MobiHealth

INF5261 Final Report

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# Table of contents

Introduction .................................................................................................................... 3
Research domain ........................................................................................................... 3
Theory ............................................................................................................................. 5
Methodology .................................................................................................................. 5
The Case ......................................................................................................................... 6
Software Solution ......................................................................................................... 10
Review of similar projects ............................................................................................ 12
Implementation of mobile reporting ............................................................................... 14
Discussion ..................................................................................................................... 18
Conclusion ...................................................................................................................... 22
References ...................................................................................................................... 23
Appendix ......................................................................................................................... 26
Introduction

In this project we have been working with reporting health data in Malawi using mobile devices. Malawi is a small country situated in the south east of Africa, with about 13.9 million inhabitants. It is amongst the least developed countries in the world, with many challenges in the health sector. However, there has been a substantial growth in the prevalence of mobile phones in recent years, making mobile devices a potential tool for reporting health data. Currently, at least 14 out of 100 Malawians own mobile phones. In comparison, there is no more than 1 personal computer and less than 2 fixed phone lines for the same number of people (Manda 2009:1).

Our aim was to set up a tool that allows health workers to report data from the field using mobile devices. As a proof of concept, we have been using a paper reporting form that is already in use in Malawi, and have shown that mobile devices can in fact replace paper forms for reporting health data. We believe that this can help developing countries improve their health data reporting and management. We also believe that providing correct health information at the community level will empower and help the national health administration make better decisions (Bush 1996:38)

During the project, we have done research about what health reporting systems that are in use, and looked at similar cases where mobile devices have been used to report and communicate health data. One of our group members have been in Malawi, where he has been in-touch with health personnel and made an interview with a health facility supervisor.

We start this document by giving an introduction to the research domain and relevant theory, as well as the methodology. Then, the current situation in Malawi will be introduced in detail, before we present our proposal for an implementation of such a system. Finally, we discuss how feedback and data quality could be improved with our solution, and what we believe the challenges of an implementation in Malawi would be.

Research domain

This project concerns ways in which health information can be shared and accessed with the use of mobile devices. Therefore, it is important to first present a basic understanding of health information systems (HIS) and the domain of mobile health reporting.
Health Information Systems

The World Health Organisation defines HIS as one of the six building block of a health system (World Health Organisation 2007:19), and information systems have in the last years been seen as increasingly important to improve the health sector in developing countries such as Malawi (Staring 2011:6; Chaulagai et al. 2005:375). A HIS is a central system consisting of various subsystems dealing with data in different domains within the health sector (Chaulagai et al. 2005:379). The health data in such systems is aggregated data, as will be discussed below.

The main purpose of the HIS is to collect data and present it in a meaningful way so that it can be analysed and used to support decision making. The HIS provides information and knowledge to health managers that allows them to make evidence-based decisions. To allow the various actors of the health system to use the information that is collected, it is not only important that data is sent from facilities to the central level, but also that feedback is given in the other direction. This will be discussed later in the paper.

mHealth - Mobile Health

Mobile Health (mHealth) concerns the use of mobile technology and devices in health care, for example PDAs, mobile phones or more specialised devices (Istepanian, Pattichis, & Laxminarayan 2006:3-4). mHealth is an area that is becoming increasingly relevant for developing countries as more and more people have access to mobile phones, and the capabilities of even low-cost phones increase. In countries like Malawi, mobile phones have become much more widespread in recent years, more so than fixed line phones and internet, making the introduction of mHealth possible (Manda 2009:1-2). Our project takes advantage of this situation, as we aim to build a tool that can be used on common phones used in Malawi.

Data types

When dealing with health data, electronic or not, the first thing that comes to mind is often patient records, containing the complete medical history of the patient. In HIS, aggregate health data is also important. Aggregate data is statistical data that is not connected to any individual, and thus can be aggregated to be used for analysis and health management.

In our project we are not dealing with traditional patient records, but with some person specific data together with aggregate data. The solution we use tracks the progress of individuals through specific health programs, thus only data specified as
relevant to these programs will be collected. In contrast, a patient records systems would contain all available health data for a patient. Only aggregated data from the person-specific programs will be reported and used outside the health facility.

**Theory**

There are several theoretical concepts that are relevant for our work, all based on Information Infrastructure (II) theory. These concepts are *standards, gateways* and *installed base*.

**Standards and Gateways**

Within the HIS domain, standards play an important role. A complex infrastructure like a HIS consists of a variety of components, often unrelated, that must work together as a whole. Standards must therefore be developed to allow interoperability of different parts of the system. These standardised interfaces between the systems can then be connected through gateways (Hanseth 2001). In many developing countries, large parts of the HIS is paper based. These gateways are therefore not purely between computers, but also exists between paper and electronic form (Hanseth & Lundberg 2001:363). Finding an appropriate way to connect our solution with the rest of the Malawian HIS require that we take this aspect into account, and make appropriate gateways to the rest of the system.

**Installed Base**

Installed base is another important concept in II theory. An infrastructure or system will never be built from scratch, there will always be something there from beforehand forming the basis of any new development (Hanseth & Monteiro 1998:46). This installed base does not only represent physical elements such as computers or networks, but also routines, standards, human resources and so on. As a consequence, changes to a system or infrastructure must always take into account the installed base, which can have both enabling and limiting effects (Hanseth & Monteiro 1998:47). This is also the case in our project. We must take into account the existing installed base and develop our system from there, since our aim is to integrate our solution with the larger Malawian HIS.

**Methodology**

This project is a qualitative study. Besides literature reviews, we have primarily used interviews and prototyping to obtain data, as discussed in the following sections.
Interviews
Several of the issues we were working on had few written sources that we could work with. In order to obtain the information required to set up our solution, we therefore did a total of three interviews. We started by interviewing a PhD student at the University of Oslo who is studying the Malawi health system, specifically issues around maternal health. In addition to providing general information on the Malawi health system, she introduced us to the paper form that we used as a proof of concept.

Because the software we are using is still a work in progress, it is not well documented. We were therefore able to do an interview with one of the developers of the software, who gave us useful insights on what is possible and not as of today. Finally, one of the group members was in Malawi during large parts of the project, and he was able to visit a health centre and make and interview with a community health worker supervisor, which gave us a much better understanding of the context our solution would be aim at.

Prototyping
Besides the use of interviews and review of literature to gather information, our project made use of prototyping to test out the practicability of transforming a paper-based data collection form to mobile phone-based reporting and data hosting on a DHIS 2 server. We chose to prototype because prototyping is a good way to work through ideas, by testing and refinement (Jones and Marsden 2006). In testing out our proposed solution, a high fidelity vertical prototype of our test solution was created. The prototype was developed around one of the many paper-based forms currently being used for reporting in Malawi. The prototyping involved creating an electronic version of the paper form in DHIS 2 and testing out with mobile phone based reporting. A vertical prototyping approach was chosen as the method involves deep implementation of selected features of a system (Beynon-Davis et al. 1999; Jones & Marsden 2006). Having such a functional prototype also made it possible for our team to test interaction with the solution, a thing that could not be achieved well with a low fidelity prototype.

The Case
About the country of Malawi
The republic of Malawi is situated at the Southeast Africa, as shown on figure 1. The population of Malawi is estimated to be around 13,9 million. Lilongwe is the capital. It is important to notice that Malawi is classified to be among the world’s least
developed and most densely populated countries.

Malawi’s economy is mostly agricultural, with about 82 percent of the population living in rural areas and about 41% of the population living under the poverty line (WHO 2006). Given the economical situation in Malawi, the country depends on the support of the donor community, such as the IMF (International Monetary Fund).

If we consider developing countries, Malawi ranks as 164 on the UN’s Human development index (UNDP 2007). It is categorised as a Low-Human-Development country, which is the lowest level on the scale, and is one of the poorest countries in the world. The UN report also states that a newborn child is given a 44.4% chance of dying before it reaches 40. The WHO states in a recent report (WHO 2008) on Malawi’s health profile that the life expectancy is between 52 and 54 years. Malawi also struggles with many other health issues. The prevalence of HIV is 11.9% and is causing a lack of labor and drains the government expenditures, which influence the gross domestic product (GDP) of the country. Out of all the children (under 5 years old) that dies, 17% of the deaths are caused by Malaria.

Organisation of the health system
When it comes to the health system of Malawi, it is constituted of government, private, and mission hospitals. The mission hospitals are under the Christian Health Association of Malawi (CHAM). The health care services provided in Malawi are all free of charge in the governmental hospitals. When it comes to the maternal health services, these are free as well through a government service level agreements with the CHAM.

At the highest level of Malawi’s public health system is the ministry of health and Population (MOHP). Under the MOHP there are 28 districts, which are each headed by a district health officer (African Development Bank Group 2005). The country of Malawi has four tertiary hospitals and each district has a distinct hospital and satellite
health centres. However some of the cities do not have a distinct hospital but tertiary hospitals; these are Blantyre, Lilongwe, Mzuzu, and Zomba. Figure 2 shows the organisation of the health system.

**Figure 2. Organisation of the Malawi health system.**

At the district level, district health offices have established computerised systems and process data from health facilities, including the district hospitals, within their jurisdiction. This data includes data on national indicators for district health services, diseases, and human resources. At the highest level, the ministry compiles data from all districts and central hospitals and produces quarterly monitoring aggregated and comparative reports for use by different national programs and other stakeholders (MOHP 2003).

On a different note, Malawi’s health system is burdened with disease and lack of adequate medical personnel required to provide a minimum level of health care. Like many developing countries, Malawi faces ever increasing resource constraints. Per today, the population of Malawi has for long outstripped the capacity of the social infrastructure, including health services (MOHP 1999). This situation still holds today. About 46% of the population has to travel more than 5 km to get to the nearest health facility. Malawi’s problems are further compounded as poverty, diseases such as Malaria and tuberculosis (TB), and chronic malnutrition have combined with the Aids pandemic to drastically reduce the quality of life. In some cases, basic health services are also unavailable at many health facilities in Malawi.

**Health Surveillance Assistants**
The health surveillance assistants (HSA) are health workers functioning at the community level. They go around within the community to check on specific people...
mentioned on their list. These people could have previously been admitted at a hospital and need follow up, or it could be for other reasons such as in a maternal health programme. As they go around, they have with them health forms to be filled in about the person visited and they must fill in also what they have done on that specific day. At the end of each month, community health workers normally submit paper based activity reports to the hospital, on what they have done that month. As their routines, the community health workers record their daily activities in books. The book entries are then used for the compilation of monthly activity reports.

Problems with current reporting setup
Our group member in Malawi was able to do an interview with the supervisor of Health Surveillance Assistants at the Chankhungu Health Centre. The supervisor indicated that having HSAs only report at the end of the month complicates report compilations at health centre level, as there are many reports that need to be reviewed and aggregated. The respondent indicated that weekly reporting would among other things permit:

• Report compilations at health centre level to begin much earlier, thereby minimizing the pressure that is usually faced when doing this kind of work at the end of the month.

• It would be possible to monitor within the month visits of HSAs to clients, against submitted planned visits. For example, if a HSA had planned 4 visits for a particular month, progress towards the attainment of these goals would be monitored against reported weekly visits.

• The health centre to have an overview picture of the health situation within its catchment area at shorter intervals than it is right now

Telecommunications
At the moment, mobile phones are the ones mostly diffused and used within the communication technology, above the fixed telephone lines, personal computers, and the internet. As an example, the number of people subscribing to the mobile telephony per 100 Malawians jumped from 0.43,
in the year 2000, to 7.55, in the year 2007. Figure 3 shows this trend. Over the same period, the number of fixed telephony subscribers only jumped from 0.4 to 1.26, per 100 Malawians (ITU 2011).

**Mobile and internet services**
Mobile internet coverage largely coincides with the GSM coverage, which are quite extensive in Malawi. While the two telecom companies networks in Malawi are continuously extending their coverage, there are still some areas without any coverage (Manda 2009:47-48). Still, 93.3% of the population had GSM coverage in 2009 (AICD 2010:29). The mobile internet service is mostly GPRS, although 3G has been rolled out in some areas, mostly in the larger cities and tourist areas.

**Software Solution**

**District Health Information System**
The DHIS software (version 1.x) was developed initially in South Africa, where it became the national standard. Its success there led to it being piloted and/or adopted in several other developing countries, including Mozambique, India and Malawi (Braa et al. 2004:345). However, DHIS 1 was based on Microsoft Access
technology, and it was decided in 2004 to build a new version from scratch using free and open source frameworks (Øverland 2010:2). This became DHIS 2 (see figure 4). The last couple of years, a new name based module has been developed. This module allows DHIS 2 to keep track of individuals beneficiaries though fixed programs, that consists of different stages at fixed time intervals (Interview 09.03.2011).

**DHIS Mobile**

Like the name based module in DHIS 2, DHIS Mobile is also a relatively new tool. DHIS Mobile is a mobile java application that can be used for reporting data to DHIS 2 using SMS, and in the newest version with mobile internet. Earlier versions of DHIS Mobile had to be hard coded with the datasets to be reported, and only aggregate facility data could be reported by way of SMS. Furthermore, it required a GSM modem and server side configurations. The latest version under development has made several enhancements. It is no longer hard coded and it allows reporting of name based records (called activities) along with facility data. This newer version uses mobile internet instead of SMS (Interview 09.03.2011). It has possibility to store a data entered locally and connectivity only required when updating the mobile application and sending reports to the server.

![Screentshots from DHIS Mobile](image)

**Figure 5. Screenshots from DHIS Mobile. From left: Login screen; main menu; list of beneficiaries; data entry screen.**

With a mobile application using mobile internet instead of SMS for reporting data, one could ask why a mobile website directly connected to the DHIS 2 server would
be preferable. Perhaps the most important reason for this is that the low end phones used in developing countries have very poor web browsing capabilities (Boyera 2007:13). Another important pro with using an application is local storage, allowing data to be entered and saved locally in areas without coverage.

The Health Information Systems Programme
The DHIS software is developed under the lead of the the Health Information Systems Programme (HISP). HISP is a research network devoted to the development of HIS in developing countries, organised by the University of Oslo. It stems from the effort to build a HIS in post-apartheid South Africa in the mid 1990s, but has now spread and includes partners in many parts of Africa and Asia (Braa, Monteiro, & Sahay 2004:344, 346). HISP has two main areas of focus. The first is research into HIS in developing countries, including running PhD and masters programmes. The second objective for HISP is to lead the development of the DHIS software (Braa et al. 2004:344).

Review of similar projects
There have been many discussions around mHealth in recent years, and there are several different projects under developed or in use in the developing world. While we have not found any projects that are identical to ours, we here present a few cases that are in the same domain to show some of the current developments.

DHIS Mobile, SMS Reporting
DHIS Mobile started out as the Sub-center Data Reporting & Transmission (SCDRT) application, developed by HISP India as a pilot involving mobile reporting of routine data to DHIS 2 (DHIS Mobile Wiki 2009). The big disadvantage of this SMS-based solution is that it requires a custom application to be build and deployed according to the exact data to be reported. Thus for every change in reporting requirements, a new custom application must be built and deployed to all mobile phones. However, this SMS-based solution is robust and has been piloted and/or deployed in several countries, with up to 5000 phones (DHIS 2 2011b).

FrontlineSMS
FrontlineSMS is an open source desktop software that allows computers with a GSM Modem to function as a SMS hub. While this software is not health-specific in itself, it has been used in health care project in several countries (Foster 2010:45). A typical use case is communication with community health workers. One example of this is a pilot at St. Gabriel’s hospital in Malawi, where FrontlineSMS was used as a link between personnel at the hospital and community health workers (CHW) (Herstad &
A total of 76 mobile phones were included in this pilot (Manda 2009:51).

The FrontlineSMS solution has proven to have several advantages, including faster communication between CHWs and the hospital and increased mobility of the CHWs, typically defined as their «independency from geographical constraints» (Kakihara & Sørensen 2001:33). Also, the SMS solutions aids in the actual work of the CHWs by allowing automated advice on administering drugs (Herstad & Manda 2010:97-98). At the same time, both technical factors such as GSM coverage and the literacy of the workers has posed challenges (Herstad & Manda 2010:98-99). The authors point to several paradoxes and unintended consequences of the introduction of this solution, in line with Arnold’s argument that the «mobile phone provide a rich source of examples of an ironic or paradoxical kind» (Arnold 2003:232).

Open Data Kit
Open Data Kit (ODK) is an open source suite of tools for data collection, based on the Android platform (Lerer et al. 2009:97-98). It is currently deployed in several different settings, including a pilot for AMPATH in Kenya - the largest HIV treatment programme in sub-Saharan Africa (Open Data Kit 2011). Under the Home-Based Counseling and Testing (HCT) program, a part of the AMPATH, counsellors survey and test people for HIV/AIDS at their homes (Lerer et al. 2009:99). Counsellors that take part in the pilot are given Android phones with ODK installed, which they use for entering patient data, including acquiring GPS coordinates, scanning barcode ID-cards and handling referrals. The patient data is transmitted by GPRS to OpenMRS, an open source medical record system (Lerer et al. 2009:99).

The memory stone
Another similar project is «The memory stone». This is a study conducted in Denmark, where pregnant women were given a small digital artefact called a memory stone. This memory stone should contain personal information about themselves and about their pregnancy, like test results, instructions, recommendations, diary notes and photographs. (Tollmar & Enquist 2008:1)

Surveys and workshops conducted during the study found that health personnel spent a lot of time administrating data about pregnant women, and that it would be advantageous to have all the data collected in one place. It was also a complaint about a lack of communication and coordination between the different parties of the
health sector. To solve these problems, the idea of the memory stone came to life. (Tollmar & Enquist 2008:3)

The motivation behind this research was similar to that of our project, in that they wanted to minimise the use of paper, by using mobile devices instead.

**Implementation of mobile reporting**

In Malawi today, most medical forms are paper based. The goal for this project is to get some of these forms used in Malawi today onto a digital format. These forms will now be filled out using DHIS Mobile, and sent to a DHIS 2 database using the mobile internet.

A PhD student from Malawi provided us with some forms to work with. These forms cover the data collection of antenatal care (ANC) and postnatal care (PNC) (meaning collection of data during, and after pregnancy respectively). These data forms are now being used by Health Surveillance Assistances (HSA) to monitor pregnancy in Malawi. We chose to work on the ANC form (appendix a).

**What data to represent**

Our first goal was to get the ANC form onto the DHIS Mobile and DHIS 2. Therefore it will be fair to go into greater detail about what this specific form will contain. This form should be used by a HSA four times during a pregnancy, and consists of the following parts:

- **Mother information**: The form will first of all contain some information about the mother, like her name, age, household code and what village she's from. Furthermore the form contains parity (how many children she already have), estimated time of delivery (EDD) and last menstrual period (LMP).

- **HSA information**: Here there will be some information about the HSA who are filling out this form, like the name of the HSA, what district and health facility he/she belongs to and the name and title of her/his supervisor.

- **ANC visit**: This part of the form summarises the ANC visit. It include what month of pregnancy the visit take place; how many iron/folic acid tablets where given; if HIV Testing and Counseling (HTC) was done; if sulfadoxine-pyrimethamine (SP, a malaria drug) was given, and if it was first or second dose; the tetanus vaccine (TTV) completion date; and what date bed nets (ITN) was given.

- **Client assessment**: Describes the condition of the pregnant woman. First, it contains the date and number of the HSA visit. Then it describes what month of the pregnancy the woman is in and if there are any danger signs or other illnesses
noted and if there are any actions taken to address these issues. Lastly, it contains a field to tell whether counselling cards have been used.

- **Additional antenatal services**: Tells about what additional services have been provided. These services consists of:
  - Have albendazole been given and what date? (Albendazole is a drug used to cure worm infestations)
  - Have haemoglobin levels been checked and at what date? (Haemoglobin is the iron-containing oxygen-transport in the red blood cells)
  - Have syphilis screening been conducted and at what date?
  - Have prevention of mother-to-child transmission (PMTCT) of HIV actions been taken and at what date?
  - Other services.

- **Birth plan**: Tells if the mother have a birth plan, if it's complete and if there are any missing components/sections.

- **Supervisor information**: This part contains information about when the form is submitted to supervisor, when the supervisor reviewed it and supervisor notes. Additionally the form says when the data is submitted to processor.

### Representing a form in DHIS

It is not too complicated, technically speaking, to represent a paper form and its data fields as a digital representation in DHIS 2. It is rather the decisions to be made that makes the process complex. The many aspects to consider when creating the digital representation may be important to investigate extensively, because a systematic approach and a good design may lead to better usability. Usually, a form is relatively large, meaning it keeps records of many text-fields, check-boxes, etc. If the form should tend to make use of the DHIS Mobile, then the size and complexity of the form is crucial. A good design may for instance clarify which information is needed, and remove redundant information, which in turn will simplify the navigation on a (simple) mobile device, creating a better user experience.

Each of the fields that records information in the form, is in DHIS 2 called data elements. “Data elements form the basis of DHIS 2. Data elements define what is recorded in system, e.g. number of immunisations or number of cases of malaria” (DHIS 2010:23). Such data elements may be grouped based on their relationship with others. One or more of this groups may suggest what data elements that should be included in the digital form.
Above, we discussed such groups of data to present in our digital form. These groups enabled us to create our digital form right away, but it was at this point the design phase was important, and we had to ask ourselves; is all this data needed? Of course, in the paper version all of these fields were needed, but as we moved on to the digital version, some became redundant. As noticed in the ANC group, there were 4 identical instances of the visit time information, only differing on which visit it was. We saw the same phenomena within the Danger signs. Some information like, “Supervisor information” was not being filled out until the HSA returned to the health facility, so that was not needed while visiting. Also, the information about the HSA needed only to be filled once, since all forms would have this information implicit as the HSA gained the HSA user role. This brought up the time-aspect, as of what information that had to be filled at what time.

When creating a form, DHIS 2 gave us an option to publish a mobile-form to use with DHIS Mobile as well. It was therefore important to consider the aspects mentioned above. It confirmed the importance of designing our form in such a way, that no redundant information was present. Recall that the form was supposed to record and report data, but not be used as a health journal. Also, when designing the form, we had to make sure to collect all the data that the old paper form would have collected, but in an intelligent way, such that the DHIS Mobile would be as 'practical' as possible.

In this example, the (data)groups are numbered, and a design is suggested:

**PAPER FORM**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSA</td>
<td>SUPERVISOR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Paper form: All seven groups of data are brought when recording data*

**DIGITAL FORM**

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAVED ONCE IN THE NAME BASED PROGRAM</td>
<td>HSA ENTERS DETAILS BEFORE LOADING ACTIVITY SCHEDULE</td>
<td>SUPERVISOR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Mobile form: HSA brings four groups.*
Only four groups of data remains, as to be brought when recording data. Group 1 and 2 are filled out once before recording and the group 7 is recorded afterwords by the supervisor. This illustrates that the same information is gathered in both cases, but the digital form makes has a bit more structure that makes reuse of the data.

When using a mobile terminal, such as a cellphone, to report health data, there must be a way of transmitting the data. The first versions of DHIS hard-coded a structured SMS message into the DHIS Mobile, but that had limited space. Even compressing the SMS would only improve the data capacity with 28% (Ahmad Affandi, Saparudin 2011:1). The current, improved, situation in Malawi opens new possibilities for transferring the data using GPRS. Using this technology, it is possible to transfer large amounts of data which is much cheaper then sending the same amount of data by SMS. The newest version of DHIS 2 makes use of GPRS, which makes it possible to export dynamic forms to the cellphone and make it a fully integrated and synchronised part of the DHIS system.

**Using the DHIS Mobile to report beneficiary data**

To overcome the paper-based data collection problems, the DHIS 2 team developed mobile solutions that represented paper based forms digitally and simplified the work of collecting data. The health workers from different countries can install mobile applications to their private mobile phones and later download simpler forms. There are two main mobile solutions for DHIS 2, web-based and SMS based solutions.

With these challenges, DHIS Mobile still offers the advantage of mobility since the HSA in Malawi will collect data and report at the location. It also provides opportunity to reach in the village environment that was unreachable a few years ago. Generally, DHIS Mobile is much more useful and familiar device in the rural context.

To overcome the paper based forms and facilitate the way HSAs collect data, we need to design DHIS Mobile forms that represents data as a digital form. Designing such forms requires high competence skills. One have to know which data to keep just to avoid redundancy.

Similar as DHIS 2 instance, data collected with DHIS Mobile are presented in digital form and it contains fields and records. In DHIS 2 instance data are stored for a long period while DHIS Mobile data are temporary stored. After transferring data to the DHIS 2 instance, it will be deleted.

Above we mentioned seven groups that represented data digitally into DHIS 2 instance. Do we need to collect data from all seven groups? Do we need to design
DHIS Mobile forms for them? The answer is no. In the paper form both the HSA group and the supervisor group have to fill the form, but with DHIS Mobile only the HSAs need to logon with their initials to connect to the central database. The supervisor group would not use DHIS Mobile at all. Both groups were registered in DHIS 2 database and we are not interested to capture their indicators.

The other remaining 5 groups will be needed as DHIS Mobile forms because we are collecting data from them, even though the data from the mothers group can be removed: their names are already forwarded from the name based record in DHIS 2.

Discussion

 Providing feedback to HSAs

In discussions of HIS, feedback is often an important aspect. In this section, we will discuss what role feedback plays in a HIS, the way feedback is handled today between facilities and HSAs, and how our mobile reporting implementation can facilitate better feedback mechanisms.

Feedback can be seen as consisting of three components: «First, a part of the output is fed back as input. Second, this input in turn reveals shortcomings in operation. Finally, the input results in self-correcting action» (der Lei 2002:76). All three components are important in our case, where we focus on feedback at the lowest level, from the facilities to HSAs.

The first component implies that the HSAs should be given reports and summaries, feedback, on the data they are reporting. Problems and challenges both in the operation and the reporting of the HSAs can then be identified. This, in turn, allows HSAs to improve their work and their reporting, and data quality increases.

Feedback also contributes to better data quality by increasing the awareness of health workers. It can be a problem that health workers are sloppy with data reporting, because they do not see or believe that the data is being used. Feedback can help remedy by demonstrating that the data is analysed and made use of (Sauerborn 2000:44).

While improving data quality is an important reason for having good feedback mechanisms in a HIS, it is of course also important because it allows health workers to make better use of the data they collect in their tasks. The primary goal of a HIS is to facilitate information use and evidence based decisions (Health Metrics Network
2008:44). This required that the information gathered from the collected data is not spread, and feedback plays an important role in this.

Current Situation
To understand the current situation, one group member has interviewed a HSA supervisor at a Malawi health centre March 2011 (Interview 05.03.2011), as has been mentioned earlier. At that facility, feedback to HSAs are given on a quarterly basis. This feedback consisted mainly of tables with figures, with data from the health centre level only. However, the supervisor expressed that he would like to increase the frequency of feedback to every month, and also to use additional ways of communicating the findings, for example graphs. Because of the time required to make these reports, neither is possible with the current paper based system.

Immediate Improvements with Mobile Reporting
There is as of today no way of providing feedback to the users of DHIS Mobile directly. However, DHIS 2 and DHIS Mobile still provides new opportunities of providing feedback to HSAs. Foremost, DHIS 2 has several different reporting functionalities. Statistical data that can be aggregated from the mobile reports, and then used as a source for making charts, simple tables, Excel Pivot tables or complete reports. Although they require some time for configuration and design, standard report templates can be made with all the data the supervisor wants to give feedback on, including charts and tables. Once they are designed, these allows for the creation of new reports in a matter of seconds, greatly facilitating the work of the HSA supervisor.

Besides allowing the compilation of feedback reports more quickly, DHIS 2 has several useful tools that the HSA supervisor or other management staff at the facility can use to monitor health service delivery and performance.

A more indirect benefit of implementing a mobile reporting solution for the HSAs is that the facility inherently gets another way of providing feedback as well, though telephone or SMS. While this is unlikely to be used as the only way of providing feedback, it provides another option for shorter messages.

Long Term Benefits
It could be possible to implement a simple feedback mechanism into DHIS Mobile if that is deemed desirable. There are several obstacles to this, however, including bandwidth costs and hardware limitations. What is perhaps most important is that by
having the data in digital form on DHIS 2, new mechanisms of feedback can more easily be developed compared to in a paper based system.

Looking at a longer time perspective, another implication of this reporting system is that the data delivered from the facility to higher levels in the HIS will hopefully be of a better quality. This will in turn allow managers at higher levels both to make better decisions, and provide better and more accurate feedback to the lowest levels.

**Challenges of setting up the proof of concept**

If we look at our system from an information infrastructure perspective, clearly we had a solid installed based to start from when setting up our DHIS database and applications. First, we were able to obtain a copy of a DHIS database containing the organisational hierarchy of Malawi. Furthermore, we received help from one of the developers of both the name based module of DHIS 2 and of DHIS Mobile. As some of the groups members had worked with the DHIS software before, we even had much of the supporting infrastructures, such as database software and developer tools, readily available.

Despite having a strong installed based, we faced quite a few difficulties in having DHIS Mobile and the server-side DHIS 2 work together. There were two main reasons for this. The first was version incompatibilities. For the mobile and server application to work together, there must be standardised interfaces between them (Hanseth 2001). However, since DHIS Mobile and DHIS 2 is under continuous development, it was at times difficult to find versions that were able to communicate with each other, and the database. The second problem is also related to the fact that the software is a work in progress, as we experienced many exceptions and bugs.

We made the decision to make use of DHIS 2 which is not backwards compatible with the DHIS 1, and therefore we did not at this point have to deal with backwards compatibility, concerning the installed base. However, it is worth mentioning that in the future, when the tool is shipped, this becomes important again, to manage through cultivation to comprehend with lock-ins.

Therefore, when we made both the digital form for the DHIS 2 and the mobile form for DHIS Mobile, we aimed to use the principle of leanness (Hanseth 2002). When creating the form, there could be important data fields that we did not include in our form, and data fields that were not needed. Considering this, we made the form as small and simple as possible.
When switching from paper to electronic storage we aimed to enhance the advantages paper provided within the digital version. The mobility of the paper, might be the easiest to notice. Even though the paper has positive properties like light weight and no power requirements, the mobile makes it possible to store much more information at much less space. While everyone could read the paper when holding it, the mobile will request an authentication to read the data, so to some extent it is a little bit safer. Also, the electronic version may, of course, be shared between different locations at the same time. So if there ought to be a misunderstanding, a supervisor at the office could in a phone-call discuss a record with a HSA in the field.

**Challenges of Implementing the solution in Malawi.**

Technical challenges we have encountered in going about our work act as pointers to potential challenges that would be faced when implementing this system in Malawi. For example, to implement such a solution there is need for competencies in mobile based applications development, to permit the development of mobile phone-based data entry forms from existing paper-based ones. Further to this, there is also need for solution implementers to have knowledge of the name-based DHIS 2 solution used on the server side. Such competencies are not adequately available in Malawi. These challenges can be compounded with the fact that most of the active developers of the solutions used in this project are based in Oslo, which would make it hard for implementers based in Malawi to readily access them when need be. Human resource forms part of the installed base on which systems are built (Hanseth & Monteiro 1998:47). The challenges mentioned here can therefore negatively impact the performance and possible scalability of the solution tested in this project.

The context in Malawi also possesses other socio-technical challenges that could not be replicated within the setting of a developed economy like Norway, making it hard for project team members to experience certain adverse factors first hand and consider appropriate mitigations. For example, only 11% of the population in Malawi has access to electricity and the growth access to electricity is 0,6% (AICD 2010). This entails the need for renewable energy solutions in places where there solution tested in this project has to work. Our project has not tested out how well such solutions would work. Such design-reality gaps between the context of systems development and on-the-ground reality have been known to result in the failure of information system implementations (Heeks 2003). Furthermore, as has already been alluded to, the installed base can have both enabling and limiting effects on system implementations (Hanseth & Monteiro 1998:47).
**Conclusion**

In this project we have been working with reporting health data in Malawi using mobile devices. We have set up a tool that allows community health workers to report data from the field using mobile devices. As a proof of concept, we used a paper reporting form that is already in use in Malawi.

To do this, we digitised the paper form using DHIS 2 and DHIS Mobile software. This software is currently under development, which led to considerable problems in setting up the prototype. Another challenge was to transform the papers forms into electronic format in the DHIS system.

We have also discussed how this solution can improve the feedback from health facilities to community health workers in the target context. Furthermore, our experiences in going about this task highlights potential problems and benefits that can be encountered should this solution be implemented in our research context of Malawi.
References


e-Infrastructure and e-Services for Developing Countries (p. 1-10). Presented at the 1st International ICST Conference on e-Infrastructure and e-Services for Developing Countries, Maputo.


**HSA Home Visiting Form- ANTENATAL SECTION**

**MOTHERS INFORMATION**

<table>
<thead>
<tr>
<th>Code (VHR)</th>
<th>Name: ________________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>District:</td>
<td>______________________________________</td>
</tr>
<tr>
<td>Village:</td>
<td>______________________________________</td>
</tr>
<tr>
<td>Health Facility:</td>
<td>______________________________________</td>
</tr>
<tr>
<td>Age:_____</td>
<td>Parity:____</td>
</tr>
</tbody>
</table>

For the following section, please write/copy information on the mother’s antenatal visits to a health facility from her health passport.

<table>
<thead>
<tr>
<th>Month of Pregnancy</th>
<th>Iron/Folic Acid (No. tablets given)</th>
<th>TTV</th>
<th>HTC Done</th>
<th>SP (1=1st dose; 2= 2nd dose)</th>
<th>Month of Pregnancy</th>
<th>Iron/Folic Acid (No. tablets given)</th>
<th>TTV</th>
<th>HTC Done</th>
<th>SP (1=1st dose; 2= 2nd dose)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st ANC Visit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd ANC Visit</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Month of Pregnancy</th>
<th>Danger Signs or Illnesses Noted</th>
<th>Action Taken</th>
<th>Counseling Card Used</th>
<th>Additional Antenatal Services</th>
<th>YES</th>
<th>Date Received</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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<td>2</td>
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</tr>
</tbody>
</table>

Does the mother have a Birth Plan? **Y** / **N**

1. **Y** 2. **N**

**FOR OFFICIAL USE ONLY**

Submitted to Supervisor on: ___________________ Initials: __________

Reviewed by Supervisor on: ___________________ Initials: __________

Supervisor Notes: ________________________________

Submitted to Data Processor on: ___________________ Received by: __________

Date entered on: ___________________ By (initials): __________

A copy of this form should be filed at the District Health Office, once the data has been entered into the system.