). In the following sections, I will discuss the implementation of these
40 stages as well as challenges experienced during them in more detail.
41
42

43 ***Stage 0. Define requirements in Jira***

44 Unless they are very straight forward or provided with significant details, issues of
45 interest to core developers will often generate follow up discussions in Jira to further
46 clarify the issue. However, not all issues are subjected to this treatment and some never
47 see a response. To aid this process, one RCAT member created a template that specified
48 how requirements should be submitted. However, according to one RCAT member,
49 issues in relation to defining requirements exceeded merely following this template,
50 noting developers also need to share feedback on how they prefer requirements are
51 written, noting:
52
53

54 *'When I get no feedback, I assume that they either did not understand it or they do not*
55 *want it.'*
56

57 ***Stage 1. Compile separate list of issues***

58 Aside from some minor issues (whereby the task of gathering issues was cascaded down
59 to other team members of the RCAT member organisation who did not have access to
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3 edit the Google document created for RCAT members to upload their requirements) all
4 but one node contributed with a separate list of issues.
5

6 *Stage 2. Compile common list of issues*

7
8 During this step, the RCAT secretary took all the requirements (based on Jira Issue
9 Keys) from the individual member lists and joined them into a common list. The
10 deadline was maintained sharply to enable the core development team to make
11 commitments. For many RCAT members, the period provided to gather requirements
12 was too short. In some cases, the task of gathering issues from other team members was
13 placed on someone who did not have access to the google document. In one case, this
14 resulted in a situation where the google document was locked by the time replies from
15 team members were gathered and forwarded to the one who has access. In addition, a
16 big event that hosted 3 RCAT members for 2 weeks during which requirements needed
17 to be compiled and submitted, challenged the participation of a relatively large part of
18 the RCAT.
19
20

21 *Stage 3. Add priority to the common list*

22
23 Another deadline was set for RCAT members to prioritise the issues on the long list of
24 common issues which had compiled 69 requirements in total (see table 4). However,
25 the proposed mechanisms for prioritising requirements did not have the envisioned
26 effect. First of all, RCAT members were asked to rate issues. However, only 2 RCAT
27 members (out of 8) engaged in voting: one RCAT members voted for 3 issues and only
28 one applied voting rates to all of them. Some expressed concerns about the voting
29 process. For instance, because not all issues are of interest to all countries. Another
30 problem that made the process of prioritising difficult, was that certain features need to
31 be done first in order for other features to be implemented. Because of these layers, the
32 prioritisation process is not always a straight forward matter of rating the ones that are
33 most urgently needed.
34
35

36 *Stage 5. Feedback from HISP UiO*

37
38 The long list and ratings provided by 2 RCAT members was discussed with the core
39 development team by the RCAT secretary. To the core development team, the list was
40 already considered relevant, as it increased their insight into what countries needed
41 most. However, because not all RCAT members contributed to prioritising the long list,
42 it was difficult for core developers to know which requirements had priority for several
43 RCAT members. The total amount of 69 requirements were too many to be processes
44 during one release, given that the core development team also has obligation to
45 implement requirements of investors (donors). As a result, the RCAT secretary decided
46 to repeat the previous steps (2 and 3), only this time asking countries to send a top 5 of
47 requirements directly to the RCAT secretary for compiling.
48
49

50
51 The meeting between the RCAT secretary and the core develop team was able to draw
52 the attention of core developers toward RCAT issues, which then saw increased activity
53 in Jira. 39 issues out of the 69 issues on this long list were labelled 'RCAT' in JIRA by
54 the core development team the following day, and a feedback processes was initiated
55 to further clarify some of them. However, this action was not systematic and the basis
56 for the previous selection was unclear.
57

58
59 The decision to re-do the previous steps in a changed format to ensure wider
60 engagement of all RCAT members generated frustration among the only RCAT

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3 member that had made the effort to rate each requirement on the long list that was
4 compiled previously. The RCAT secretary attempted to resolve this conflict by noting
5 that the current RCAT process was subjected to a learning curve. One of the reasons
6 that contributed to this tension, was the fact this RCAT member represented the needs
7 of several countries they were active in or collaborating with that either did not have a
8 local developers team or one that was not represented in the RCAT, as a result of which
9 this member found it difficult to split their requirements between them. The RCAT
10 secretary decided that for now, the initial boundary set for the RCAT process should be
11 maintained and later on it could be evaluated whether membership should be
12 broadened.
13
14

15
16 The previous process resulted in a new shortened list of 28 requirements. With one
17 exception, this list did not introduce new requirements, however, some RCAT members
18 did use the opportunity to change requirements they submitted.
19

20 *Stage 6. Finalisation of common prioritised list*

21 The core development team was asked to comment on the items on the short list. This
22 step, however, was not completed in time before the team broke for holidays and
23 feedback to the RCAT on the further processes of the requirements was postponed. At
24 this stage, the previous Jira selection by the core team furthermore worked confusing,
25 as it no longer applied after a new round of submissions was able to trim the 69-item
26 counting long list down to 28 in an attempt to better understand priorities. 19 of these 28
27 items had been labelled on Jira as 'RCAT' and 9 had no such label, while 28 RCAT
28 labels no longer applied after the long list was revised. However, because both the core
29 team as well as the RCAT secretary broke for holiday, this was brought to the attention
30 of the lead developer (who made the previous selection) relatively late in the process,
31 namely during the Expert Academy discussed in the next section.
32
33
34

35 Comparing the long list from the 1st round with the short list from the second round,
36 only 1 additional item was not reported on the longlist already (submitted by F). This
37 means that the second round did in fact function as a way of prioritising what was
38 already on the long list, which proved to be extensive. Combining what we know about
39 who suggested issues on the long list with issues prioritised on the short list, we find
40 that 1 issue is shared by 4 RCAT members; 4 issues are shared by 3 RCAT members;
41 19 issues are shared by 2 RCAT members and 4 issues concern only 1 RCAT member.
42 This means with exception of 4 issues, the remaining 24 issues are shared by at least 2
43 RCAT members or more, validating that most of the issues emerging from the RCAT
44 process are generic ('global') in nature.
45
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47

48 **4.2 DHIS2 Expert Academy**

49 Several members of the RCAT travelled to Oslo (August 2017) to attend the yearly
50 DHIS2 Expert Academy at this stage in the RCAT process. Among others, various so
51 called 'roadmap' sessions were held during this academy, as well as 'what is new in
52 DHIS2'-sessions which go over the most recent as well as some upcoming features.
53 During the roadmap sessions, different developers (working on different modules such
54 as tracker; android; data visualisation, community-health; disease surveillance) host
55 sessions during which they ask feedback from the audience on feature requests –
56 NGO's, some Ministry staff, DHIS2 consultants, funders, experts and HISP nodes
57 among whom also RCAT members. The android team, for example, went over a list of
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3 features they send out to the user-list and prioritised based on a voting-procedure.
4 During this academy, it became clear that developers themselves were unsure of how
5 to prioritise features and lacked structure to attract and manage community input. The
6 academy was an important medium for them to obtain such input, and every roadmap
7 session was structured differently. There was no standardisation evident among
8 different teams, and after presenting their findings to each other and the wider audience
9 in a primary session on the final day many confessed to learn from other approaches
10 seen that day (such as the use of a voting tool as well as the use of a dashboard in Jira).
11 When asked about this, one core developer commented:
12
13

14
15 *'We are gathering requirements left and right, also as part of these sessions... but there*
16 *is no system for how to process them. It is very organic, unlike in some other large*
17 *organisation where you will find a more structured process'*
18

19 Also, it became evident many developers were not familiar with the RCAT process –
20 they had heard of it and noticed the RCAT-labels in Jira, however, seemed unaware of
21 its efforts and role in selecting and prioritise requirements. On the final day of the
22 academy, a presentation was held that properly introduced RCAT to the team as well
23 as the wider audience attending. However, at this stage, it was still unclear how
24 requirements would be prioritised amidst the different plans to create dashboards and
25 track requirements in Jira raised and presented during the academy. Some RCAT
26 members ended up wondering which channel to use. One RCAT member noted:
27
28

29
30 *'We [2 HISP node team members] spent 6 hours going through all the requirements*
31 *on the [long] list. (...) I want to know: what is Oslo's [university of Oslo] motivation*
32 *for the RCAT? Is it to make us feel like we participate, or is it to actually regulate the*
33 *requirement process? Because it should be more broadly implemented in that case.*
34 *Right now there are all these sessions to give requirements in the academy. I had some*
35 *new requirements and they are already given more priority in Jira. What does that*
36 *mean?'*
37

38 For another member, the ability to explain a requirement with one of the core
39 developers directly had resulted in its allocation on the roadmap after he had been
40 stressing it for over a year. As it turned out, it was easy to implement, and the core
41 developers could work on it right away.
42

43 A brief feedback session was held while several RCAT members could physically be
44 present, and some feedback was collected about the process. Some of the comments
45 during this session are listed below:
46
47

48
49 *'The developers have no context – we just don't know what their priority is and what*
50 *they are working on. There is no communication, who decides, what is the thought*
51 *process? All the issues we voted for: do they understand them?'* (node F)
52

53
54 *'I have worked with the core team for a long time now, and I am surprised there was*
55 *involvement at all [with the RCAT]. The dev-team also faces a lot of challenges. RCAT*
56 *should be a venue for them to ask clarification. We are a team of experts that they can*
57 *go to.'* (node C)
58

59
60 *'It is a common response to say just file a Jira-issue'. But they [core team,] they don't*
feel the impact, they don't feel the heat. These ministries are our clients.' (node F)

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3 The idea was taken up from one of the RCAT members to create a dashboard in Jira,
4 after attending a presentation of such a dashboard during the Expert Academy from one
5 of the developer teams surrounding a specific set of features. The dashboard was meant
6 to provide a venue for the RCAT members as well as the wider community to identify
7 and track the progress of requirements in Jira, which had thus far generated a sense of
8 disappointment among the RCAT members. At this stage, the lead developer was
9 briefly engaged to explain more about how RCAT requirements would be processed.
10 During this meeting, it became clear that ‘heat’ was felt on both sides, as the core-
11 development team faced current capacity issues which limited the number of
12 requirements that would be implemented in the next release, and a holiday break had
13 further hampered the team’s productivity. The lead developer committed to providing
14 feedback on the short-list soon, before ‘the big freeze’ that would happen in 2 weeks
15 when the roadmap for the new release would be locked. Notably, stage seven to
16 complete the RCAT process as agreed upon in the beginning of the initiative (see table
17 3 appendix A) was not implemented.
18
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21

22 **4.3 Outcome**

23 After a new feedback round, the core development team committed to implementing
24 13 feature requirements in the upcoming version out of the shortlist of 28 requirements,
25 approx. 1 week before the roadmap for the upcoming release would be locked. Again,
26 the basis on which these features were selected by the core team remained unclear.
27 Based on the selection made, fair distribution between countries was not taken into
28 consideration. In addition, the (late) timing of the commitment suggests assessment
29 could have been based on features already largely (planned to be) developed at that
30 time. When the RCAT secretary communicated the previous outcome, only two RCAT
31 members responded: both of which saw most of their requirements committed to by the
32 core team (A and E). A third RCAT member (F) that also saw a majority of their own
33 requirements committed to by the core team nevertheless expressed disappointment in
34 the overall result, urging a quick follow up on issues that were pushed to the next
35 release.
36
37
38

39 A dashboard was put into place and the roadmap for the next version (2.28) was
40 ‘frozen’. After a period without further communication or response to the previous
41 reaction, the RCAT was informed the RCAT secretary was being changed to someone
42 who was part of the implementer team at UIO and more involved with the requirement
43 process on a daily basis. In Jira, 10 out of the 13 issues committed to were scheduled
44 for 2.28. 14 out of 28 issues (50 %) had not been scheduled at all at this point (status
45 ‘open’), whereas 2 actually had been scheduled for earlier releases (2 for 2.27 and 1 for
46 2.26 – marked at resolved) and did not make it on the 2.28 schedule. One requirement
47 was found non-applicable by the core team. An overview of requirements emerging from
48 the RCAT process and their follow up is provided in table 4 and figure 4. While
49 information from the long list was provided, the process centralised on the short list
50 only which was therefore highlighted in the table. The total of requirements submitted
51 during different stages of the RCAT process are indicated with brackets.
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Table 4. Outcome requirements process

HISP node:	A	B	C	D	E	F	G	H
Commitment from the core team:								
long list	5(20)	1(8)	1(5)	1(5)	1(7)	6(31)	1(2)	0(3 through voting)
Short list (out of 5 max) 28	4 (5)	2 (5)	1 (5)	1 (5)	3 (6)	1(5)	1(2)	0(0)
Done at time of release:								
Long list	3	-	1	1	1	(1 N/A)	1	-
Short list	2	-	-	1	1	-	-	-

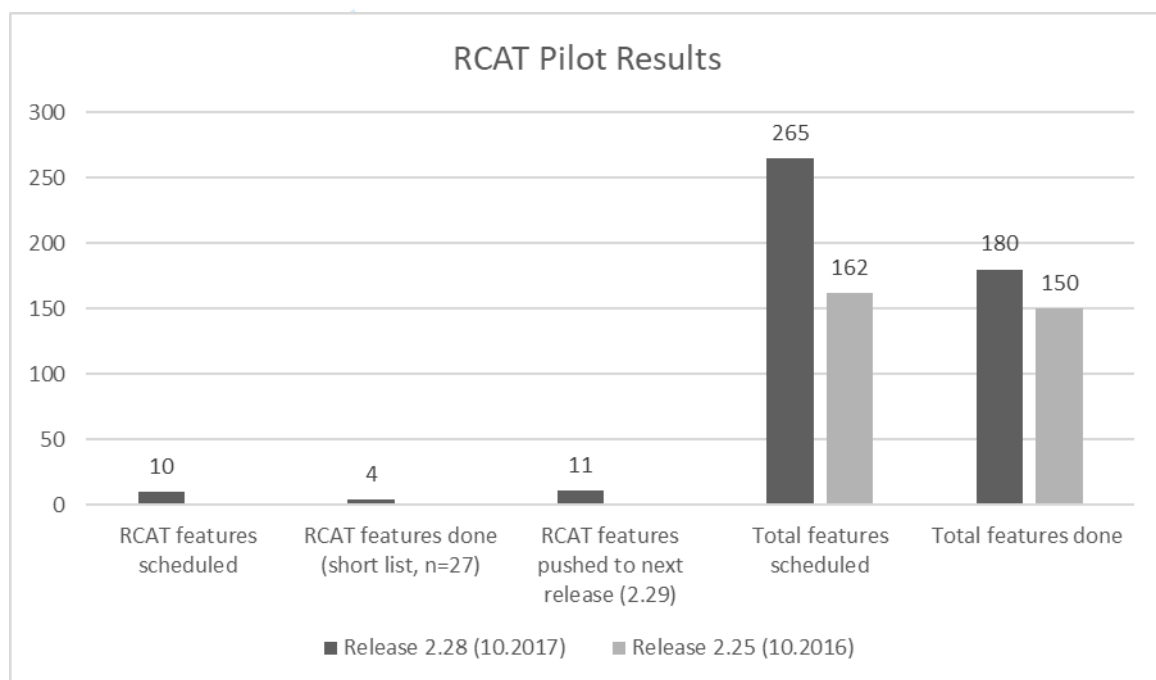


Figure 4. Details of the release (version 2.28)

As visible in figure 4, the RCAT initiative influenced only 2.2 % of the release and was allocated 4 % of the features scheduled in the next release³ at the time of writing. Notably, the scheduled features for this release were significantly less than the past 2 releases (between 450 and 500 scheduled and almost 400 completed). However, it is not possible to check whether completed issues from previous releases were completed after the release date. Nevertheless, this result is similar to the previous release scheduled after the same holiday period a year before. It is fair to conclude the influence of the RCAT initiative on the roadmap was minimal if not neglectable. However, it must be noted that this does not mean individual RCAT members or other Ministry representatives did not influence other features that did appear in the new release. It does indicate that aims to make this process more transparent were not achieved; and that collectively, the influence of these actors can be considered weak.

³ 270 at present, though this number is likely to change.

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Case-data did not include a possible overlap between RCAT requirements with NGO requirements in the final release. However, as previously discussed, the boundary that distinguishes between requirements that come from RCAT members and from donor organisations whom invest in the core development of DHIS2 tends to become blurred in the field. A member from the UIO management team explained that *'RCAT is important and will get a fair chunk of the development time for each release, but the global implementation projects we are involved in like [project x] obviously also want a fair chunk.'* Ultimately, however, this intention is not reflected in the outcome of the process, which could indicate how the previous logic poses a risk to the requirements from RCAT members. As mentioned by a core developer, *'donors can ask for something to be done right now'*, which can compromise their ability to focus on requirements from others. On the other hand, some RCAT members can also use this mechanism. One RCAT member noted that, when certain issues they submitted would not make it onto the final list, *'we will have to deal with them via [donor] (get [donor] to push HISP-UiO)'*. The previous data does not reveal whether RCAT requirements were pushed through different channels. Though RCAT members are free to self-organise, this could potentially hamper the function of the RCAT to counter-balance such powers. In addition, this can only work for (donor funded) project-based issues that are not necessarily also in the best interest of the Ministries, which could further increase this unbalance.

5. Case Analysis

In the previous case, the design needs of problem owners at Ministries of Health in developing countries are represented by spokesmen at so called HISP nodes toward the core development team at UIO. When we look more closely at the dynamics that shape these practices, it is noteworthy that these technical spokesmen are well capable of coordinating collective action. They collectively identify shared requirements and prioritise them, even though they are geographically distributed and represent different clients. What potentially helped in this process is that they consisted of a fairly small group (n=8), knew each other well and – consistent with many open source communities, were all developers despite differences in skills, capacity and cultural backgrounds.

However, analysis reveals that this relatively well functioning action arena was not properly nested as part of rules (and sanctions) in place and that patterns of actions were such that the actors involved were powerless to address this weakness. Despite initial suggestions from RCAT members and process commitments made in the initial stage, mechanisms to ensure commitment from the development team and transparency about RCAT requirements in relation to the rest of the roadmap were either not included in its design or neglected during its implementation. This implementation appeared to be based on a certain level of 'trust' which did not reflect in past experiences that inspired the initiative nor resonated with past experiences from RCAT members. Accordingly, what can be considered negative outcomes of the action taken for the RCAT has no significant impact for the overall community attributes in the absence of such rules. This is evident in the way there were no repercussions for core developers when they failed to integrate requirements in to the release as promised, or even failed to make such promises. In addition, informal practices in the action arena - such as involvement of a broader team of core developers - could have given RCAT increased visibility and therefore increased its influence. However, RCAT was started in silence and not actively promoted among developers whose parallel practices continued (as evident

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3 during a DHIS2 Expert Academy). The previous challenges can be primarily related to
4 community attributes, rather than located in the physical environment. While
5 developers reduced capacity and high intensity of the development process could
6 explain why ‘quick fixes’ were more likely to be integrated over complex feature
7 requests for an upcoming release, these reasons are not sufficient in accounting for the
8 marginal influence of the RCAT on the roadmap.
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11 An important factor that is likely to have influenced a failure to ‘nest’ the RCAT
12 initiative in rules in use, is the absence of rules in use for the community in general.
13 Even for developers, prioritisation of different user groups was unclear. Here, there was
14 a task for management, core developers as well as the RCAT secretary, that was unmet.
15 Nevertheless, the question remains how much difference the previous interventions
16 would have made considering the lack of capacity in relation to pressures from the core
17 team to commit to donor requirements. Although the influence of donors is unclear
18 based on the previous case, it is unrealistic to suspect that a majority of the remaining
19 176 requirements completed in the latest release were the result of RCAT members (as
20 main representatives of Ministry needs) via informal channels, knowing donors
21 together supply in the primary resources required for the developers-team to operate.
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25 While a dashboard could potentially address a lack of transparency toward the rest of
26 the community and other developers (on requirements needed by ministries and process
27 made in addressing them) this would only increase the influence of the RCAT when
28 they can use it to pressure for repercussions or show how the overall roadmap represents
29 an unbalance. In this regard, it was also noted that RCAT members can also serve donor
30 requirements instead of those of Ministries. Importantly, donor requirements may also
31 be of interest to Ministries in countries in which they operate, which illustrated how the
32 previous process is subject to many grey areas which further hamper transparency. The
33 introduction of the RCAT initiative could also have been an opportunity to clarify rules
34 in use.
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38 Previous challenges could be expected to benefit more from increased transparency at
39 the level of the outcome and/or action taken, which would require an increased level of
40 engagement from developers with the RCAT. This was not stimulated by management
41 or the core team, and it was not facilitated by the RCAT secretary. In turn, this
42 negatively affected participation of participants and countering it would have required
43 strong leadership efforts that generate a sense of being heard, understood, and
44 communicated with.
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46 47 **6. Discussion**

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49 This paper has focused on the emerging domain of ‘Open Development’ (Reilly and
50 Smith 2013) which captures a recent trend among ICT4D researchers to adhere to the
51 challenge raised by Walsham (2012) “to make a ‘better’ world with ICTs”, in which
52 ‘better’ tends to be equated with ‘open’. It was also noted how this would require
53 collective action-based production processes for which open source development and
54 open models can be a pre-requisite, but not a substitute. In fact, as discussed in this
55 paper, the application of open models could potentially hamper collective action efforts.
56 This study explored to what extent Open Development practices can balance on both
57 pillars – open models as well as collective action – in line with objectives to realise
58 development outcomes.
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6.1 Understanding Collective Action as part of ICT-enabled Open Practices

The RCAT case discussed in this paper is an example of a collective action effort in which an ICT4D project attempts to actively engage different stakeholders in its open innovation process. Findings from this case illustrate that some collective-action challenges that could potentially cripple Open Development practices (such as low quality of contributions (Benkler and Nissenbaum 2006) as well as an overwhelming number of contributors (Shaikh and Vaast 2016) can be overcome by forging strategic partnerships with skilled developer teams whom, as a result of open models in place, are able to represent Ministries of Health in developing countries. In addition, most of the issues emerging from the RCAT process could be considered generic ('global') in nature, and would, therefore, be suitable for integration in a software platform. These findings show that modularity and granularity aspects of CBPP processes can be transferred to Open Development practices. However, despite their ability of suggesting relevant features for different modules, these contributors are unlikely to belong to the 'inner circle' that has the mandate and skills to translate such feature requests in to software code.

Accordingly, the RCAT initiative concentrated on the integration stage of the CBPP process (Benkler and Nissenbaum 2006) in which core developers had a gatekeeper position (Krogh and Speath 2002). However, findings from this case illustrate that this is where the practical implementation of CBPP processes as part of ICT-enabled open practices becomes problematic. The collective efforts of technical representatives of Ministries of Health in developing countries (enabled by ICTs) appeared fruitless in the absence of rules in place (and in use) at an institutional level necessary for members to correct each other (Ostrom 1994). However, in this case, this challenge did not occur in the orchestration of collective action initiative itself, but in the institutional structure surrounding the initiative that failed to legitimise its practices. In part, a lack of commitments, non-transparent decision-making and contradictive as well as confusing and/ or nonresponsive management were symptoms of a management and the core development team that struggled with whom to give priority and how to meet donor demands upon whom they depended for process resources.

These findings underline that, while certain challenges may be overcome, realising collective action in the previous context remains extremely difficult and failure can be expected (McGinnis 2016). In this regard, it is furthermore important to highlight a challenge that institutions may be faced with of attempting to balance local development needs on the one hand and securing resources for their ongoing production on the other. In the RCAT case, dealing with the complexity of balancing different stakeholder needs suffered from the absence of effective coordination strategies - which McGinnis (2016) has coined the Achilles heel of collective action efforts. Notably, this issue may also be addressed outside of the institution, in the global aid environment in which it operates. While Ministries, their technical representatives and international donor agencies often work together and toward a shared goal, findings indicate such collaborations are not part of a systematic and integrated approach, as a result of which they may find themselves in competition. Collective action suffers when subsystems (as well as meta-systems) - such as donor systems - are not aligned to support their success (McGinnis 2016, Ostrom 1994).

6.2 Implications for Open Development

The previous findings have implications in terms of how ICT-enabled open practices are understood and implemented under the Open Development umbrella. First, these findings imply Open Development definitions and discussions could be enhanced by signifying specific processes of collective action and clarifying the importance of integration. Specifically, this study encourages open development proponents to address whether the aimed transformation of development can primarily be seen to result from the enabling of granularity and modularity alone (as presently seems to be the common perception) or whether this requires rules to be in place in the integration stage that negotiates a balance between different groups of contributors. Notably, this case has discussed collective action challenges of a complex, large scale ICT4D project, and different challenges may be encountered in smaller projects that are less geographically distributed. On the other hand, it is perhaps especially important for Open Development conceptualisations to consider such complex scenario's. One could argue scaling of transformative solutions can not only be expected but should, in fact, be aimed for from the very beginning of such projects.

Second, these findings urge us to approach Open Development first and foremost as a coordination matter in which major global stakeholders, as well as legislative bodies, have an important role to play. As such, they contrast the common perception that open models in development – and innovation in general - will lead to the dissolving of hierarchies and enhance bottom up, grassroots solutions by making collective action possible. Rather, releasing their collective action potential will require top-down integration as well as horizontal (domain wide) efforts, both at the level of institutions as well as the wider environments in which they operate. The level of change this would require may seem tremendous and radical, even overwhelming and unrealistic to some. In this regard, it is important to note that failures such as the one discussed in this paper may be an important driver to pave the way in achieving the aforementioned transformation. As pointed out by McGinnis (2016);

'even imperfect proto-polycentric systems of governance provide actors with continued access to multiple mechanisms for improvement hold out the hope that the most negative consequences of these tendencies can be ameliorated'

Constantinides and Barrett (2015) further point out the challenges of defining detailed governance rules in advance as part of IS projects, and that collective action initiatives need to be 'progressive nested' to gradually enable the definition of more defined governance rules which need to consider how different actors and their ideologies frame the collective action. In this regard, it is worth mentioning that the RCAT-case concerned a pilot, it is possible that challenges encountered will be addressed over time when the initiative continues to provide input for new releases to come. At the same time, a certain level of transformation may also occur when only partial collective action is facilitated (Von Krogh and Von Hippel 2003) and we must also consider the option that not all processes are suitable for collective action (McGinnis 2016).

To move forward in the previous discussion, more research is needed to understand the transformative attributes of ICT-enabled open practices in ICT4D, and the context or adjustments this would require. To this end, this study has furthermore illustrated the use of the IAD framework (Hess and Ostrom 2005) as a valuable analytical tool for unpacking ICT-enabled open practices and their collective action potential.

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Appendix A

Table 3. RCAT process structure and commitments

Stage	Description	Responsible actor
0 – Define requirements in Jira	New requirements are shared and vetted on the mailing list (users[at]dhis2.org) before suggested as improvements in Jira. The creation of improvements and definition of issues will be done independently of RCAT. RCAT will also give priority to existing issues.	RCAT members individually
1 – Compile separate lists of issues	Each HISP group provide a list of relevant issues from Jira for the next release. These issues can be already defined (by others) or defined by the HISP groups as part of the process described here.	RCAT members individually
2 – Compile common list of issues	The common list of issues will show all relevant issues for HISP Groups. To get rid of duplicates, a list with unique issues is compiled based on the lists from stage 1.	RCAT secretary
3 – Add priority to the common list	Each HISP Group gives each of issues on the common list a priority from 0 – 3 where 3 is the highest priority.	RCAT members individually
4 – Compile common list of issues with priority	Based on the priorities given in stage 3, a common list of issues in a prioritized order is compiled.	RCAT secretary
5 – Get feedback on list from HISP UiO	The common prioritized list is scrutinized by the HISP UiO software developer team and suggestions for changes/adjustments is provided. Focus on dependencies and quick estimation of resource demand per issue. Feedback will be given if other software teams can work with the issues.	HISP UiO Software Development Team
6 – Finalization of common prioritized list	Based on the feedback from stage 4 and any other concern, a final prioritized list is compiled.	RCAT (joint)
7 – Decision on issues related to the roadmap	The common list of requirements is considered by HISP UiO and a final decision is made on the issues on the roadmap for the release in question. Feedback is offered to RCAT (what and why). Any changes in priorities during the work with the release in question will be communicated to RCAT without delay by the HISP UiO Software Development Team.	HISP UiO Management