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Exploring the Role of Technology in the Institutionalization of Health Information Systems: An Actor-Network Analysis of Information Systems Integration

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Background and Purpose: Information systems (IS) integration is a complicated exercise. This paper discusses the process of IS integration for a healthcare sector in a resource constrained context. In recognition of power play between the different actors involved, the paper underscores the complexity related to coordination of actors and institutionalization of organisational routines in order to achieve the goals of Health Information System (HIS) integration. In particular, the paper explores how artefacts (software, policy guidelines documents) can be used to facilitate coordination of the actors involved.
Methods: The study employed actor network theory concepts of inscription and alignment to guide the data collection and analysis. Data collection methods include participant observation, documents review, and interviews, both formal and informal discussion groups.
Results: The study reports implementations of an action research project in Tanzania (Zanzibar, and Mainland), where two case studies are presented, comparing how different technologies in line with implementation mode (decentralized/centralized) occurred. The article describes HIS integration as a combinatory actor network building process that needs to consider the nature of the technological artifact, and the manner in which it is implemented, coupled with the policy guidelines which inscribe and prescribe the use of the system.
Conclusions: The article reveals that success in actor network building process (the HIS integration process) in the backdrop of myriads of heterogeneous actors with multiplicity of interests can be achieved by a combination of interventions where the agenda needs to be inscribed in a technological artefact and policy guidelines, and reinforced with the implementation mode (centralized).
Keywords: integration, power, health information systems, actor-network-theory, inscriptions, alignment.

1 Introduction

As part of development efforts, developing countries are engaging in the process to improve healthcare status of their populations [19]. Development partners, both bilateral and multilateral are highly involved, considering the economic status of the countries which prove difficult for them to catch up with the existing and emerging healthcare needs primarily caused by high disease burdens and poor capacity to provide basic primary healthcare aimed for disease prevention and improving the well being of the people. Donors usually organise their support in 'vertical' health programmes mode, specialising in a particular disease or service. Ultimately, the programmes devised the way to ensure proper accountability of the resources they provide. In this way, information systems (IS) were designed to provide tools for monitoring and evaluation of resources and impacts of individual programme initiatives. In turn this resulted into fragmented IS serving the healthcare sector, and its impact is viewed in both the quality of data collected as well as increasing burden to already overloaded healthcare staff [1][2]. Moreover, by focusing on specific programmes, the fragmented IS failed to address the sector-wide information requirements.

To address this condition of ineffective IS, countries have invested in projects to develop integrated health information systems (HIS) aimed at providing comprehensive and shared data that serve the whole sector. The initiatives are sponsored by individual countries supported by donor agencies, often those involved in healthcare provision initiatives. The health metrics network (HMN) outlined an integrated

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approach to data warehousing as an alternative to providing comprehensive health sector-wide data [3]. Despite these initiatives, integration has proved to be a challenging process, and hence receiving attention from the IS research community. While some research has focused on the technological issues such as challenges of legacy systems, others are more concerned on organisational aspects of integration. This is mainly based on what rise as the enduring challenge in the concerned projects.

In this article, we formulate a discussion on the organisational aspects of IS integration. The context of the study is Tanzania, a developing country in which donors play a major role in supporting healthcare service provision and hence have had myriad influence on the HIS integration exercise. Empirically, our discussion is based on two case studies drawn from two healthcare organisations (Tanzania Ministry of Health and Zanzibar Ministry of Health[1]). The two healthcare organisations has taken measures to integrate various HIS supporting different health programmes and employed District Health Information Software (DHIS) to capture and process data for the sector wide information system. The discussion is centred on the challenges in the coordination of actors and institutionalization of organisational routines in order to achieve the goals of HIS integration project.

Theoretically the discussion is based on actor-network theory (ANT), particularly the concept of inscription which is used to describe the socio-technical configuration of the HIS /integration exercise. The empirical material is construed towards understanding power relations between actors involved and how this affects the coordination of the actors involved and institutionalization of routines necessary to achieve the goals of HIS integration. The pivotal point of the discussion is the role of artefacts (software and policy guidelines) in facilitating coordination of the actors involved.

The article is organised as follows. Following this introduction, a theoretical foundation is built based on ANT concept of inscription and how power is constituted. A section on research methods follows, followed by the presentation of the cases. The case description is followed by the comparative analysis and discussion linking the cases with the theoretical arguments presented earlier. The last section presents the concluding remarks.

2 Materials and Methods

2.1 Actor Network Theory – The Dynamics of Power

Actor network theory (ANT) originated from the field of science and technology studies (STS). Rooted on the study of micro-processes of the way science is actually done and the way technological artefacts are actually designed, ANT is generally concerned to research how actors do what they actually do [4]. It does this by studying the mechanics of power as actors develop them as they construct and maintain actor network [5]. The network is constituted by both human and non-human actors forming a heterogeneous actor-network. Thus, ANT focuses on tracing transformations of heterogeneous networks which includes how they are constituted, how they emerge and come to being, how they are maintained, how they compete with other networks, and how they are extended in space and time.

ANT rejects the control of social actors' mastery of technology. Instead of intentionality and consciousness perceived as source of power, the focus in ANT is on the organizing powers of combinations or on the effects of an association [6]. The focus is on what is being generated by virtue of an arrangement, rather than speculation on the intrinsic qualities of different constituent actors. Thus power is not something exercised between two or more combatants or adversaries divided over some issue, one to the other. Rather, power is more a question of ongoing and active structuring of the possible field of action of others, and is always open to resistance, transformation and renegotiation. Those who are powerful are not those who *'hold'* power but those who are able to enrol, convince and align others into associations allowing these initial actors to *'represent'* all the others.

Thus to understand power one need to examine how collective actions come about or how actors come to be associated, and how they work in unison [7]. This is captured very well using the concept of inscription and materials/resources for inscriptions. Inscription refers to the way material resources embody interests meant for structuring possible actions of others. It can also be defined as a process of creating technical artefacts such as software artefacts (for example DHIS in our case), policy guidelines documents etc, that

[1] Organizational setup of healthcare system is outlined in section 3 – Research Context

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would ensure the protection and achievement of an actor's interests [6]. According to Murdoch and Marsden [7], resources play an important role for accumulating power, as they put on:

> *If power 'lies' anywhere it is in the resources used to strengthen the bonds … and we need to analyse how these resources are defined and linked and how actors impose definitions and linkages upon others. To be successful, an actor must 'colonise' the worlds of others.* [7] p.372.

In terms of technological artefacts, Akrich [8] argues:

> *Designers (...) define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways. A large part of the work of innovators is that of "inscribing" this vision of (or prediction about) the world in the technical content of the new object. I will call the end product of this work a "script" or a "scenario"* [8] p.208.

The inscribed scenarios of action define roles to be played by users and the system. Thus, by inscribing a scenario of actions into a piece of technology, the technology becomes an actor imposing its inscribed program of action on its users [8]. An example of inscription materials with scenarios of action in our case study is the use of policy guidelines documents which defines some specific routines to be followed by actors including things like reports submission dates, specified category of actors to be sent to, types of reports etc. However, inscriptions vary; some structure the pattern of uses strongly, others weakly. The strength of inscriptions, whether they must be followed or can be avoided, depends on the irreversibility of the actor-network they are inscribed into [9].

A number of researchers have employed the concept of inscription to analyse a number of Information System projects. [10] used the concept of inscription to analyze the challenges of inscribing standardized protocols in an Electronic Medical Record (EMR), whilst taking into account local work practices. The authors argued for the need to implement weak inscriptions of the protocols in some cases and strong inscriptions in other cases as a strategy to address the challenges.

Conversely, [11] used the notion of inscription device to discuss how use cases in a requirements specification for a digital health care information system are used as a frame of reference for how specific clinical work processes are carried out in 14 Danish hospitals. The author argued that use cases share common characteristics with inscription devices, because they translate complex organizational situations - the clinical work processes, rules on reimbursement, professional boundaries, clinical standards, accreditation standard etc. - into agreed representations.

Furthermore, in the study of Electronic Patient Record (EPR) implementation in Norway, [12] looked at how elements of discipline and control are inscribed in the EPR technologies, as it is experienced by health personnel. As the EPR technologies are perceived and used by health personnel, prescribe discipline and control regarding documentation of patient information, use of time, access to information, and the relations between different professions.

Our study attempts to make contributions on the ANT IS studies, by drawing on the concept of inscription to do a comparative analysis between two HIS case studies with a gist to understand how power is constituted, the effect of the network configuration chosen (centralized/decentralized) and how this affects the coordination of the actors involved and the institutionalization of the routines that are necessary for the eventual realization of the HIS integration goals.

2.2 Research Context

The research setting is the United Republic of Tanzania, a low income country. It is the largest country in East Africa, occupying an area of about 945,087 sq. km, and has common border with 8 neighbouring countries. Tanzania is formed by the union of Tanganyika (now referred as Tanzania Mainland) and Zanzibar. The union government is composed by two organs vested with administrative authority, the government of the United Republic of Tanzania and the Revolutionary Government of Zanzibar. Thus, matters that fall under the union are clearly defined and handled by both parties under the Union Government. Other matters such as healthcare are not part of the union. In addition to the union matters, the union government deals with Mainland part for non union matters, since the Mainland does not have her own government, and the Zanzibar government deals with issues related to Zanzibar. Thus, in this article, unless stated otherwise, the Ministry of Health Tanzania means the one responsible for Mainland

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Tanzania, and the Ministry of Health Zanzibar means the one that is responsible for Zanzibar. Although created as independent bodies, there are extensive collaborations between the two healthcare ministries. Specifically, the empirical basis for this research is based on efforts to integrate routine HIS in the two healthcare ministries, Mainland and Zanzibar.

2.3 Research Methodology

The study draws on an interpretive epistemology. Interpretive researchers attempt to understand phenomena through assessing meanings that people ascribe to them [13] [14]. As interpretive researchers, our study relies on participant observation and interviews with healthcare organizational members, and uses qualitative analysis to interpret the HIS integration process. [14] argues that interpretive researchers often use an underlying theory as sensitizing device for collecting and analyzing research data.

The study employed ANT concepts to guide the data collection, analysis and reporting. Both formal and informal interviews were carried out to different actors ranging from the Ministry of Health and implementing partners' officials, regional and district HIS staff, to DHIS technical staff. The interview questions at the national and regional levels focused on the need to understand the availability and use of HIS policy and guidelines, data flows from the sites and whether its accessibility, and coordination of the partners engaging in the implementation process. At the district level, the focus was on the need to know the data capture and submission status, challenges faced in using the new system, and the kind of technical support provided to them etc. Conversely, the focus for the implementing partners' interviews for the was on understanding the scope of their implementation in terms of the data sets, number of districts/regions covered and whether there was a plan to scale up the implementation to other districts/regions. Table 1, shown the number of interviews, formal and informal, conducted.

Table 4. Interviews Conducted

Informants	**Number of Interviews**
National level staff	9
Regional/Zonal staff	5
District staff	7
DHIS technical staff	5
Implementing partners	6
Total	**32**

Authors of this paper have worked with HISP in Tanzania (both Mainland and Zanzibar) since 2005. As participatory observers we have worked with different implementing partners in Tanzania Mainland such as the Clinton Foundation in Mtwara and Lindi, Ifakara Health Institute in 27 districts scattered in all the regions in Tanzania, Japan International Cooperation Agency (JICA) working in Coast region, and Elizabeth Glaser Paediatric AIDS Foundation (EGPAF) working in Arusha region. In Zanzibar, we have worked at the Health Management Information System Unit (HMIS Unit), and hence working with all major players including healthcare programmes and the direct HIS sponsors such as Danish International Development Agency (DANIDA), World Health Organisation (WHO) and Italian Foundation.

The activities embarked on included installation of DHIS in the sites, training, and supporting use of the system for a period of time, as well as the development of data collection tools and HIS guidelines (in Zanzibar). This gave the authors, opportunity to get firsthand experience and learn the challenges in dealing with multiple implementing partners. Moreover, a number of documents were reviewed ranging from DHIS implementers' progress reports, Health sector strategic plan III, to summarized meetings and workshops reports. Furthermore, authors attended a number of workshops, meetings and training programs organized by the Ministry of Health (both in Mainland and in Zanzibar) and sometimes by the implementing partners.

3 Results

Two case studies are presented and are compared to how technology and institutional procedures around the technology affect the coordination of the integrated HIS. In the first case, we present Zanzibar project

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from the period 2006 – 2009 where DHIS 1.4 has been used, and later migrated from DHIS 1.4 to DHIS 2. In the second case we present project implementation in Tanzania Mainland where DHIS 2 is also used. A comparative analysis of the two case studies is later presented.

DHIS 1.4 is freely distributed software with open access to the code. The software is built on Microsoft Access for both front-end and back end. It enjoys a modular architecture and the separation of back end and front end makes it possible for one site to deploy different data files by switching between databases. DHIS 1.4 is a desktop application and its deployment is based on installations at implementation sites. Reporting from one level to another is based on file export (xml or coma delimited txt files) that will be imported into DHIS installed at that site. Data are transferred by emails or physically by exchanging flash disks storing the exported file.

DHIS 2 is platform independent, java based application. It can be installed in a web server or local machine. It can be configured to run in a standalone or online mode, by making use of supporting infrastructures such as local area network or the Internet. DHIS 2 is built in the same logics as DHIS 1.4 but is built in more sophisticated technologies. At the back end it uses PostgreSQL or MySQL, both free database management systems. It also deploys built in geographical information system (GIS) component based on the open source technologies and has a mobile component.

Both DHIS1.4 and DHIS 2 are products of global network of research and development based at the University of Oslo called Health Information System Programme (HISP). HISP aims to develop proper health information system that support data needs for healthcare departments in the developing countries. HISP initiatives in Tanzania Mainland dates back to 2003 while in Zanzibar started in 2005. The project implementation presented in this paper falls under HISP initiatives.

3.1 Case 1: DHIS Implementation in Zanzibar

DHIS 1.4 Implementation

DHIS 1.4 was adopted as the National standard from January 2006 and data from hospitals and primary healthcare units/centres were reported trough two databases, with the master databases located at the HMIS unit. Each district maintained its own instance of DHIS 1.4 where data was captured monthly and exports files sent to the HMIS unit where it was imported into the central level DHIS 1.4 database. Despite some improvements in data collection as compared to the period prior to the integrated HIS, there were some challenges that were noticed that could have jeopardised the future of HIS. These included delays in reporting and hence reducing trust from the programmes, data inconsistency caused by parallel reporting of some data that had to be reported in both systems, and more general the imbalance in the structure of HIS reporting among the stakeholders. Details are presented in [15]. As solution to minimise delays and also improve programmes' accountability on data, which could improve quality, an alternative reporting scheme was suggested. In this scheme, the plan was to utilise the existing resources to improve efficiency in the reporting scheme. Since districts usually use emails to transmit data to HMIS unit, it was agreed that the districts should also copy programmes and zones while emailing to the HMIS unit. Virtually, this would reduce the reporting hierarchy and therefore address the issue of delays.

This solution however, met some difficulties. First, reliance of people to export and import data did not necessarily cut the bureaucracy. While the districts would often send the data directly to the programmes as an email copy of the HMIS unit, most programmes did not show good response to effectively benefit from the new procedure. With the exception of Expanded Programme for Immunization (EPI), Zanzibar Malaria Control Programme (ZMCP) tried the first few months and later the programme turned back to HMIS unit asking for data. The Zanzibar AIDS Control Programme (ZACP) and Reproductive and Child Health (RCH) programmes never bought the idea. Despite the fact that they usually received the emails they never updated their databases. RCH continued to request data from HMIS unit, though on irregular basis. Surprisingly ZACP designed new tools apart from the mainstream HIS tools and distributed to the health facilities. The health facilities never used the tools designed by the programme, and hence the programme missed data for the whole 2009 and 2010.

While the programmes did not fully buy the idea, on the other hand not everyone in the HMIS unit were also happy with idea of parallel reporting. Some, especially non technical personnel still believed that the right reporting mechanism is through the HMIS unit, and the programmes must get data from the unit. For example, in one occasion, RCH programme requested data from HMIS unit and HISP staff supplied the

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data to the programme, when that data was presented in a meeting, a senior officer from HMIS unit claimed that the it was not official, thus insisting that they must be approved before being distributed to programmes.

Following these constraints, HIS implementation team comprising both HISP and HMIS staff discussed the potentials for using DHIS 2 which was well tested in other HISP implementation countries. The need to upgrade to DHIS 2 was highlighted in technical limitations of DHIS 1.4, the problem of version management, and the bureaucratic reporting procedures that caused data delay. This delay had impact on data quality as the programmes could not give timely feedback, and also on the programmes reporting requirements to donors.

DHIS 2 Implementation.

DHIS 2 implementation started in April 2010, first aimed to be pilot project for the whole 2010 and subsequently implemented as the national standard upon successful test. During this transition period DHIS 2 ran in parallel with DHIS 1.4, and the data entry clerks were entering data twice. First, they had to enter data into DHIS 1.4, which was the official data reporting system and later enter the same data into DHIS 2. The purpose of the double data entry was to expose users to the software in order to give them enough experience, at the same time the technical team (local HISP) used feedback as the way to enhance the software as well as learning user perceptions towards the new system. The data entry clerks were paid for the extra work in order to motivate them towards the new software. In January 2011, DHIS 1.4 was phased out and DHIS 2 took over as the national standard.

Contrary to setup in DHIS 1.4 where there were two separate databases, one for hospital and one for primary healthcare data, in DHIS 2 only one database was configured containing datasets for both hospital and primary healthcare data. The database is installed at the central web server located at the HMIS office. Districts and hospitals access the data warehouse to directly enter data from their locations. Zone and programmes can easily access the data once entered. All districts, hospitals, zone and programmes are connected to the internet.

The process of software development and implementation can be described in terms of both technical and political processes that were aimed at addressing the problems that HIS faced during the DHIS 1.4 period. Technically the software was aimed at improving data access through the use of web technologies, seamless integration between hospital data and primary healthcare data, improved version management, and improved feedback mechanism.

On the political and administrative aspects, the software was implemented to solve the problem of reporting where despite the change in reporting procedures that were proposed after the originally planned and implemented reporting scheme failed to improve the HIS especially on timely reporting. With timely reporting and direct access of the data DHIS 2 was aimed to facilitate immediate data analysis by programmes and hence speed up feedback, and subsequently improve data quality. The programmes will also be able to report to their donors in timely manner. Below, we present response of some selected programmes on the implementation of DHIS 2.

Expanded Programme for Immunization (EPI).

DHIS 2 has been used as official data reporting system replacing DHIS 1.4 for just a half a year, from January 2011. However, the Expanded Programme for Immunization (EPI) decided to use DHIS 2 for the year 2010 instead of DHIS 1.4, though it was in the piloting stage.

Responding to the question of how they compare DHIS 2 with DHIS 1.4 in relation to improving their activities, managers from EPI were optimistic:

> *"We are supposed to report to Nairobi regional office not later than 10th of each month. Usually we report any amount of data we have and later update them. The regional office evaluation is based on the day we made our first reporting and then how quick we update the data. The availability of data online really helps to this. For example, last year (2010) we effectively used the system and we have reasonably improved timeliness. We have realised that most districts start data entry earlier than we thought, and thus, we can report earlier too"*

Zanzibar Malaria Control Programme (ZMCP).

With special interests covering wider range of activities, Malaria programme has diversity in type of data collected, from disease surveillance and monitoring mortality, to recording number of households

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covered in indoor residual spraying and recording number of treated bed nets. With this respect, the programme agreed from the beginning that they will collect data from HMIS unit for disease surveillance, monitoring pregnant mothers against the disease, and hospital admissions and deaths. The rest of the data shall be collected by the programme itself through different tools. This means much of the data are collected by the programme itself.

Moreover, the programme does not usually use the data from the mainstream HIS on monthly basis. In the past, the programme seemed to request data on ad hoc manner and thus when the parallel reporting of data using DHIS 1.4 was introduced it did not help them much since the programme officers would usually neglect the emails that consist of the export files and hence often ended with asking back to HMIS unit when they needed data. Often, this caused pressure to HMIS unit and also led to a situation when they could not be guaranteed the data as the HMIS unit officers might be busy with other activities. Thus with DHIS 2, the data is always in the server and the programme can access them anytime they want. A manager from Malaria programme added:

> "*Having the data online makes things easier. You know we have a plenty of data from different systems covering different and we do not always rely on the data from HMIS only. However, when we need data it is usually urgent, sometimes we may be asked for reports by donors and we must call you. This does not guarantee fast response. Now we do not need to worry, as long the server is up we get data without contacting you*".

Zanzibar AIDS Control Programme (ZACP).

Since the new HIS was put into use in late 2005, the programme was in a continuous swing between using the mainstream HIS and using their own system which have been in continuous changes. There are many reasons, which are beyond the discussion on this article, but what is interesting for this paper is how the agreed reporting procedures along with the installed software (DHIS 1.4) could not be institutionalised into the programme's reporting scheme and how DHIS 2 could find its way in the programme's sphere.

In 2009, for almost two years, HMIS unit officers and HISP staff were in negotiation to re-harmonise the data collection tools for the programme after the programme stopped using the mainstream HIS tools. After the new tools were designed (with inputs from both the old tools and the tools introduced by the programme), the development team managed to convince the programme to use the mainstream HIS (as redesigned) with a promise of implementing an online database solution. This, the arguments were made, will help to minimise the programme's reliance on HMIS unit for data reporting. Despite the fact that the programme did not have firm reasons to switch to their own data collection tools, DHIS 2 was used as a tool to clear any doubt they had on the possibility of data delays.

Three months after DHIS 2 was used as national standard, officers in charge of data at ZACP expressed their hope in the new system.

> *"This is promising, when you have all the data available online there are reasons to believe that we are guaranteed with our data. Previously this was not the case"*
>
> *"I like the fact that all data are stored in the same database. Our data are collected from a range of sources from antenatal clinic, VCT [voluntary counselling and testing], STI [sexually transmitted infections] clinics, maternity ward and CTC [care and treatment centre]. When you have different sources captured in different databases makes it difficult for us. But now everything is in one database, including home based care"*
>
> *"I like the comprehensiveness of collecting PMTCT data, the forms collect almost every data we need and we easily access all the data"*

Health Management Information System (HMIS) Unit.

With its role as in charge of coordinating and facilitating availability of data to all stakeholders, HMIS unit maintains the data warehouse located at its office. Interesting in DHIS 2 is the balance between maintaining and coordinating the data warehouse. In DHIS 2 era, the unit is mainly responsible for ensuring the central server is up and running, the database is in good condition and the districts and hospitals enter data regularly and are provided with technical support.

Although a consensus was reached on the decision to use DHIS 2, some reservations are still there and doubts are still to be cleared among non technical officers of HMIS unit. While the technical team (from HMIS and HISP) use the agenda to solve both the technical problems and implementation hurdles, the non

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technical seem to be sceptical about the solution, apparently due to technological fear, but also a fear that the new procedure would reduce the authority of HMIS unit. An administrator at HMIS Unit added:

> *"The good thing with the new system [DHIS 2] is that I can access data any time and I do not need the technical people to load my laptop with data when updates are made. However, I am really concerned with security. I do not believe hackers will not intrude into our data... Another question is who is in-charge? If everybody will access data before we conduct quality check, how can they use the data?"*

While the argument of quality checks makes sense, this has not been the case. The HMIS unit have always been busy with a lot of activities and the quality check is usually done once a year during data cleaning workshop, prior to preparation for annual health bulletin. Moreover, the HMIS capacity is limited as compared to tha t of programmes. Thus, ensuring programmes get data on the right may be a catalyst for quality check and feedback to districts and hospitals, and hence improving the quality of data.

3.2 Case 2: DHIS Implementation in Tanzania Mainland

The current routine HIS in Tanzania Mainland was conceptualized in the 1990s through external consultants with support from DANIDA. The system consisted of paper based data collection tools at health facility and district level and computer based system at the regional and national level. However, a number of studies described the system as dysfunctional and inflexible [16]. Such inflexibilities led to difficulties in absorbing changes and new requirements from different health programs and healthcare services. In an attempt to resolve the HIS challenges, a pilot action research study was conducted in 2002 by HISP team in two districts (Kibaha and Bagamoyo) located in Pwani Region [17]. Implementation of DHIS 1.3, which was later upgraded to DHIS 1.4 in the year 2005, was done as part of the pilot study. The software was installed at district level, where paper reports from all health facilities were captured in a monthly and quarterly basis, depending on the reporting frequency of a particular data set. As a result, the software was demonstrated as flexible and capable to handle multiple programs and data sets in an integrated manner. However, it took almost five years period of intensive translation processes involving negotiations and discussions with the Ministry of Health officials, before the software could be endorsed as a standard for countrywide implementation in 2007 [18].

However, a number actors working with various healthcare programs used their resources to review and standardize their paper based data collection tools, and were in search for an electronic artefact for data processing and management. For instance, National AIDS Control Programme (NACP) supported by the Japanese International Cooperation Agency (JICA) revised paper-based recording and reporting tools for Sexually Transmitted Infections (STI) and Voluntary Counselling and Testing (VCT) services. The actors then approached the Ministry of Health and the HISP team, requesting implementation of DHIS in one region –Pwani. Following the approval, HISP team advised the Ministry and NACP/JICA to use current version of the software - DHIS 2. With the capacity to be used as web solution or standalone, an agreement was made to implement DHIS2 as standalone. Customization of the software was effected where STI and VCT paper-based tools were implemented in the database and rolled out into all six districts in Pwani Region, including regional offices. Data entry is done at the district level and an export file is transmitted to the region where it is imported into the regional DHIS2.

Results from STI and VCT implementations spurred other actors working with different initiatives in the same region to support implementation of other data sets. Supported by the WHO, the national PMTCT program revised their paper tools including registers and monthly summary tools in 2008. In need of an electronic tool for computerizing the summary reports, the national PMTCT officers attended a stakeholders meeting where DHIS2 with the results from the Pwani Region were presented. Among other things the partners learned the capacity of DHIS2 and that it had been endorsed as a national standard. Promptly, a decision was made to implement PMTCT summary tools using DHIS2 within the Pwani Region. By July 2009, all the new PMTCT data sets were codified in DHIS2 and rolled out into all the six districts in the Pwani region. The Norwegian Agency for Development (NORAD) supporting child and maternal health program provided funds to implement the rest of the data sets using DHIS2 within Pwani Region.

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DHIS2 Enrols other Actors to the Network.

Other actors working with different initiatives in various sites using their resources negotiated their way into DHIS2 implementation. For instance Clinton Health Access Initiative (CHAI) has been collaborating with the MoHSW since 2005, to expand access to HIV/AIDS care and treatment in Mtwara and Lindi. In need of a monitoring and evaluation tool CHAI approached the Ministry of Health and the HISP team requesting to implement DHIS2 in the two regions. An agreement was reached to implement DHIS2 in two regions including all data sets implemented in the Pwani Region. By October 2009 DHIS2 training was conducted by the HISP team, followed by installation of the software into all districts and the regional level, both in Mtwara and Lindi. CHAI hired one personnel who was trained on DHIS2 as a super user to provide technical support to the districts and the regional levels.

> *"CHAI provides regular supportive supervision to the districts and the regions. This involves solving problems encountered during use of DHIS"* (Technical personnel, June 2011).

However, due to ICT related problems CHAI contracted a company to provide regular ICT support to both Mtwara and Lindi regions in terms of computer repair and maintenance (hardware and software).

Another actor which drew on their resources and implemented DHIS2 to provide informational support to their programmatic decisions is Elizabeth Glaser Paediatric AIDS Foundation (EGPAF). Among other things EGPAF focuses on expanding the provision of comprehensive PMTCT services and improving access to HIV care and treatment. Arusha is one of the regions where the PMTCT services are supported by the foundation. In January 2010, EGPAF through the HISP team implemented DHIS2 in all districts in Arusha including the regional level. However, the NGO was ready to support only PMTCT data sets. The implementation process included training and installation of the software in all the districts and including the regional level. EGPAF hired one ICT officer who also received DHIS training in order to provide support to the districts and the regional level.

However, some other actors run DHIS2 implementation not just as way to get information support for programmatic decision making but as a separate project with earmarked resources such as funds, and human resources. Ifakara Health Institute (lHI) is a research and training non-governmental institution. In 2010 IHI launched a health research project called Sentinel Panel of Districts (SPD) in 27 districts of Tanzania Mainland, aiming at improving availability of data. According to the IHI official, the project dwell on facility based information and population based demographic and mortality data in all the districts. The project has received support for five years and will provide annual, age, sex and cause-specific mortality estimates from a population of about 25,000 to 30,000 in a sample of 27 districts.

IHI approached the HISP team upon being sanctioned by the Ministry of Health, to implement DHIS2 in 27 districts. The implementation included training of data clerks and CHMT members, and installation of DHIS2 in all 27 districts. IHI recruited one information officer in each district, to do data entry, to follow up reports from the health facilities which have not yet reported and to perform data analysis and transmission to the central IHI offices. IHI maintains a DHIS2 server, where export files from the districts are imported. Moreover, IHI recruited one ICT personnel who was later trained as a super user on DHIS2 to provide recurrent support and maintenance of the district DHIS2 installations.

Challenges in the DHIS2 Decentralized Setup.

To ensure a functioning DHIS 2 in every district the DHIS 2 implementing actors maintain ICT support personnel who provide regular support to the districts. However, user support was reported by some of the district data clerks to be poor. Once DHIS 2 problems were reported to the central support staff, support was not provided on time and sometimes it could be left pending without any response. Other districts reported that sometimes they were given solutions which could not solve their problems. As one of the actors noted, the big problem in the districts with computer systems is viruses causing most of computer crash problems.

> *Our computer running DHIS 2 software crashed several times and we could not enter data for more than three months (District data clerk, March 2011).*

Another challenge experienced in DHIS 2 implementation is the need to ensure uniform versions of the standards across sites. This is important in order to ensure integration and central data analysis. For instance, in most districts visited it was noted that data entry clerk's accounts in DHIS 2 were given full administrative privileges, giving them room to change anything in the system. As a result, one technical

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personnel reported that some actors introduced changes in the system causing difficulties in integrating data across sites.

> *Some users had added new health facilities in DHIS 2 without consulting the central support team. This made their database different from the central database which presented difficulties in importing data sent from the districts (Technical personnel, March 2011).*

Moreover, the problem of ensuring uniform standards across sites is compounded with the need to upgrade from one version DHIS2 to another which requires all sites to be visited and updated. This happens as a result of a new added feature in DHIS2 artefact or introduction of new data sets or data elements which need to be collected and captured across sites. However, the challenge comes when not all implementing actors are ready to incur costs for updating the system at the same time.

Other routines necessary to ensure the decentralized DHIS2 implementation serves the needs of multiple actors, is the need to ensure data transmission to the central data warehouse. Until the time of writing only one actor was transmitting data to the national database – the Pwani region. Explaining the difficulties in coordinating the multiple actors with multiple DHIS2 implementation, one national HIS officer argued.

> "*The implementing partners have resources and multiplicity of interests. That's why after getting what they want, they don't bother about other things like data transmission to the central level*".

Though data flow guidelines were developed during the Pwani DHIS2 implementation, enforcing the routines stipulated in the guidelines proved rather difficult.

> "*Yes, we developed a guideline document for the districts to use. And the districts officers were involved in the process, giving their comments until it was complete. But they don't seem to use it. That's why we are experiencing similar problems addressed in the guidelines"*

4 Analysis and Discussion

The two cases presented have similarities and differences. A common feature for the two cases is the multitude of stakeholders that are involved in the HIS integration projects in both Tanzania Mainland and Zanzibar. However, the differences are on the extent to which donors are directly involved in the project, and on how the ministry of health managed to lobby its role as the coordinator of the HIS integration exercises. Another difference between the cases is the type of technology used and the mode of implementation and how this had great impact on the process to create a common, integrated data repository.

The two cases presented provide a ground to discuss the challenge of coordination as part of HIS integration process. The cases outline the power struggle between actors as they draw on different resources available to them as material for inscribing their interests.

4.1 The Role of Technology in the Institutionalization of HIS: A Comparative Analysis

In our analysis we conceptualize the integration process as an actor networking building process where a number of actants such as the ministries of health, donors, vertical programmes (RHC, HIV, Malaria, EPI, etc), implementing partners, software artefacts' (DHIS), policy and guideline documents, to mention just a few, are engaging in the processes.

Striving to Build and Stabilize an Actor Network amidst Weak Inscriptions

The actor network process using DHIS1.4 artefact in the Zanzibar case was initiated by the Ministry of Health under the HMIS unit supported by DANIDA. By drawing on the financial resources from the donor, the HMIS unit as a focal building actor aligned the interests of all other actors forming one actor network. The activities of aligning all the actors' interests went hand in hand with revision of data collection tools, codifying the tools into the software artefact (DHIS1.4), and rolling out the software and the revised tools to all the districts in Zanzibar.

However, the actor network built using DHIS1.4 was aligned using guidelines which inscribed the manner in which the technology should be utilized by the multiple actors involved. Some of the inscriptions in the guidelines were related to the manner in which data should flow from the districts to the national level and then from the national level to the vertical programs and to other actors.

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Nonetheless, the fact that DHIS1.4 setup configuration was decentralized in terms of having an instance of the same on every district including the national HMIS unit and at the programme level, various challenges ensued related to availability of timely data and in maintaining all the instances led to the weakening of the bonds of the actor network.

Though the HMIS Unit politically had the mandate to prescribe the use of the DHIS1.4 and maintain its position as a focal actor in the network, weakening of the bonds forced it to succumb that position. This is in-line with the argument that those who are powerful are not those who *'hold'* power but those who are able to enrol, convince and align others into associations. As the case suggests, though the actors strived to stabilize the actor network by prescribing that data from the districts could be sent to the programmes via email directly, but this was not bought by all the actors. The instructions lacked the material for inscriptions that could have been used to enforce use by all the participating actors hence it did not work as envisaged.

Similarly, implementation of DHIS2 in the Tanzania Mainland case, commenced with the Ministry of Health HMIS unit as a focal actor endorsing and prescribing the software as a standard to be used country-wide. However while the ministry was in the process of mobilizing funds to start implementation, other actors with their interests started implementation project in their respective sites. Starting from one region (Pwani) with only two data sets (VCT & STI), the enrolment of other actors supporting inclusion of the other data sets, changed the role of DHIS2 from being not just as software being implemented to an actor mobilizing other actors and aligning and enrolling them to the actor network. As a result this saw many other actors join the network supporting implementation of DHIS2 in other regions such as Arusha, Iringa, Mtwara and Lindi. This further confirms power as not being in the hands of someone trying to wield it to others, but the ability of any actor in this case the technology (DHIS2) to align and coordinate the interests of others and enrol in your network.

As was the case for DHIS1.4 implementation in the Zanzibar case, DHIS2 implementation in the mainland was decentralized in the sense that the application was installed at every district, expected to submit data monthly to the regional level and from there to the national level. However as the case suggests not much of the data from the regions was submitted to the national level. As long as the implementing actors in their respective regions fulfilled their interests of data, they did not bother to submit the same to the national level. Though there were guidelines developed to inscribe and prescribe the performance of the actors in terms of data submission routines, like was the case for DHI 1.4 in Zanzibar, they were not followed and adhered to by the actors. Similarly, the actor network bonds in this case was weakened by the fact that the actors did not succeed to inscribe use of the system using resources such as HIS policy documents, and other guideline documents. For according to [7] power lies in the resources used to strengthen the bonds of the actor network and to be successful, an actor must 'colonise' the worlds of others.

Thus the configuration of the technology being decentralized coupled with weak/lack of inscriptions challenged the stability of the actor network in both cases. [9] argued that the strength of an inscription whether it should be followed, depends on the irreversibility of the actor network in which they are inscribed. In this case, the actor network built using DHIS 1.4 in the Zanzibar case proved to be reversible, hence the decision to move to DHIS2 in a centralized mode, as explained below.

Transformation and Renegotiation in the Actor Network Building Process

The decision of the actors in the Zanzibar case of to move to DHIS2, and having it centralized with actors such as vertical programmes having direct access to their data immediately after the districts have captured them in the system, transformed the configuration of the actor network. This time the role of the ministry as a focal actor coordinating the process was taken by another actor – DHIS2 artefact. This affirms power according to ANT being a question of ongoing and active structuring of the possible field of action of others, and always being open to resistance, transformation and renegotiation. DHIS2 artefact as a focal actor altered completely the role not only of the HMIS unit which was hitherto the main actor, but also the role of other actors such as the vertical programmes.

Hence, DHIS2 artefact as an important actor in the Zanzibar case is used to institutionalize the data reporting by virtually eliminating bureaucracy while ensuring that no actor is sidelined whether purposely or accidentally as it was in DHIS 1.4. Under this setup as the case suggests, almost all the actors are happy, however the important question still remains, *"what would be the role of the HMIS unit?"* And as one of the HMIS unit informant asked, *''... who is in-charge?''*. As the case further suggests, this actor would like to maintain its role as a network builder and a coordinator. However the fate of that actor is determined not by its political and bureaucratic mandate to prescribe anything to other actors but by the actor network

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dynamics which asserts that power lies in the ability to translate the interests of others, making them yours. Precisely, the nature of the technological artefact (stand alone or web based) and the manner in which it is implemented (decentralized or centralized), coupled with the policy and guidelines which inscribe and prescribe the use of the system, are the important factors that determine success or failure of the network building process – the HIS integration process.

Moreover, from the DHIS2 implementation in Zanzibar it is clear that, though the technology used was the same as that in the Tanzania Mainland, the mode of implementation used led to the success in the Zanzibar case. Explicitly, the mode of implementation led to the development of an irreversible actor network with strong bonds making DHIS2 an actor aligning all other actors, inscribing and enforcing use. Table 2 compares and contrasts the two cases where DHIS2 was used.

Table 2: Summary of the DHIS 2 Comparative Case Analysis

DHIS2 Implementation in Tanzania Mainland	**DHIS2 Implementation in Zanzibar**
Multiple actors engaging in the implementation process in multiple sites	Single actor engaging in the implementation process by aligning other actors
Decentralized mode of implementation	Centralized mode of implementation
Guidelines are in place but not in use. No policy documents in place as materials for inscriptions	Guidelines and policy documents exists and in use
Limited data submitted to the higher levels and other stakeholders	All data submitted and accessible at higher levels and other stakeholders
DHIS2 as an actor failed to coordinate and align other actors due to its decentralized implementation setup and configuration	DHIS2 as actor succeeded to coordinate and align other actors into a strong actor network due to its centralized implementation setup and configuration.
Expensive and difficult to maintain multiple software instances at various sites	Only single instance exists, hence cheaper and easier to maintain for the common good

5 Conclusion

Information systems integration is a very challenging undertaking, more so in the healthcare context of developing countries, characterised by multiplicity of actors and initiatives to address diseases burden. This comes from the fact that IS integration is not a mere technical exercise rather is a complex socio-technical process of aligning not only the technologies but also routines associated with those technologies. Through two case studies, this article has compared and contrasted the process of integration where the importance of deploying proper technology in line with inscribing right policy guidelines has been highlighted.

By drawing on ANT concept of inscription, the article described HIS integration as a *combinatory* actor network building process that need to consider the nature of the technological artefact (stand alone or web based) and the manner in which it is implemented (decentralized or centralized), coupled with the policy guidelines which inscribe and prescribe the use of the system. The article reveals this combination as an important factor that determines success or failure of the network building process (the HIS integration process) in the backdrop of myriads of heterogeneous actors with multiplicity of interests.

The implication of the study to policy and practice when it comes to HIS implementation in developing countries setting is that first, decentralized mode of technology implementation setup and configuration presents similar challenges irrespective of the technology used (the use of DHIS 1.4 in Zanzibar and DHIS 2 Tanzania Mainland attest to this fact); secondly centralized mode has a very high chance of success when implemented in such a way to cater for the multiple actors involved; and thirdly use of policy guidelines in a centralized mode as material for inscriptions helps to inscribe use of the system which is pertinent for its eventual success in terms of coordinating and aligning the interests of the multiple actors involved.

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