

---

# User Acceptance of Instant Messaging in DHIS 2

Master's Thesis in Computer Science

Simon Pettersen Nguyen

27th May 2015  
Halden, Norway





# Abstract

As businesses and organizations are becoming increasingly dependent on information systems to improve their work productivity, the effectiveness of communication within businesses and organizations has become a salient aspect necessary for the success of IS implementations. Instant Messaging is a medium which enables real-time electronic communication, which is being increasingly introduced in business and organisations. In this study, an IM feature based on XMPP technology was assembled and implemented in the Health Management Information System DHIS 2 in Rwanda. From an information system research perspective, is both interesting and important to understand the adoption of the IM feature. The Technology Acceptance Model is a model particularly tailored for studying user acceptance of Information Technology, which asserts the individual's behavioural intention to adopt an information system is determined by its perceived usefulness and ease of use. By conducting a survey, this study aimed to examine how the implemented IM feature was initially received, and how it was perceived as useful and easy to use, and how these perceptions potentially correlated with the actual usage of it. The results showed that the users had used the IM feature to some extent, but only over short periods of times and quite infrequently. Furthermore, the users perceived the IM feature to be moderately useful and easy to use. In addition, there were indications that the perceived usefulness and ease of use of the IM featured correlated with the actual usage of it.



# Acknowledgments

First of all, I would like to address my warm gratitude to my main supervisor Harald Holone for the guidance and feedback during the research and writing process. I also thank my external supervisors at the University of Oslo, Lars Kristian Roland and Johan Ivar Sæbø, for giving me the opportunity to take part in the HISP project, and for helping me with both practical and technical matters.

Special gratitude must go to Andrew Muhire and Venuste Nsanzumuhire for patiently taking time from their hectic days to assist me throughout my field trip in Rwanda. I would also like to thank the rest of the HMIS unit at the Ministry of Health in Rwanda for being utterly warm and welcoming.

I would also like to acknowledge Niclas Halvorsen for our collaboration on the implementation, and Bob Jolliffe for assisting me with his extensive knowledge of system administration and related security concerns.

Finally, I would like to thank Monica Kristiansen for the assistance with the statistical analysis.



# Contents

<b>Abstract</b>	<b>i</b>
<b>Acknowledgments</b>	<b>iii</b>
<b>List of Figures</b>	<b>ix</b>
<b>List of Tables</b>	<b>xi</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Motivation . . . . .	1
1.2 Research Questions . . . . .	2
1.3 Thesis Outline . . . . .	2
<b>2 Background</b>	<b>3</b>
2.1 Introduction . . . . .	3
2.2 Health Information Systems . . . . .	3
2.3 The Research Project – Health Information Systems Programme . . . . .	4
2.4 DHIS 2 . . . . .	4
2.5 Participatory Design . . . . .	6
2.5.1 Participatory Design in the HISP project . . . . .	7
2.6 Networks of Action . . . . .	8
2.7 Current Communication Features in DHIS 2 . . . . .	9
2.7.1 Messages . . . . .	9
2.7.2 Interpretations . . . . .	9
2.8 Instant Messaging . . . . .	9
2.8.1 The Strategic Value of Adopting Instant Messaging . . . . .	12
2.8.2 User Acceptance of Instant Messaging . . . . .	13
<b>3 Case</b>	<b>15</b>
3.1 Introduction . . . . .	15
3.2 The Rwandan Context . . . . .	15
3.2.1 Demographics in Rwanda . . . . .	15
3.2.2 History in Rwanda . . . . .	15
3.2.3 Politics in Rwanda . . . . .	16
3.2.4 Economy of Rwanda . . . . .	16
3.2.5 Languages in Rwanda . . . . .	16
3.2.6 HIS Background in Rwanda . . . . .	17
3.2.7 Health System Structure in Rwanda . . . . .	17

3.3	Key People . . . . .	18
3.3.1	Head of Integrated Health Management Information Systems . . . . .	18
3.3.2	System Administrator . . . . .	18
3.3.3	HISP PhD Student . . . . .	19
3.3.4	HISP Master's Student . . . . .	19
3.4	Usage of Current Communication Features in DHIS 2 in Rwanda . . . . .	19
3.4.1	Examples of DHIS 2 Messages Usage in Rwanda . . . . .	20
3.5	Field Trip . . . . .	22
3.5.1	First Week of the Field Trip . . . . .	23
3.5.2	Second Week of the Field Trip . . . . .	23
3.5.3	Third Week of the Field Trip . . . . .	24
3.5.4	Fourth Week of the Field Trip . . . . .	24
3.5.5	Finalizing the Implementation After the Field Trip . . . . .	24
<b>4</b>	<b>Theory &amp; Method</b> . . . . .	<b>27</b>
4.1	Introduction . . . . .	27
4.2	Theory . . . . .	27
4.2.1	Technology Acceptance Model . . . . .	27
4.2.2	Critical Mass . . . . .	28
4.3	Method . . . . .	29
4.3.1	Choosing Data Collection Method . . . . .	29
4.3.2	Instrument Development . . . . .	30
4.3.3	Pinpointing the Critical Mass . . . . .	30
4.4	Participants . . . . .	31
4.5	Internal Consistency of Constructs . . . . .	32
4.6	Correlation . . . . .	32
4.7	Statistical Hypothesis Testing . . . . .	33
<b>5</b>	<b>Design &amp; Implementation</b> . . . . .	<b>35</b>
5.1	Introduction . . . . .	35
5.2	XMPP . . . . .	35
5.3	Evaluating and Selecting a XMPP Server . . . . .	35
5.4	Integrating Openfire with DHIS 2 . . . . .	36
5.5	Evaluating and Selecting a XMPP Client . . . . .	37
5.5.1	Converse.js . . . . .	38
5.5.2	JSXC . . . . .	38
5.5.3	Candy . . . . .	39
5.5.4	TrophyIM . . . . .	39
5.5.5	SparkWeb . . . . .	39
5.5.6	Final Selection . . . . .	39
5.6	HTTP Binding . . . . .	39
5.7	Server-side Authentication . . . . .	40
5.8	Developing and Implementing a Log In Script . . . . .	41
5.9	Implementing Converse.js in DHIS 2 . . . . .	43
5.10	Final Architecture . . . . .	45



<b>6</b>	<b>Results</b>	<b>47</b>
6.1	Introduction . . . . .	47
6.2	Data Collection . . . . .	47
6.3	Internal Consistency of Constructs . . . . .	47
6.4	Construct Results . . . . .	48
6.5	Items Results . . . . .	48
6.5.1	Actual Usage . . . . .	48
6.5.2	Perceived Usefulness . . . . .	49
6.5.3	Perceived Ease of Use . . . . .	49
6.6	Correlation Between Perceived Usefulness and Actual Usage . . . . .	50
6.7	Correlation Between Perceived Ease of Use and Actual Usage . . . . .	51
6.8	Difference Perceived Usefulness and Ease of Use Based on Times Used . . . . .	52
6.8.1	Correlation with Perceived Usefulness Based on Times Used . . . . .	53
6.8.2	Correlation with Perceived Ease of Use Based on Times Used . . . . .	53
6.8.3	Comparison of the Results From the Two Samples . . . . .	54
6.8.4	Statistical Hypothesis Testing . . . . .	55
<b>7</b>	<b>Discussion</b>	<b>57</b>
7.1	Introduction . . . . .	57
7.2	Initial Reception of IM in DHIS 2 . . . . .	57
7.3	Perceived Usefulness of Instant Messaging in DHIS 2 . . . . .	58
7.4	Correlation Between Perceived Usefulness and Actual Usage . . . . .	59
7.5	Perceived Ease of Use of Instant Messaging in DHIS 2 . . . . .	60
7.6	Correlation Between Perceived Ease of Use and Actual Usage . . . . .	61
<b>8</b>	<b>Conclusion</b>	<b>63</b>
8.1	Summary of Discussion . . . . .	63
8.2	Reflection . . . . .	64
8.3	Future Work . . . . .	65
8.4	Proposed Follow-up Study . . . . .	65
	<b>Bibliography</b>	<b>71</b>
<b>A</b>	<b>Questionnaire - English</b>	<b>73</b>
A.1	Introduction . . . . .	73
A.2	Demographics . . . . .	73
A.3	Actual Usage of the IM Feature in DHIS 2 . . . . .	73
A.4	Perceived Usefulness of the IM Feature in DHIS 2 . . . . .	74
A.5	Perceived Ease of Use of the IM Feature in DHIS 2 . . . . .	75
<b>B</b>	<b>Questionnaire - French</b>	<b>77</b>
B.1	Introduction . . . . .	77
B.2	Données Démographiques . . . . .	77
B.3	Usage Courant de la Fonction Chat sur DHIS 2 . . . . .	78
B.4	Perception de L'utilité de L'application Chat sur DHIS 2 . . . . .	78
B.5	Perception de la Facilité D'usage de la Fonction Chat sur DHIS 2 . . . . .	79



# List of Figures

- 2.1 Example of a dashboard in DHIS 2 . . . . . 6
- 2.2 Example of messages in DHIS 2 . . . . . 10
- 2.3 Example of an interpretation in DHIS 2 . . . . . 11
  
- 3.1 Timeline of HISP in Rwanda . . . . . 18
- 3.2 Amount of messages sent within DHIS 2 in Rwanda from 2012 to 2014 . . . 20
  
- 4.1 Map of health facilities in Rwanda . . . . . 31
- 4.2 Formula for calculating Cronbach’s alpha . . . . . 32
  
- 5.1 The process of the authentication provider for Openfire . . . . . 38
- 5.2 The process of the prebind web application . . . . . 41
- 5.3 Process of the login in script . . . . . 42
- 5.4 Process of the Converse.js integration in DHIS 2 . . . . . 44
- 5.5 Screenshot of the IM feature in DHIS 2 . . . . . 45
- 5.6 Final architecture of the IM feature . . . . . 46
  
- 6.1 Box plot describing the actual usage of the IM feature . . . . . 50
- 6.2 Box plot describing the perceived usefulness of the IM feature . . . . . 51
- 6.3 Box plot describing the perceived ease of use of the IM feature . . . . . 52
- 6.4 Box plot comparing the perceived usefulness of the two samples . . . . . 54
- 6.5 Box plot comparing the perceived ease of use of the two samples . . . . . 55



# List of Tables

- 4.1 Rule for describing internal consistency using Cronbach’s alpha . . . . . 32
- 6.1 Demographics statistics of respondents . . . . . 48
- 6.2 Construct results . . . . . 48
- 6.3 Item results . . . . . 49
- 6.4 Matrix showing the correlation between perceived usefulness and actual usage 50
- 6.5 Matrix showing the correlation between perceived ease of use and actual Usage . . . . . 52
- 6.6 Correlation with perceived usefulness based on times used . . . . . 53
- 6.7 Correlation with perceived ease of use based on times used . . . . . 54
- 6.8 *t* values and *p* values from the students *t* tests for the given hypotheses . . 56



# Chapter 1

## Introduction

As businesses and organizations are becoming more and more dependent on information systems (IS) to improve their work productivity[7], the effectiveness of collaboration within businesses and organizations has become a salient aspect necessary for the success of IS implementations[15]. While Email has long been considered to be the standard medium for electronic communication in business and organizations, it has lately been regarded as an inadequate medium for for real-time electronic communication[40]. A medium more adequate for real-time electronic communication is Instant Messaging (IM), which is being increasingly introduced in business and organisations[51]. In this study, an IM feature based on XMPP technology was assembled and implemented in the Health Management Information System DHIS 2 in Rwanda. From an information system research perspective, is both interesting and important to understand the adoption of the IM feature. The Technology Acceptance Model (TAM)[22] is a model particularly tailored for studying user acceptance of Information Technology, which asserts the individual's behavioural intention to adopt an information system is determined by its perceived usefulness and ease of use. This study aims to examine how the implemented IM feature was initially received, and how it was perceived as useful and easy to use, and how these perceptions potentially correlated with the actual usage of it.

### 1.1 Motivation

In 2012 I spent a semester studying abroad at the University of Cape Town (UCT) as a part of my Bachelor's Degree in Applied Computer Science. The courses I attended were thought with a completely different perspective then the courses back at my University in Norway. Whereas the courses at my University had a focus on how to apply the different lessons of Information and Communication Technologies (ICT) for business and enterprise purposes, the courses at UCT had a focus on ways to apply ICT for development. In the course I attended at UCT, the question "How can we apply this knowledge for development?" was consistently being raised throughout the different courses, be it in electronic commerce, information systems and so forth. Consequently, my semester abroad was an eye opener as the angle of incidence of the professors at UCT appealed to my ideals on how I wanted to contribute to society through ICT and academic research.

Returning home to Norway with new insight on how ICT can be applied to help those in disadvantaged circumstances, I got my first encounter with ICT for health through my bachelor's thesis. In my bachelor's thesis, I and a fellow student collaborated with a

clinical psychologist and research fellow at the Oslo and Akershus University College of Applied Sciences on the development of an app for toddlers with pervasive developmental disorders. The app is now being used in research by the aforementioned researcher to study if it is possible to use it to improve the communication and response pattern of toddlers with a disorder within autism spectrum. If proven to be possible, the app can according to the researcher contribute to significantly increase quality of life for the person living with the disorder.

Wanting to continue on the path of contributing to society through my studies and having travelled through several developing countries seeing the different disadvantaged situations, I came in contact with researchers in the HISP project through my supervisor. As the HISP project is working on the development and implementation of a sustainable and integrated health information systems that aims to empower communities, health workers and decision makers to improve the overall quality, coverage and efficiency of healthcare services, the HISP project can be said to be a true attempt on applying ICT for development. I feel privileged for getting the opportunity to be a part of the HISP project as it enabled me to positively contribution to a part of the world where it is needed.

## 1.2 Research Questions

This study aims to examine how the implemented IM feature was initially received. The first research question in this study is therefore as follows:

**RQ 1** *How is Instant Messaging in DHIS 2 initially received?*

This study also aims to study how the users perceived as the IM feature as useful, and how the perceived usefulness correlates with the actual usage:

**RQ 2** *How is Instant Messaging in DHIS 2 perceived as useful, and how does the perceived usefulness correlate with the actual usage?*

Finally, this study will try to examine how the users perceived as the IM feature as ease to use, and how the perceived ease of use correlates with the actual usage:

**RQ 3** *How is Instant Messaging in DHIS 2 perceived as easy to use, and how does the perceived ease of use correlate with the actual usage?*

## 1.3 Thesis Outline

Chapter two provides the practical and theoretical foundation of this project. The third chapter presents the Rwandan context and key people involved in this project. Chapter four describes the theories and methods used to try to answer the research questions. The fifth chapter explains the process of designing and implementing the IM feature used for this study. In chapter six, the results from the data collection is presented, while they are discussed in chapter seven. Finally, a conclusion is given in chapter eight by summarizing the discussion, providing a reflection and presenting future work and a potential follow-up study.



# Chapter 2

## Background

### 2.1 Introduction

This chapter describes the practical and theoretical foundation of this project. A short introduction to Health Information Systems is given, and the the research project, the Health Information Systems Programme, is presented. Furthermore, the Health Information System which is used within the Health Information Systems Programme called DHIS 2 and its development using participatory design is described. Further, the theory of Networks of Action, a network which this project is a part of, is described. In the last half of this chapter, the current commutation features in DHIS 2 will be presented before describing instant messaging and the strategic value of adopting it. Finally, I will presented related work which have studied the user acceptance of instant messaging.

### 2.2 Health Information Systems

A Health Information System, or HIS, can be defined as an “integrated effort to collect, process, report and use health information and knowledge to influence policy-making, programme action and research” [42]. AbouZahr and Boerma[1] defined HIS as “a combination of people, equipment and procedures organised to provide health information to health workers (and others) in a way that enables them to make informed decisions”. These definitions show that the term HIS does not only concern a technical system, it also covers the people involved in the use of the system, the process of collecting and analyzing health data for the system, and the use of data from the system to make informed decisions. The health data is often collected at the lowest levels and turned into useful information used for management at all levels, ranging from local healthcare facilities to international health care organizations[48].

It is argued that the adoption of HIS can potentially lead to major benefits for health care, both in terms of financial benefits and improved health care due to reduced medical errors[34]. In fact, using a HIS in health care has showed to be able to prevent more than half of serious medication errors from being made[8].

## 2.3 The Research Project – Health Information Systems Programme

Today, most of the HISs in developing countries are in the form of routines for collecting health data by paper. These routines are often insufficient in terms of supporting health care as data is often collected only to be sent higher levels in the health system. The process of reporting the data is often delayed, and it can take months, even years, for the data to arrive at national level[43]. A project contributing to solving this problem, which this master's thesis is a part of, is the Health Information Systems Programme (HISP).

The HISP project started as a pilot project in post-apartheid South Africa in 1995 with the development of a district-based HIS. The project was initially a collaboration between the University of Cape Town, the University of the Western Cape and the University of Oslo. Today, the HISP project is a global academic action research project between Norway and number of developing countries including South Africa, Mozambique, India, Tanzania, Ethiopia, Malawi, Mongolia, Cuba, Ethiopia, Nigeria, and China. The primary goal of the HISP research is to:

*design, implement, and sustain HIS following a participatory approach to support local management of health care delivery and information flows in selected health facilities, districts, and provinces, and its further spread within and across developing countries[10].*

This goal includes three main aspects:

- Design, development and implementation of the open source “District Health Information Software” (DHIS), and using it as a tool for improving the information use[10]
- Development of organizational and human resources[10]
- Development of both practical and theoretical knowledge regarding the challenges of implementation of DHIS in development countries with a focus on problems with sustainability and scalability[10]

The HISP project supports the integration of information systems through data exchange mechanisms and open standards in cooperation with ministries of health, NGOs, universities and private companies. With a focus on local solutions for developing country contexts, the HISP project advocates for the free and open source philosophy by sharing the products produced within the HISP project, such as as software solutions and training materials, and by promoting access to and use of information for action[58].

## 2.4 DHIS 2

DHIS 2, or District Health Information System 2, shown in Figure 2.1, is the HIS used within the HISP project. The development of the first version of the DHIS software started in 1997 by the HISP project in South Africa. It was developed on the Microsoft Access<sup>1</sup> platform as it was the de facto standard in South Africa at the time. The development of the second version, DHIS 2, started in 2004 in coordination by the University of Oslo.

---

<sup>1</sup><http://office.microsoft.com/access/>

DHIS 2 was built on the data model from the first version and as a modular web-based software package built with free and open source frameworks[11]. Braa and Sahay[11] defined DHIS as:

*a tool for collection, validation, analysis and presentation of aggregate statistical data, tailored to supporting integrated health information management activities*

DHIS 2 is the preferred HIS in 30 countries and even more organizations across four continents, and is currently being used at various levels in 46 countries<sup>2</sup>. It is designed to act as a district-based country data warehouse to accommodate both local and national needs. It is a generic tool instead of a preconfigured database application, as it has an open meta-data model and a flexible user interface which allows the user to specify their content without the need for programming. The DHIS software with its flexibility and modularity has from the very beginning been a central element of the approach of the HISP project; it is used as a tool for communicating design to users and for making it possible to provide results from the outset to then expand while in full operation, as more features, datasets and other items are added[11].

---

<sup>2</sup><https://www.dhis2.org/>

DHIS 2 is typically used as national HIS for:

- managing data and analysis purposes
- mapping available services and as a facility registries
- logistics management
- monitoring and evaluating health programs
- mobile tracking of pregnant mothers in rural communities

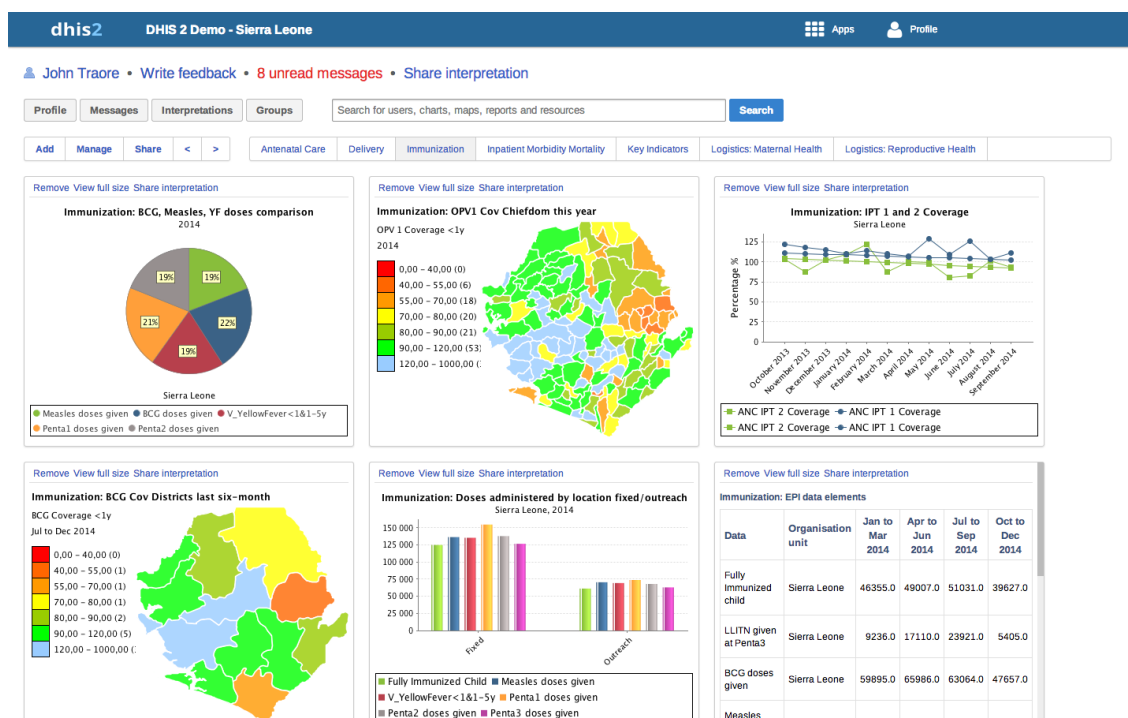


Figure 2.1: Example of a dashboard in DHIS 2

## 2.5 Participatory Design

Even though participatory design has not been directly applied in this project, it is important to give an introduction to what participatory design is and its role in the HISP project, as it is essential knowledge for understanding how the HISP network and research is driven.

Participatory design strategies have been urged by many researchers, but the concept is still controversial. In participatory design, the users are directly involved in the collaborative design of the product. It is argued that extensively involving the user leads to more precise information about tasks and gives the users an opportunity to influence the design decisions[66].

Participatory design has its roots in work by Scandinavian researchers in the late 1960s. There were two influences leading to this work; the labour union movement fighting for

democracy in the changes in their work environment, and the urge for a better flow of information regarding complex systems. The workers were given a right by laws to influence changes in their work environment in the late 1970s, laws that are still in force today[57].

During these times there were a number of projects trying to involve users in the design process. Rather than focusing on simply producing a product, the projects tried to focus on the work process. Perhaps the most disputed project, is the UTOPIA project from the 1980s. The UTOPIA project was a collaboration between research institutions in Sweden and Denmark and the Nordic Graphics Workers Union with aim to develop a software for text and image processing[57]. The UTOPIA software system was developed using participatory design as an measure to strengthen the position of the printer and typographers union, and to protect them against potential new technologies introduced to the printing business[9]. Participatory design initially had strong links to the labour unions, but as unions have lost some of their influences the links have weakened[38]. Nevertheless, delegating more power to the users has remained as the main principle of participatory design.

### 2.5.1 Participatory Design in the HISP project

The HISP project was initiated by public health researchers and activists with roots from the anti-apartheid struggle in collaboration with informatics researchers with background from the Scandinavian participatory design and action research tradition. From early on, the explicit objective of the HISP project was to apply the lessons learned from the Scandinavian participatory design and action research tradition to Africa, and to study to what degree these lessons could be helpful in developing African participatory design approaches. The fundamental principles of Scandinavian Participatory Design tradition involves user participation in system design and workplace democracy and empowerment. These principles were well received in post-apartheid South Africa where there was a focus on empowering the people that had suffered under apartheid[11].

The participatory design process of the HISP project has been going through three phases and is now in its fourth phase. In the first phase (1995-2000), the participatory design process occurred on two joint levels: the broad participatory design process of reforming of the datasets used for reporting while engaging users and stakeholders at all levels, and the more narrow participatory design process of developing the DHIS software where developers and users worked in close collaboration[11].

The second phase (2000-2006) is characterized as the first wave of the HISP extension, where networks of action were created outside South Africa. The expansion occurred due to creation of pilot projects based on participatory design, and these projects were linked to both master's and doctoral studies. The flow of the students participating in these educational programmes within countries and to other countries led to spreading of learning, software and best practices in the HISP network. However, it was discovered in this phase that empowering the users is not advantageous in all settings, as most of the projects failed to sustain and scale[11]. This discovery led to the idea of "networks of action", which is discussed later on in this section.

In the third phase (2006-2010), a new technological paradigm was brought to the HISP project as significant technological change occurred. The Internet and mobile networks were now spreading rapidly through the developing countries leading to an explicit change

from stand-alone to network applications within the health systems. In addition, development of open source technologies escalated quickly. The HISP researchers responded to these changes by starting the development of the fully open source and web-based DHIS 2, which was easier to adopt than its predecessor. However, the successor was a lot more complex than its predecessor and the development was now restricted to the core developers. The development of DHIS 2 led to a shift in the participatory design focus from involving the users in the design of a *software* to involving the users in the design of a *system*. As a result, the implements of DHIS 2 acted as intermediaries between the developers and the users[11].

The HISP project is now in its fourth phase, where different technological shifts have introduced challenging new arenas for participatory design in the HISP project. The mobile networks in developing countries have improved rapidly, which has made it possible to facilitate online web-based services and cloud computing. As the system was moved to the cloud, a question is raised on how participatory design can contribute to empowering the user, and enable local control and ownership. HISP researchers explored this issue in Kenya in 2011 and found that online data made it easy for the users to compare local health data with health data from other areas, which potentially had an empowering effect on the local communities. The researchers argue that participatory design approaches are necessary in order to enable such a potential empowerment[11].

Alongside with these phases, four interconnected cyclic participatory design development processes in the HISP project have occurred[11]:

1. Participatory design in the development of the DHIS software application
2. Participatory design in the development information system with essential data and indicator sets used in the DHIS
3. Participatory design in the development of the information for the action cycle - the process of converting collected data to indicators used for taking action for improving the health services
4. Participatory design in the development of the action research cycle which facilitates the development of the above mentioned cycles

## 2.6 Networks of Action

HISP researchers[10] have identified two underlying problems in unsuccessful attempts of implementing HIS in developing problems; sustainability and scalability. To address these issues, the researchers have developed a theory for sustaining and scaling HIS implementations called Networks of Action. This theory is highly relevant in terms of understanding the ever-changing HIS implementations. The theory originates back to 2004 when Braa, Monterio and Shahay[10] defined sustainability as something that works over time and not within a limited time frame. In order to obtain sustainability in action research projects, Braa, Monterio and Shahay[10] argued that there should be a focus on the building of networks. Furthermore, the authors defined scalability as the issue of making one, working solution spread to other sites and successfully adapting it there. Success on a local site is not sufficient in order to be sustainable; it has to be spread to new sites and be scaled up. The HISP researchers argued that successful scaling should include

not only the technical aspects of scaling, but also the spreading of funding, artefacts, people, learning process and experiences required to make the system work.

As successful pilot implementations and research at single sites often do not scale and only work within a limited time frame, the HISP researches argue that there should be developed “networks of action” between the individual research, projects and pilot sites. These networks should work as a system for the spreading of funding, artifacts, people and knowledge, making the solution scalable and sustainable. I have been a part of these networks of action, and so will also the knowledge obtained and the artifact created (the IM feature) be, as it hopefully will spread out within the HISP network, making sure the research conducted in this project sustains and scales.

## 2.7 Current Communication Features in DHIS 2

Looking into the user acceptance of a new medium in DHIS 2, it is of interest to present the current communication features in DHIS 2. DHIS 2 currently has two features enabling communication between different users and users groups; messages and interpretations. These features are considered important for enabling user feedback concerning timeliness of submissions, the quality of data, or to simply answer questions from other users[71]. The different communication features are presented in the following sections.

### 2.7.1 Messages

The messages feature, shown in Figure 2.2, provides a simple way for communication between users, both for one to one conversations and larger group sessions. It is possible to send a message to a whole user groups, for example to everyone at a particular facility, in a particular district, or even to the whole country. This makes the feature a fast and efficient way for distribution of information amongst users, and is often used for purposes such as notifications, user feedback and general information to users[71]. The messages are sent to an inbox within DHIS 2, but they can also be sent to the email addresses of the users or to their mobile phone by SMS.

### 2.7.2 Interpretations

The interpretations feature, shown in Figure 2.3, is used for writing and sharing of data interpretations of certain analysis-related resources in DHIS 2, such as maps, charts and pivot tables. An interpretation is simply a link to a one of the aforementioned resources together with a text written by the user who shares it, expressing some insight about the data. Upon creation of the interpretation the user can specify who that should be able to view the interpreted data. The users can comment interpretations they are allowed to view, and the feature is therefore often used for starting discussions.

## 2.8 Instant Messaging

As business and organizations are becoming increasingly dependent on information systems (IS) to improve their work productivity and to pursue new business opportunities[7], the effectiveness of communication between organizations has become a salient aspect necessary for the success of IS implementations[15]. Email has long been considered to be

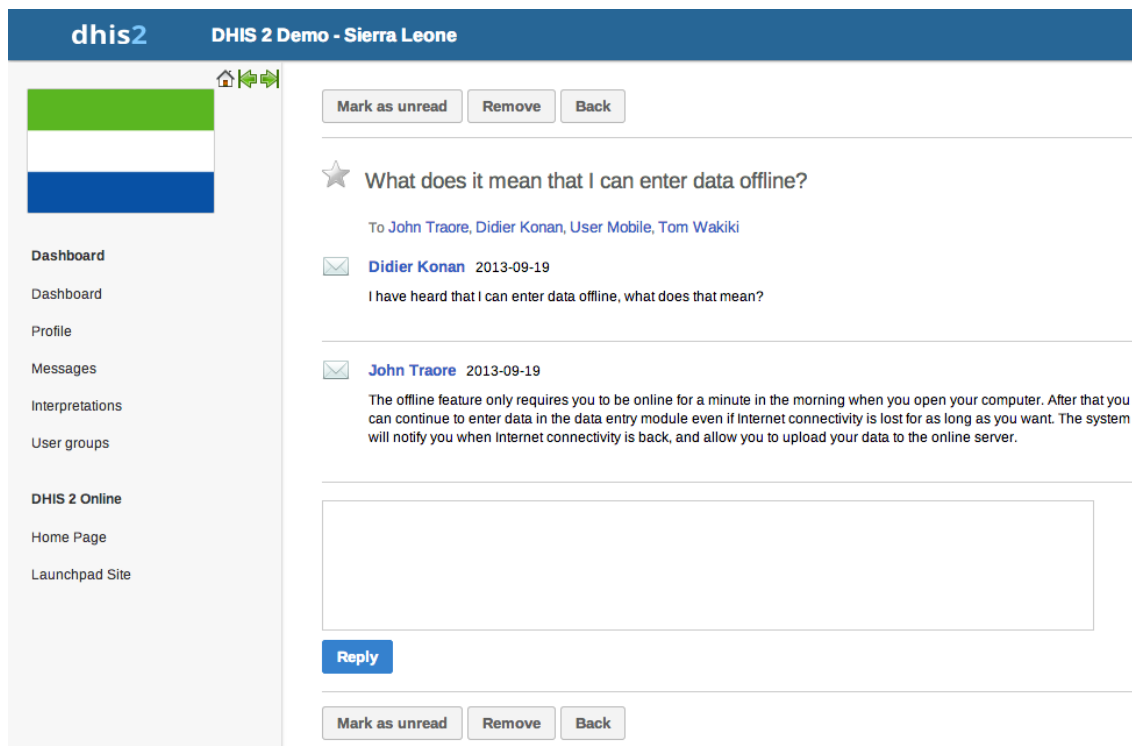


Figure 2.2: Example of messages in DHIS 2

the standard medium for electronic communication in business and organisations, but has lately it has been regarded as an inadequate medium for for real-time electronic communication[40]. Instant messaging (IM), the most commonly used medium for electronic near-synchronous text communication among recreational users and teenagers[30], is being introduced in business and organisations and could be altered to an essential business application with its range of capabilities for interaction and outeraction[51]. In addition to facilitate informal communication in business where phone, email and fax are widespread, IM supports some of the underlying mechanisms which makes the elusive sharing of information throughout business and organisations feasible[47]. With event notification and presence awareness, IM is embarking as a revolution in business and organisation communication mainly propelled by individual employees to enhance communications at work and to stay connected[47]. To meet the demand of the end-user and to apply this technology, many organizations are interested in understanding how their employees adopt IM or communication among their organizational divisions[47]. Intrinsically, there is an interest evoking and timely need to study the key factors important for the adoption of IM in businesses and organisations at the individual level.

Modern, Internet-based, GUI-based messaging clients as they are known today, began to take off back in 1996 in after Mirabilis created ICQ<sup>3</sup> to meet the growing demands of a burgeoning Internet community who “were connected but not interconnected”[47]. ICQ rapidly initiated a new division in the the virtual world. Since then, a variety IM

<sup>3</sup>www.icq.com





Figure 2.3: Example of an interpretation in DHIS 2

tools has mushroomed, such as AOL Instant Messenger (AIM)<sup>4</sup>, Yahoo! Messenger<sup>5</sup>, MSN Messenger<sup>6</sup> and Skype<sup>7</sup>. Past research [21, 32, 33, 62, 60, 24, 35] have identified 11 key characteristics of IM:

1. Presence awareness
2. Immediate closed loop communication
3. Multi-party collaboration
4. Anytime, anywhere access
5. Opportunistic interaction
6. Roadcasting of information or questions
7. Negotiation of availability for interaction

<sup>4</sup>[www.aim.com](http://www.aim.com)

<sup>5</sup>[www.messenger.yahoo.com](http://www.messenger.yahoo.com)

<sup>6</sup>[www.wikipedia.org/wiki/Windows\\_Live\\_Messenger](http://www.wikipedia.org/wiki/Windows_Live_Messenger)

<sup>7</sup>[www.skype.com](http://www.skype.com)

8. Within-medium polychromic communication
9. "Pop-up" recipient notification
10. Silent interactivity
11. Ephemeral transcripts

These characteristics make IM a powerful medium for communication within businesses by increasing the individual productivity and efficiency, even though the medium is to some extent akin to email and the telephone in terms of text-based communication and interactivity and intrusiveness, respectively[47].

IM is diversified for two separate purposes: Personal Instant Messaging (PIM) for personal use and Enterprise Instant Messaging (EIM) for business communication use. Nardi et al. [51] defined EIM as "a near-synchronous computer-based interactive communication medium that facilitates and enhances business applications collaboration and presence information within corporations and between businesses." As opposed to PIM, which is aimed toward personal entertainment use, EIM can be implemented different enterprise applications, such as document sharing applications, project management tools or a HIS such as the one used in this project.

### 2.8.1 The Strategic Value of Adopting Instant Messaging

Effective communication is essential for the prosperity of any business or organisation[36]. Business managers being vigorously worried with time sensitivity and awareness in communications and making sure that the right information reaches the right person at right time have found the strategic values of IM, which makes it possible for the employees to communicate with remote colleagues in a responsive, effective and near-synchronous way. In other words, the strategic value of IM is its capability to speed up the process of making decisions in addition to significantly reducing the non electronic communication cost because of its real-time nature[47]. These values are assumed to be the main reason why businesses and organizations adopt IM as measure for gaining competitive advantages by enhancing inter-organizational collaboration[15], making the business or organization appear as more flexible than their competitors that only relies upon asynchronous technologies such as email and fax.

IM is now viewed as a possible requirement for many business or organisation due to its strategic value, as it can enable the employees to use it for more flexible and effective ways of working, which can possibly lead to improved productivity, reduced stress, enhanced job satisfaction, flexibility and remote working capability[47]. As a consequence, business managers are interested in implementing EIM and understand how their employees would accept IM in the workplace and use it for enhanced communication, collaboration and productivity[47]. A report[54] by International Data Corporation shows that about 60%-70% of all business considered collaboration, productivity improvements, and best practices as the key factors for IM adoption by their employees. In IBM<sup>8</sup>, employees send over 1 million instant messages a day to each other. IM has significantly reduced the amount of email sent within the company, and has reduced the amount quick inquiries cluttering inboxes and made it possible for co-workers to communicate while a question is

---

<sup>8</sup>[www.ibm.com](http://www.ibm.com)

still fresh. Studies show that the use of IM in businesses is growing and industry sources concur that this growth is exponential[53, 54]. Even though the anticipations of penetration of IM in businesses and organisations vary, the trend advocates that the adoption of IM will continue to grow pervasively toward ubiquity in the workplace[47].

The prominent competitive advantage of adopting IM in any business or organisation is its capability of providing real-time communication, and for employees, the information about the presence of co-workers given by IM systems makes the communication efficient, targeted, secure and cost effective. As a consequence, IM has become a vital technology in which business managers are willing to invest[47].

### 2.8.2 User Acceptance of Instant Messaging

Several studies exploring the user acceptance of Instant Messaging have been conducted in the past. For instance, Luo et al. [47] studied the salient factors responsible for the adoption of IM in enterprises and used theories such as technology acceptance, technology diffusion and critical mass to develop a research model for measuring the acceptance of IM among corporate employees. To test their model, an empirical study was conducted by inviting approximately 400 subjects across several companies of different industries to complete a questionnaire survey formulated on a basis of TAM, perceived enjoyment and playfulness, Innovation Diffusion Theory and the Theory of Critical Mass. The results from their study show that employees drive the adoption of IM as they demand a more flexible and efficient way of working, and that the adoption of IM in enterprises will continue to grow in areas where the primary work responsibilities are compatible with using IM. Furthermore, their study found that the having more employees using IM helps increase the value of their networks in addition to drive the use of IM. Their results also suggested that security concerns, can be an important factor for IM adoption in enterprises, and that organizations could benefit by developing security measures and policies to relieve the employees of these concerns.

An empirical study by Lou et al.[45] examined the adoption of IM in a social context. As opposed to study conducted by Luo et al.[47] which focused on the adoption of IM in business, the paper by Lou et al.[45] has a focus on the social use of IM in the building and maintaining social relationships among friends, family members, and others. The main goal of their study was to disclose the underlying factors for the adoption of IM in everyday life, and they developed a research model for explaining the behavioural intention to continue using IM in social context. The research model was based on TAM combined the Theory of Critical Mass further enhanced with three antecedent factors from interpersonal relationship theories. The authors developed a questionnaire based on the aforementioned theories and distributed it to 400 undergrad students. Results from their study show that behavioural intention to continue using IM in everyday life can be predicated by perceived usefulness, perceived enjoyment, and perceived critical mass. Furthermore, their study implies that IM is a useful and enjoyable medium for satisfying the need for attachment and commitment and for gathering online with friends, family members, and others. Additionally, perceived enjoyment was found to be the most important factor for explaining grassroots adoption of IM.

In another study, conducted by Wang et al.[75], the IM adoption behaviour was examined by developing a model based on past research in the same manner as the aforementioned studies. The model was made by combining TAM with the theory of perceived number of users to represent a network externality utility, and the Theory of Technology

Utility to represent a standalone utility. In order to examine the proposed model, the researchers construed a questionnaire survey based on the components of the model. The questionnaire was completed by 437 students, and the results showed that TAM combined with the theory perceived number of user and the Theory Technology Utility was useful for explaining the acceptance of IM in the presence of network externality, and the authors believe that the model would apply to for other IT products and services than IM.

Lu et al.[46] developed a research model based on the Theory of Planned behaviour, the TAM, and the Flow Theory to examine the intrinsic and extrinsic motivations that affect Chinese user's acceptance of IM. The authors used a questionnaire survey divided three into part for testing their theoretical model. The first part had questions about what kinds of IM systems the participants had experience with and how much they much they have used IM. The second part consisted of questions measuring the constructs in the research model. The third part asked the respondents about demographic data. Results from the study demonstrate that user's perceived enjoyment and perceived usefulness remarkably affect their attitude towards using IM, which in turn influences their behavioural intention. In addition, results showed that the users' concentration and perceived usefulness in addition to two components of the Theory of Planned Behaviour, subjective norm and perceived behavioural control, had significant impact on the behavioural intention of the user.

In comparative study by Li et al.[41], the differences in the individual's behavioral intention to use IM in social interactions between two groups of college students in the United States and China were investigated by following a rigorous group comparison approach using structural equation modelling[37, 68, 14]. The authors developed a survey questionnaire based on the scale of behavioral intention[3], the scales for perceived enjoyment and perceived usefulness[3, 23], the scale for relationship commitment[12] and items for perceived critical mass[44]. The survey was distributed to a questionnaire to a total 400 undergraduate students in the US and 550 to the graduate students in the China. The authors found that the American students paid more attention to the effect perceived usefulness in their behavioural intention to use IM, while the Chinese students placed more emphasis on the effect of perceived enjoyment. Furthermore, the results showed that it relationship commitment was more important for explaining perceived enjoyment for the Chinese than for the Americans. In addition, their study found that effects of perceived critical mass on perceived usefulness and perceived enjoyment were stronger for the Americans than for the Chinese. The results also showed that the effect of relationship commitment on perceived usefulness was stronger for the Americans than for the Chinese.

# Chapter 3

## Case

### 3.1 Introduction

In this chapter I will present the Rwandan context and the key people who were involved in this project. I will then describe how the current commutation features in DHIS 2 in Rwanda are being used by the users. Finally, I will describe the field trip to Rwanda where the implementation of the IM feature started, and how it was later finalized.

### 3.2 The Rwandan Context

The Rwanda context is presented, as it is important to give an overview of the environment which has shaped this project and its outcome. The Rwanda demographics, history, politics, economy, languages, HIS background, health system structure is presented in the in the following sections.

#### 3.2.1 Demographics in Rwanda

As of July 2014, Rwanda is projected to have an estimated population of 11,689,696 people[13], which gives Rwanda one of the highest population densities of any country in Africa[13]. The population is young: an estimated 42.7% are under the age of 15, and 97.5% are under 65[13]. The total fertility rate of Rwanda is estimated at 4.62 children children born per woman, the 27th highest in the world[13]. Rwanda has the 26th lowest estimated life expectancy out of 223 countries and territories in the world at only 59.26 years[13]. While the ethnic identities a very much a taboo subject in Rwanda, the population is estimated to be composed of Hutu (Bantu) 84%, Tutsi (Hamitic) 15%, Twa (Pygmy) 1%[13].

#### 3.2.2 History in Rwanda

Rwanda was formerly a part of German East Africa. The area covering what is now known as Rwanda and neighbouring Burundi was ceded as war dividends to Belgium after the the first World War. Under Belgian rule the minority group called Tutsi became the ruling ethnic group, and in 1931-32 identity marks indicating ethnicity was introduced in Rwanda. After World War II Rwanda was still ruled by Belgium, but now under a UN-led program that would later lead to independence. From 1958 the country was suffering

from unrest and rebellion, which resulted in independence from Belgium in 1962. The Tutsis were now longer the ruling ethnic group, and the country was now dominated by the largest ethnic group, the Hutus. The country's Tutsi population was suppressed and tried displaced several times throughout the 60s, 70s, and 80s. In 1973 the Minister of Defence, Juvenal Habyarimana, took control of the country in a military coup, and sat as president until he was killed in a plane crash outside the capital Kigali 6. April 1994[19].

In October 1990, the Tutsi-dominated Rwandan Patriotic Front (RPF) attacked Rwanda from the boarder areas of Uganda and Rwanda. On August 4, 1993, five peace accords were signed in Arusha, Tanzania between Habyarimana's regime and the RPF. When Habyarimana was killed, a power vacuum arose in Rwanda and the Arusha Accords were broken. The next hundred days about a million Tutsis and moderate Hutus were killed in one of the most gruesome genocides of modern time. A UN peacekeeping force was in place to support the Arusha Accords, but was not able to prevent genocide. In July 1994, the RPF military took control over Kigali and stopped the massacres. RPF's military leader, Paul Kagame became vice-president and later president of Rwanda[19].

### 3.2.3 Politics in Rwanda

Rwanda is formally a republic with a multi-party system, where the president has excessive power. The president is elected for seven-year terms and may be re-elected once. After the genocide, the country has been ruled by various coalition governments with Tutsis and Hutus. However, in 2000 Paul Kagame was elected president and the Tutsi party have gained more and more power ever since. The opposition has recently been threatened and harassed by the authorities and is now no real challenge to the government. This, and the fact that the country's economy has improved significantly, and that the political situation has been relatively stable, resulted Kagame being re-elected in 2010[19].

Politically Rwanda still affected by genocide 90s. The country adopted a new constitution in 2003, which prohibits political parties to identify with a particular ethnic group, religion or clan. However, there is still differences between the different ethnic groups[19].

### 3.2.4 Economy of Rwanda

Rwanda is a poor country where 90 percent of the population works in agriculture. The genocide destroyed the former economy, but he country is now bad back on its feet as a popular aid country with little corruption and well managed finances. The International Monetary Fund and The World Bank have remitted large parts of the country foreign loans, and by the end of 2009, Rwanda spent 14.4% of the GDP on loan repayments, down from 85 percent at the beginning of the decade. Authorities heavily prioritize programs to overcome poverty, yet more than one third of the population is undernourished[18].

### 3.2.5 Languages in Rwanda

The official languages of Rwanda are Kinyarwanda, English, and French. After the genocide, a relational conflict between Rwanda and France occurred. And as large number of Tutsi refugees returned from anglophone Uganda, and United States intervened in the country's affairs, English was increasingly used by more of the population and administration than before. This ultimately led to the government changing language of instruction from French to English in 2008[16].

### 3.2.6 HIS Background in Rwanda

The Health Management Information System (HMIS) unit of the Ministry of Health in Rwanda has mandate to coordinate activities for gathering, storing, analyzing, interpreting and reporting key routine data related to health. The HMIS unit is also responsible for ensuring the availability of the quality data and managing the sharing and use of routine facilitate data in the ministry and among partners and stakeholders.

In order to carry out the aforementioned mandate and to support the data management needs, the HMIS unit started developing a HIS called Gestion de Systems Information Sanitaire (GESIS) in 2007. GESIS was developed using SQL<sup>1</sup> server and .NET<sup>2</sup>, and was a standalone application which needed to be installed on a computer in each facility. Using this application the data managers at the different facilities could send files to the higher levels for report submission.

The application turned out be rather inconvenient, as the data managers had issues with installing and troubleshooting it on their local computers. In addition, the developers of GESIS stopped providing support for moderations and enchantments of the application. At the same time the government of Rwanda started to heavily invest in development of Internet connection through the country, which enabled them to make web servers available at central level. Ultimately, the data managers and information users gained access to data from remote areas on central server via the Internet.

With the new infrastructure set up, the HMIS unit at the ministry saw an opportunity for overcoming the barriers and limitations of the existing application and accordingly made a document describing the functional requirements for a new system to replace the GESIS. The main goal of the document was to find a open source web based system for gathering and aggregating data from all health facilities thorough the health system hierarchy up to central level. After extensive investigation, the HMIS unit found the DHIS 2 to meet more of the functional requirements than any other system investigated.

DHIS 2 was implemented in Rwanda in 2012, and proved to be great solution in accordance with the ministry's vision of implementing an integrated health system as a one stop data shop that provides the possibility access and share data at any level in the health system hierarchy in a managed way based on assigning user roles and rights.

A timeline of HISP in Rwanda can be seen in figure 3.1.

### 3.2.7 Health System Structure in Rwanda

The health system in Rwanda consists of different channels for reporting, which in the past made it difficult to access and share data throughout the health system. As a consequence, the ministry program offices and projects used parallel system for reporting which led to a lot of duplication of effort for the people collecting and reporting data at health facilities. In fact, staff at health facilities reported having to complete over a dozen different forms for reporting each month in 2008. To solve this problem, the Ministry of Health held a workshop where a minimum package of indications for the health sector was selected, and the reporting formats were streamlined and harmonized. The new Rwandan Health Management System (RHMS) was now configured into six reporting forms, one of them being the HMIS monthly reporting, which is the system used in this project.

---

<sup>1</sup>[www.wikipedia.org/wiki/SQL](http://www.wikipedia.org/wiki/SQL)

<sup>2</sup>[www.microsoft.com/net](http://www.microsoft.com/net)

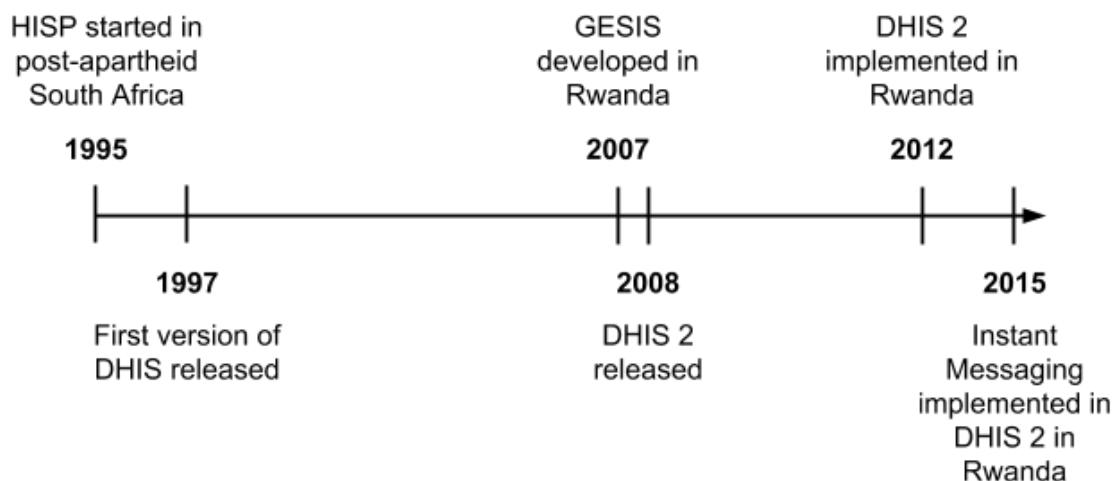


Figure 3.1: Timeline of HISP in Rwanda

The HMIS monthly reporting involves the gathering and reporting of routine health data on chosen disease morbidity, key services provided and stores information about tracer medicine and financial data from the health facilities. The reporting formats in HMIS are adapted to the bundle of services provided at each level. Data managers at the different facilities together with the Monitoring and Evaluation Officers and the clinicians are in charge of services and fill out each their section in a form in HMIS, making a comprehensive monthly report.

### 3.3 Key People

Key people involved which have been involved in this project in different ways to different extents is presented in the following sections. It important to present these people for the understanding on how they have contributed and had an impact on this project, as they will be referred to throughout the thesis.

#### 3.3.1 Head of Integrated Health Management Information Systems

My first day in Rwanda I met the Head of Integrated Health Management Information Systems at Ministry of Health in Rwanda together with the Coordinator of Regional E-Health Center of Excellence at University of Rwanda College of and Health Sciences. The Head of Integrated HMISs is responsible for all health management information system activities in Rwanda. During my field trip, The Head of Integrated HMISs had the overall responsibility for me as a student at the Ministry of Health and was responsible for putting me in touch with the right people and provide me with the information and access necessary for me to conduct the implementation.

#### 3.3.2 System Administrator

A System Administrator at the Rwandan Ministry of Health was assigned by the Head of Integrated HMISs to work with me on a day-to-day basis addressing technical matters.



The System Administrator introduced me to the different servers and their set-ups and supported me in setting up the instant messaging server.

### 3.3.3 HISP PhD Student

A HISP PhD student and has been involved with the Rwanda HMIS implementation for the past 3 or 4 years and generally kept an eye on their servers and give them advice when requested. This PhD student helped me set up the Instant Messaging server on the HMIS production instance, in addition to consult with me regarding potential security issues with the implementation.

### 3.3.4 HISP Master's Student

The integration between DHIS 2 and the IM server was mainly developed by a master's student at the University of Oslo. The student was working on a IM client for Android and we therefore collaborated on the IM server, as we with both needed it for our IM clients. This student also finalized the implementation in Rwanda.

## 3.4 Usage of Current Communication Features in DHIS 2 in Rwanda

DHIS 2 has been running for a number of years in Rwanda and is used by many hundreds of users and has accumulated a significant amount of data. They rightly refer to it as the main electronic system within the ministry. In terms of using DHIS 2 as medium of communication, the Head of Integrated HMISs informed me that both DHIS 2 Messages and Interpretations is used by the users, in addition to traditional mediums such as email and SMS. The Head of Integrated HMISs explained that DHIS 2 Messages is mainly used for technical support and feedback, and conversation often take places in groups. In fact, the Head of Integrated HMISs assumed that approximately 80% of all conversations takes place in a group. A user can ask a question in a group message and the first person available who knows the answer to the question can respond. Consequently, time used by the people at central level used responding to questions is eventually reduced. Noticeably, the Head of Integrated HMISs told me about the desire to move as much as possible of the communication amongst to users to DHIS 2 Messages. To fulfil this desire, the Head of Integrated HMISs has taken measure by informing all the users that general information for everyone will only be given by DHIS 2 Messages, forcing the users to turn to DHIS 2 Messages for necessary information. In addition, the Head of Integrated HMISs informed the users that the people working at central level will respond more quickly to DHIS 2 Messages than email. The Head of Integrated HMISs explained that this approach was desirable for accumulating information from conversations in one place and to take full advantage of the potential of DHIS 2. Figure 3.2 shows the amount of messages sent within DHIS 2 in Rwanda the past three years. The System Administrator at the Ministry of Health explained that as DHIS 2 was introduced in Rwanda in 2012, a large amount messages were sent from the end users to central level as the system was new and the users had many questions on how to use it. The the amount of messages sent continued to increase in 2013 as the users were getting to know the system, until 2014 when the amount of messages decreased as the users were familiar with the system. Furthermore,

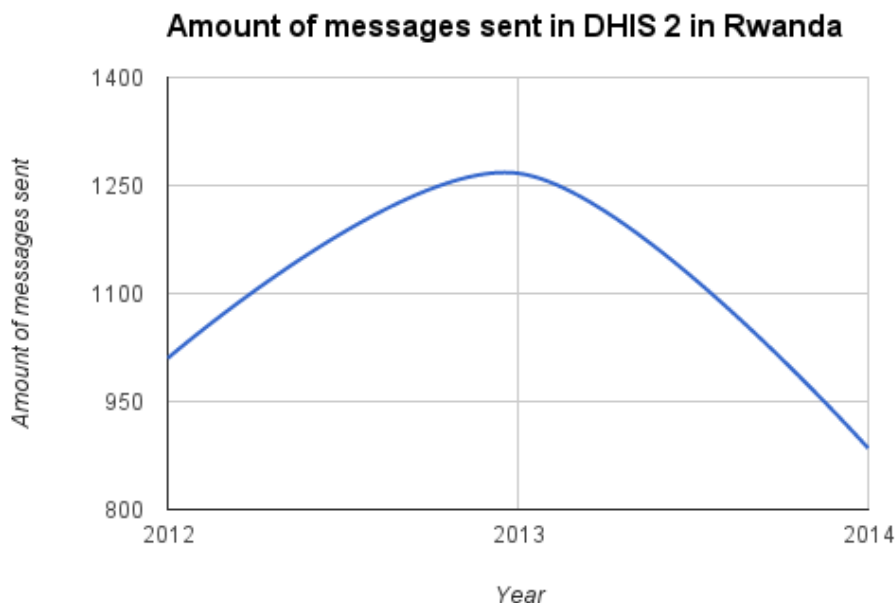


Figure 3.2: Amount of messages sent within DHIS 2 in Rwanda from 2012 to 2014

the System Administrator informed me that several new modules were implemented in the HMIS in September 2014, and consequently, the amount of messages sent increased once more, as the users had inquiries on how to use the new features.

In terms of usage of DHIS 2 Interpretations in Rwanda, the medium is seldom used according to The Head of Integrated HMISs. He explained that there will be more focus on data usage in the future, and therefore also a greater focus on making interpretations. The goal of the Head of Integrated is to make sure the users have adequate knowledge with DHIS 2 before teaching them how to interpret so they can start making interpretations. In other words, the Head of Integrated HMISs wants to reassure that the users are confident enough with DHIS 2 to make interpretations.

### 3.4.1 Examples of DHIS 2 Messages Usage in Rwanda

For the purpose of demonstrating what type of communication DHIS 2 Messaging is used for in Rwanda, excerpts from a few conversations using DHIS 2 messaging is presented in the following sections. Parts of the conversations have been translated to English as both Kinyarwanda and French are often used in addition to English as languages for communication among the users. The names of the participants in the conversations are replaced with fictive names for the purpose of anonymizing the users.

**Message Subject: "How the new data elements"**

**(26-02-2015) Bob:** hi all how is the new data elements? are you familiar with them?  
we are waiting for your comment

**(26-02-2015) Chuck:** which one

- (26-02-2015) **Chuck:** ?
- (26-02-2015) **Bob:** from new reporting form CANEVA 2015
- (26-02-2015) **Bob:** DH AND HC
- (26-02-2015) **Chuck:** on new reporting form for Health Center there are some indicators which require to be transferred at higher level
- (26-02-2015) **Bob:** for example?
- (26-02-2015) **Chuck:** tomorrow I will give you a list, but most of the time some Chronic diseases
- (26-02-2015) **Chuck:** Do you have a Microsoft word of Reporting form? Or you can convert PDF to Word?
- (26-02-2015) **Bob:** no problem I am going to send it
- (26-02-2015) **Chuck:** thx
- (26-02-2015) **Chuck:** are we going to come to Ministry of Health tomorrow?
- (26-02-2015) **Bob:** YES
- (26-02-2015) **Chuck:** Yes when? Are you going to communicate?
- (26-02-2015) **Dan:** tomorrow at which time? I didn't know
- (26-02-2015) **Bob:** the meeting is scheduled tomorrow at 11:00 with observed findings. or any other recommendations. how to improve dhis2 messenger.
- (26-02-2015) **Bob:** the meeting will be short
- (26-02-2015) **Bob:** dear all are you aware for tomorrow's meeting
- (26-02-2015) **Carol:** ok will be there
- (26-02-2015) **Carol:** And we will discuss more on new hmis reporting form
- (26-02-2015) **Carol:** for I have some observations on new HMIS reporting form there are some repetitions for example in Integrated Management of Childhood Illness for children under 5.

In this conversation, there was 13 participants. The conversation is initiated by Bob, who is working at the Ministry of Health, who is prompting the users for their feedback on some new data elements introduced in DHIS 2. The conversation then moves on to scheduling a meeting at the Ministry of Health where a user responds to the meeting invitation with proposing a topic to discuss in the meeting.

**Message Subject: "Today's meeting"**

(06-03-2015) **Bob:** hi all hope you are fine. just to remind you for today's meeting. at  
11 am

(06-03-2015) **Alice:** thx

(06-03-2015) **Chuck:** Dave, Where are you?

(06-03-2015) **Alice:** We're preparing report but we are coming

(06-03-2015) **Craig:** what is happening to you?

(06-03-2015) **Craig:** What are you reporting on 6th?

In this conversation, there was 12 participants. The conversation was initiated by Bob inviting the recipients to a meeting. The conversation then moves on to the participants asking for their colleagues whereabouts, and what they are reporting on.

**Message Subject: "Annual report status"**

(25-02-2015) **Bob:** Hi all, what is the status and completeness of annual report in your health facility?

(25-02-2015) **Chuck:** About 50%

(25-02-2015) **Bob:** can you try to communicate

(25-02-2015) **Bob:** to all users that the reporting form

(25-02-2015) **Bob:** is on dashboard called data managers documents . . . and download Annual report infrastructure.

(25-02-2015) **Chuck:** what to complete on donors and partners sections. what is the difference between those sections?

(25-02-2015) **Bob:** Donors provide supports on specified field such as salaries, equipments . . .

In this conversation, there was 14 participants. The conversation was initiated by Bob asking for a status and completeness of a report. Bob then instructs Chuck to inform the users on where to download a form. Chuck then ask Bob about the difference between two sections in a form.

An interesting observation from this conversation; unlike mail, the messages in DHIS 2 are often fragmented as they are sent before the sentences are complete. However, fragmented messages can be associated with to how conversation are conducted over IM.

### 3.5 Field Trip

From the 16th of November till the 14th of December I was in Rwanda for the purpose of implementing the IM feature in the Rwandan DHIS 2. The field trip is described in the following sections week by week in order to give an understanding of how this project elapsed.

### 3.5.1 First Week of the Field Trip

I arrived in Rwanda the on 16th of November. The first week of my field trip I got introduced to the Head of Integrated HMISs, the System Administrator and all the other people working at the Ministry of Health. I discussed possible implementation scenarios with the Head of Integrated HMISs and we came to the conclusion that the IM feature should be implemented on a test server, called Gorilla, before implementing it on the production server. This approach was chosen in order to pre-test the feature so potential bugs could be fixed before rolling it out to the end users. Furthermore, I discussed potential users to expose the IM feature to with the Head of Integrated HMISs, but did not come to a final decision.

Later that week, I held a presentation demonstrating the IM feature and describing its architecture and my implementation plan. The presentation was held for central people working at the ministry, in addition a Senior HMIS and Data Use Advisor at Integrated Health System Strengthening Project at the Management Sciences for Health (MSH). The MSH is an organization partially funded by the USAID<sup>3</sup> and a long list of other contributors. MSH has collaborated with the Ministry of Health in Rwanda for many years, contributing to strengthening the national health system of Rwanda. The presentation attendees gave positive feedback, and stated that they believed that the IM feature could be very useful and potentially reduce the distance between users. In addition, the attendees suggest a variety of possible usage scenarios and further enhancement for the feature. Here are some of the suggestions that the attendees suggested that the IM feature could be used for:

- chat rooms for training sessions
- querying a helps desk, where one user is assigned to respond to technical questions
- broadcasting information
- socializing
- fostering an online community within DHIS 2
- developing it further by adding a video function

These suggestion will not be emphasized in this thesis due to the time resection given and they will therefore be considered potential as future work.

### 3.5.2 Second Week of the Field Trip

The second week was spent finalizing the implementation on the test server and fixing bugs. In addition, I had a meeting with the Head of Integrated HMISs where I inquired him on the DHIS 2 Messages and Interpretations usage in Rwanda. Furthermore, we discussed potential users to test the IM feature on, but did not come to a final conclusion.

---

<sup>3</sup>[www.usaid.gov](http://www.usaid.gov)

### 3.5.3 Third Week of the Field Trip

The first half of the third week was mostly spent preparing the questionnaire, as I was waiting for permission to start the implementation on the production server. The HISP PhD student presented in section 3.3.3, who was in Rwanda for the week to help the ministry, informed me that I had arrived at an very inconvenient time as they were working on a major reconfigure of the server which involved migration of systems and moving of databases. While the PhD student was in the country, I discussed potential security risks with him, and he told me that he was going to do some research on the IM server which was to be used in my implementation. At the end of the week, after the major reconfiguration was complete, I got permission to start the implementation processes. Before the week was over, I had managed to implement the IM server and its integration with DHIS 2 on the production server.

### 3.5.4 Fourth Week of the Field Trip

The Head of Integrated HMISs and the PhD student had a meeting over the weekend discussing my implementation. They reached the conclusion that the IM feature should be tested with a sample of users before the implementation was to be finalised. On the 8th of December, I travelled to Kayonza, a district in the Eastern Province of Rwanda, where a training session for DHIS 2 users was held. At the training session, the users tried the IM feature, and everything worked fine with the implementation on the test server and no unsuspected events occurred. The Head of Integrated HMISs therefore gave me permission to start finalizing the implementation on the production server. However, I had to finalize the implementation back in Norway as my field trip was coming to an end and I had to travel home.

### 3.5.5 Finalizing the Implementation After the Field Trip

Arriving back in Norway on the 14th of December, ready to finalize the implementation, I discovered that my access to the server in Rwanda was removed. After querying the Head of Integrated HMISs about this issue, he explained that my account was disabled due to security reasons. Furthermore, he explained that he was out of town and only wanted me to work on the implementation when he was available so he could understand the implementation and be able to managed it. Access to the server was not given back to me before the 30th of December, causing a 2 week delay in the implementation process. After the account on the server in Rwanda was reactivated the process of finalizing the implementation started. The final step of the implementation process was somewhat halted due to bugs in the initialisation script of IM server, but on the 20th of January the bugs were fixed and the implementation was finalized.

However, after running only for one day on the production server, the IM server was shut down by the earlier mentioned HISP PhD student after discovering a major vulnerability in the external authentication provider for the IM server. The external authentication provider was capturing DHIS 2 user passwords and storing them in cleartext a log file. The implementation was brought to a halt for an indefinite period due to this incident, and the PhD prompted the master's student at University of Oslo who wrote the external authentication provider to fix this vulnerability and do due diligence and ensure that passwords were never output to the log file. Furthermore, all the source code was to be placed

under version control in a GitHub<sup>4</sup> repository and was to be reviewed by the PhD student before being released back on the production server. The discovery of this vulnerability caused a major delay in the implementation process and the implementation was therefore not finalized before the 24th of March.

---

<sup>4</sup>[www.github.com](http://www.github.com)





# Chapter 4

## Theory & Method

### 4.1 Introduction

To summarize the research questions, as presented in section 1.2, the objective of this study was to answer the following research questions:

**RQ 1** *How is Instant Messaging in DHIS 2 initially received?*

**RQ 2** *How is Instant Messaging in DHIS 2 perceived as useful, and how does the perceived usefulness correlate with the actual usage?*

**RQ 3** *How is Instant Messaging in DHIS 2 perceived as easy to use, and how does the perceived ease of use correlate with the actual usage?*

In this chapter, the theories & methods used to try to answer these research questions will be presented.

### 4.2 Theory

In order to study the user acceptance of the users, the theoretical framework Technology Acceptance Model was applied together with the Theory of Critical Mass for involving as many users as possible. These theories and their usage is described in the following sections.

#### 4.2.1 Technology Acceptance Model

Technology adoption is an area within the field information systems(IS) which has undergone extensive research throughout the years. The area is composed of an array of theories adopted from other disciplines, theories such as the Theory of Reasoned Action (TRA)[4] and the Theory of Planned Behavior (TPB)[5], which are two of the most commonly applied theories for analyzing the behaviour and perceptions of users of technologies[73]. The Technology Acceptance Model (TAM) developed by Davis[22] is a further adaptation of TRA and is the pioneering theory particularly tailored for studying user acceptance of Information Technology. The TRA theory advocates that social behaviour is motivated by the individual's attitude toward performing a particular behaviour. However, the TRA theory fails to designate the distinct beliefs which are essential in a given situation. TAM,

on the other hand, asserts the individual's behavioural intention to adopt an information system is determined by two distinct beliefs:

#### **Perceived Usefulness**

Perceived usefulness was defined by Davis[22] as “the degree to which a person believes that using a particular system would enhance his or her job performance”.

#### **Perceived Ease of Use**

Davis[22] defined Perceived ease of use as “the degree to which a person believes that using a particular system would be free from effort”. If a system is perceived to be easier to use than another, there is a greater probability it will be accepted by the user, given that effort is a finite resource.[22].

According to Lu et al.[46], IM adoption is dependent on the user finding IM as a useful tool for enhancing the efficiency of their communication, allowing them to communicate with their colleagues more conveniently. In addition, they found that the user needs to feel that IM is easy to use in order to adopt it.

#### **Usage of TAM**

Several studies[2, 23, 31, 69, 70] have verified the presence of a relationship between perceived usefulness, perceived ease of use and usage of information technology by providing empirical evidence obtained by recreating Davis' original study[22]. Much emphasis has been laid on evaluating the validity and robustness of the questionnaire instrument and measurement scales developed by Davis[22]. For example, Adams et al.[2] replicated the work by Davis[22] and extended it to two different settings as means for evaluating the psychometric properties of the ease of use and usefulness scales, and their results provided a strong assessment of the convergent validity and discriminant validity of the two scales. Furthermore, a study by Szajna[70] demonstrated the ability of Davis' [22] questionnaire instrument to predict the actual system usage based on the user's intention to and attitude toward using the system. A study by Hendrickson et al. [31] examined the test-retest reliability of Davis'[22] instrument and found that it had high reliability. The sum of these studies provides evidence confirming the validity of the questionnaire instrument and measurement scales developed by Davis[22]. Since TAM was developed in 1989 by Davis[22], it has been widely applied to research regarding the user acceptance of different types of technologies including word processors, world wide web, e-commerce, e-mail, enterprise resources planning systems and IM[6, 22, 23, 28, 29, 56, 75].

#### **4.2.2 Critical Mass**

The Theory of Critical Mass indicates that the rate of adoption suddenly accelerates after reaching a certain number of users who have already adopted the technology[61]. The Theory of Critical mass is a widely researched theory studied within many disciplines, such as communication, marketing, economics and social science. In the discipline of social science, Oliver. et al.[52] defined critical mass as “a small segment of the population that chooses to make big contributions to the collective action”. However, communication technology is distinguished from traditional information technologies as it requires cooperative efforts and interconnection between at least two people. In a study by Li et al.[41], it is argued that the benefit of using a communication technology, such as IM, can not

be attained unless his or her communication partners have also adopted the technology. It is argued that the more users of a new communication technology, the higher its perceived value and usefulness for those who have not already adopted the technology within the same community of interest[32, 45, 49]. Therefore, for IM adoption, critical mass is of crucial importance and is believed to contribute to acceptance by the users.

## 4.3 Method

There has been a process of choosing appropriate method for data collection which will be described in the next section. After a data collection method was chosen an instrument was developed for measuring the actual usage and perceived usefulness and ease of use of the IM feature. The process of pinpointing the critical mass will be further described as well who the participants were. Finally, I will present the different calculations which were applied in order to try to answer the research questions.

### 4.3.1 Choosing Data Collection Method

The initial plan of this project was to implement IM in DHIS 2 in Rwanda during the field trip and let the users be exposed to it for a week or two before doing a qualitative study by gathering data using TAM adapted interviews in addition to observations of actual usage, alternatively complimented with quantitative data gathered with questionnaires and statistics of actual usage. As mentioned in section 3.5.5, the implementation process was not finalized until long after the field trip due to circumstances caused by conditions outside of my control. And as it proved to be problematic to conduct interviews and observation without physically being in the country, the initial plan was discarded. Making observation would be particularly difficult without physically being there. However, interviews could have been conducted by telecommunications application software such as Skype, and this option was considered, but also discarded due to a number of reasons. To begin with, the Head of Integrated HMISs at the Ministry of Health in Rwanda advised against it, explaining that it would be difficult. Even though no further explanation to the advice against it was given, it is assumed that there are a number of reasons why it would be difficult. One reason is that someone working at the Ministry of Health would have to be present during the interview to act as a translator making sure both parts understand each other. Another reason is the impractical geographic dispersion of the users. Each user works in a separate district, which means that if five people were to be interviewed, the translator would have to travel to five different districts, or alternatively, they would all have to travel to the Ministry of Health located in the capital. Additionally, the Internet in Rwanda tends to cease to function from time to time, which is something that could potentially interfere with the flow of the interview processes. Furthermore, there was a language barrier, as experienced by both the master's student presented in section 3.3.4 and myself. After trying to have conversations in English with the users at a training session during the field trip, it became evident it was not possible to acquire elaborate answers. The user usually responded to the questions simply by saying "yes" or "no", or they did not understand the question at all. This experience corresponded with the experience by master's student at the University of Oslo from conducting interviews with the users, which made him advise against using interviews as a method of collecting data from these users.

With the combination of not physically being there, the language barrier preventing elaborate answers and the geographic dispersion of the users, it became evident that using a questionnaire for collecting data would be a more suitable method. The questionnaire could additionally be translated to French, as most of the users are more comfortable with French than English. Another important advantage was the possibility to easily distribute the questionnaire throughout Rwanda. Last but not least, TAM is initially a quantitative research model. As a consequence of the circumstances limiting the possibilities of this study, a potential follow-up study is presented in section 8.4.

### 4.3.2 Instrument Development

A questionnaire survey was constructed for examining the correlation between perceived usefulness and ease of use of the IM feature and its actual usage. The questionnaire consisted of three parts; the first part solicited demographic information, including gender and age, the second part was used to determine actual usage of the IM feature, and the third part was used to measure the perceived usefulness and ease of use of the implemented IM feature. All responses were measured using a 7-point Likert scale, with answer options ranging from unlikely (1) to likely (7). As a greater proportion of the user's are more comfortable with French than English, the questionnaire was translated by a translator into French. The questionnaire was then reviewed by another translator to ensure that the translation was correct and intelligible.

The measures used to determine actual IM usage consisted of three items adapted from a study by Moon and Kim[50] applied for measuring the actual IM usage in three measurable extents; times per week, hours weekly and frequency of usage. The third part of the questionnaire used to measure the perceived usefulness and ease of use was items adapted from the original TAM scales proposed by Davis[22] reformulated to fit the implemented IM feature. An example of one of the adapted perceived ease of use items is: "I would find it easy to get the IM feature in DHIS 2 to do what I want it to do" and an example an adapted perceived usefulness items is: "I would find the IM feature in DHIS 2 useful in my job". The final instrument can be viewed in appendix A and B.

### 4.3.3 Pinpointing the Critical Mass

As a user, using IM without no other users is meaningless. From early on in the implementation process there was a focus on trying to select most highly connected pairs of users who resided at different sites for exposing the IM feature to. In other words, there has been a process of trying to pinpoint the group of user who most frequently communicate electronically with each other. The idea behind this strategy was to try to achieve a critical mass of users. After discussion with the Head of Integrated HMISs in Rwanda trying to identify the segment of users who most frequently communicate among each other, in addition to being geographically dispersed, the district hospital data managers were chosen to be exposed to the IM feature. As these users, according the Head of Integrated HMISs in Rwanda, most frequently communicate with each other, it is assumed the these users have higher probability of adopting the IM feature faster than the users who communicate less frequent. In addition, it was desired by both me and the Head of Integrated HMISs in Rwanda to exposed the IM feature to 50-100 users (10%-20% of the total amount of users in DHIS 2 in Rwanda) to begin with, and the amount of users working as district hospital data managers were within this interval.

## 4.4 Participants

Participants chosen for data collection consisted of the selected users from the process of pinpointing the critical mass which resulted in the user group of district hospital data managers. One district hospital data manager is stationed in each district in Rwanda, and these users are therefore geographically dispersed throughout Rwanda as shown in figure 4.1. However, Rwanda has 30 districts, and there should therefore be a total of 30 district hospital data managers. However, there are 74 active users registered with this user role in DHIS 2, without knowing the reason for this. It is however assumed that all these users have the same responsibilities and tasks. The responsibilities of district hospital data manager is to collect, quality assure, report, access, share and release data in addition to storing and retaining records in their respective district. All the district hospital data manager frequently communicate with each other as they often conduct the same tasks. In addition, they often meet each other at training sessions held by the Ministry of Health in Rwanda, where they learn things like filling in forms which are newly introduced in DHIS 2.

The IM feature was implemented for all district hospital data managers, which is further described in the next chapter. After the implementation was finalized, the Head of Integrated HMISs recorded a video where he demonstrated the newly introduced IM feature and explained how to use it. This video was distributed to all district hospital data managers by email.

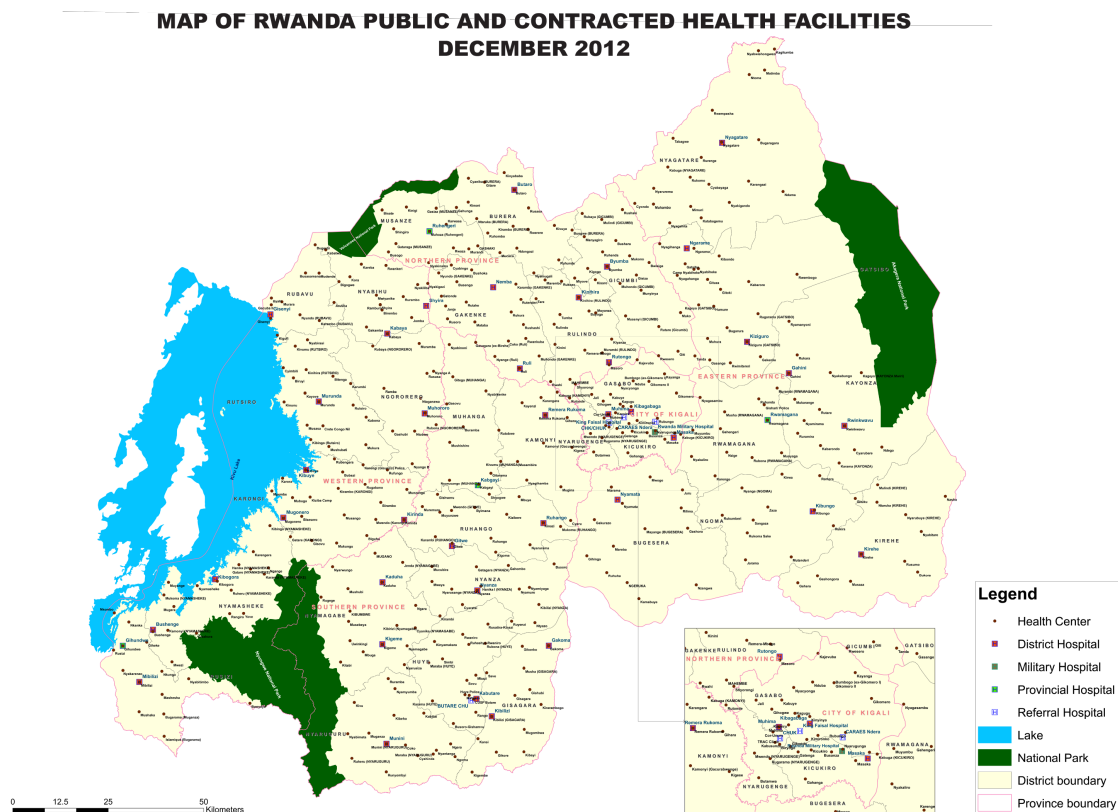


Figure 4.1: Map of health facilities in Rwanda

## 4.5 Internal Consistency of Constructs

The internal consistency of the actual usage, perceived usefulness and perceive ease of use constructs were examined. An examination of the internal consistency of a construct concerns the coherence of items, i.e. the extent to which items are correlated with each other. Reliable test scores have items which correlates positively with each other, while non-reliable test scores have items which do not correlate at all. Items that correlates weakly with each other is by definition less reliable and generally undesirable. When items correlate positively with each other, it indicates that they have something in common, and that they probably measure the same phenomenon, but different aspects of it. Items which correlates very high or almost perfectly with each other is undesirable as well, since such items measures identical aspects of the same concept.

A reliability analysis is primarily a check on how persistent the sum scores serve as measure of a construct. It is not a check of items reliability, even if the items mutual consistency (covariance) affects the sum scores reliability. The most commonly used method for measuring internal consistency is Cronbach's alpha[20]. Cronbach's coefficient alpha can be understood as a ratio of systematic covariance of total variance/covariance, specified in Cronbach's formula[20]:

$$\alpha = \frac{K}{K - 1} \left( 1 - \frac{\sum_{i=1}^K \sigma_{Y_i}^2}{\sigma_X^2} \right)$$

Figure 4.2: Formula for calculating Cronbach's alpha

In the aforementioned formula,  $K$  is the number items,  $\sigma_{Y_i}^2$  is the sum of the variance of all the items, and  $\sigma_X^2$  is the sum of all variance and covariance. The alpha value is a statistical size ranging from 0 to 1. The stronger the relationships between the items are, the better the reliability goal with Cronbach's alpha is. Usually an alpha of 0.70 is used as a lower limit for satisfactory reliability[39]. A rule[39] for describing internal consistency using Cronbach's alpha can be seen in table 4.1.

Cronbach's alpha	Internal consistency
$a \geq 0.9$	Excellent
$0.7 \leq a < 0.9$	Good
$0.6 \leq a < 0.7$	Acceptable
$0.5 \leq a < 0.6$	Poor
$a < 0.5$	Unacceptable

Table 4.1: Rule for describing internal consistency using Cronbach's alpha

## 4.6 Correlation

As means for examining how the perceived usefulness and ease of use of the IM feature correlated with the actual usage of it, the correlation between these constructs was calculated. Correlation is a statistical relationship between two variables. Correlation can be calculated in various ways, and the most common method is the Pearson correlation

coefficient,  $r$ , for measuring linear relationships. The correlation between the two measured variables can vary between 1 and -1, where figures approaching +1 or -1 respectively describes strong positive or strong negative correlation. A correlation close to 0 implies weak or absent correlation. Correlations are referred to as weak, moderate or strong, where typically figures from 0.5 to 1.0 or -0.5 to -1.0 is considered high, 0.3 to 0.5 or -0.3 to -0.5 as moderate and 0.1 to 0.3 or -0.1 to -0.3 as weak.

The  $p$  values for the different correlation coefficient alphas were calculated to see whether the correlations statistically significant or not. Statistical significance is a term used to describe the probability that something is a result of coincidences, and a statistical analysis referred to as statistically significant if it is unlikely that the outcome has occurred randomly. The  $p$  value is a number between 0 and 1.

## 4.7 Statistical Hypothesis Testing

As it is interesting to see if there was a difference in how the participants perceived the IM feature as useful and easy to use based on how many times they had used it, the results were split into two samples: those who had used the IM feature once and those who had used it more than once.

To identify any potential differences in the results for the two samples, two-sample statistical hypothesis tests were conducted. Two-sample hypothesis testing is type of statistical analysis used to test if there is a difference between two means. The hypothesis tests were used to test if the mean result for every item in the perceived usefulness and perceived ease of use construct for those who had used the IM feature more than once was greater than the mean results from those who had used it only once. Comparing two means in this manner is called a one-tailed test, as an extreme value on only one side of the sampling distribution require rejection of the null hypothesis. The hypotheses for each item in perceived usefulness and ease of use constructs were formulated in the following manner:

$$\begin{aligned} H_0 : \mu_1 &\leq \mu_2 \\ H_a : \mu_1 &> \mu_2 \end{aligned} \tag{4.1}$$

Where  $\mu_1$  is the mean result for those who had use the IM feature more than once, and  $\mu_2$  the mean result of those who had used it only once.  $H_0$  is called the null hypothesis and  $H_a$  is called the alternative hypothesis. The goal of the hypothesis testing is to rule out the null hypothesis. As the hypotheses are mutually exclusive, the alternative hypothesis is valid if the null hypothesis is rejected, and vice versa. Students  $t$ -tests were used to test the hypotheses to see if there were significant difference between the means of two samples.





## Chapter 5

# Design & Implementation

### 5.1 Introduction

In this chapter, the process of designing and implementing the IM feature is described. To begin with, the protocol which the IM feature is built upon, XMPP, is described. Further, the the process of evaluating and selecting a XMPP server and client and integrating and implemented these with DHIS 2 is presented. Finally, an overview of the final architecture is given.

### 5.2 XMPP

Extensible Messaging and Presence Protocol (XMPP) was used for developing the IM feature for this project as it is the de facto standard and the only widely adopted open protocol for instant messaging communication[59]. XMPP (formerly Jabber[27]) is an open, XML-based Internet protocol for instant messaging and presence information formalized by the Internet Engineering Task Force (IETF) in RFC 3920[64] and RFC 3921[65]. XMPP-software is deployed on thousands of servers across the Internet, and by 2003, was used by over ten million people worldwide, according to the XMPP Standards Foundation[27]. The XMPP technology is used for decentralized XML routing and enables any unit to dynamically send XMPP message to another unit[26]. A typical XMPP network is composed of clients, servers and services. Every unit in a XMPP network is recognized by a unique identifier called Jabber ID (JID)[74]. The XMPP servers host XMPP services and provides a remote range of capabilities to other XMPP units connected to the network, such as XMPP clients[74].

### 5.3 Evaluating and Selecting a XMPP Server

In collaboration with the master student presented in section 3.3.4, we evaluated and selected a XMPP server to be used for our implementations. The criteria for the server was that it had to be released under the open source licenses MIT license, BSD license, Open Source Apache license or MPL v2.0 license, run on Linux, and it should be possible to integrate it with DHIS 2. The licenses restriction eliminated most of the possibilities, and together with the operation system restriction, we were left with only two options:

Openfire<sup>1</sup> and Apache Vysper<sup>2</sup>. The latest release of Apache Vysper was released the 23th February 2011 and the latest release of Openfire was released the 6th of May, 2014. It can appear as if Apache Vysper has stopped developing and pushing updates. Openfire, however is still frequently updated and the documentation offered for it is more elaborate than the documentation offered for Apache Vysper. It also seemed possible to integrate Openfire with DHIS 2. Last but not least, there is a large, vibrant and active community revolving around Openfire. With all the aforementioned factors in mind, the choice was easy as we selected Openfire to be used in our implementation.

The Openfire source code is developed and maintained by Ignite Realtime, an open source community consisting of developers and end-user spread out throughout the world who all share a common interest in adopting cutting edge real time collaboration based on open standards to their businesses and organizations[59]. Ignite Realtime is one of the largest and most teeming open source communities, and they aim at distributing proprietary, non-open standards-based systems[59], something which can be said to be consistent with the values of HISP. Openfire is written in Java and licensed under the Apache 2.0 License[72].

Openfire offers the following features:

- Platform independent, as it is written in Java[17]
- Interface for adding and removing plugins[17]
- Capacity for more than 50,000 simultaneous users[67]
- Guided installation[17]
- User-friendly web interface[17]
- Web interface for administration[17]
- Supports SSL/TLS[25]
- Connecting with a database for saving messages and user details[17]
- Connectivity via LDAP[17]
- Highly customizable[17]

In addition, the Openfire proprietary extension enables multiple server instances to be connected together in a cloud[17].

## 5.4 Integrating Openfire with DHIS 2

In order to minimize the effort required for maintaining the user database for the Openfire server, a custom external authentication provider for Openfire was developed for authenticating the users with DHIS 2. This authentication provider is injected in the configuration of Openfire, and its job is to fetch the users from DHIS 2 and store them in Openfire. This automated process is desirable as it relieves the system administrators from unnecessary

---

<sup>1</sup>[www.igniterealtime.org/projects/openfire](http://www.igniterealtime.org/projects/openfire)

<sup>2</sup>[www.mina.apache.org/vysper-project](http://www.mina.apache.org/vysper-project)

work with keeping the Openfire user database up to date. The authentication provider is mainly written by the master student presented in section 3.3.4, but was modified by me for handling HTTPS.

The process of the external authentication provider for Openfire can be seen in figure 3.2, and works in the following manner:

1. Openfire receives the username and password from the XMPP client.
2. Openfire interoperates with the Web API of DHIS 2 by authenticating using Basic authentication, a technique where the client sends login credentials to the web server using a HTTP GET request. Described in greater detail, the username and password is encoded with Base64 encryption, prefixed with the word Basic, and then allocated as the value of Authorization HTTP header in a HTTP request. There is an important security risk with using this authentication technique, as the authentication scheme provides no security as the login credentials is sent in plain text and therefore can be easily decoded. However, as the DHIS 2 server in Rwanda is running SSL/TLS (HTTPS), the communication between server and the client is encrypted.
3. If the HTTP get request does not result exceptions being thrown, such as an authentication exception, the authentication provider creates a user in Openfire with the given login credentials.
4. The authentication provider adds the new user in an Openfire group where all the DHIS 2 users are stored. If the group does not exists, the provider creates it.

This process of fetching users from DHIS 2 and storing them in Openfire creates redundancy, as duplicate users are stored in two separate place. However, alternate solution would require either direct access to the database of DHIS 2 (which is a configuration complexity in addition to an additional privilege) ,or alternatively a superuser account to DHIS 2 for reading the list of users. The current solution does not require any elevated privilege and this benefit exceeds the drawback of the redundancy, as no backdoor access or superuser is required. However, if the a user is deleted in DHIS 2 it will still exist in DHIS 2, which is an issue which should be solved in the future.

## 5.5 Evaluating and Selecting a XMPP Client

After sorting out the server side XMPP technical aspects, an XMPP client had to be chosen. A third-party XMPP client was used for this project as it was not possible to develop one from scratch due to the time restrictions given for this project.

A total of 19 XMPP browser clients was mapped, and with the same licence restrictions as earlier, MIT license, BSD license, Open Source Apache license and MPL v2.0 license, 14 clients were eliminated as possibilities, leaving me with five potential candidates. The five candidates were further investigated in terms of documentation, frequency of updates, novelty, customizability, functions and most importantly its potential for fitting into DHIS 2 in a seamless manner. Assessments of the various candidates follows.

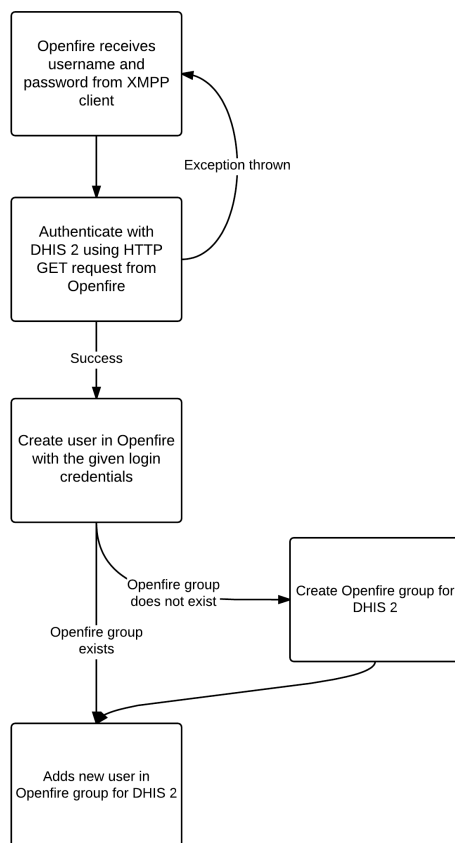


Figure 5.1: The process of the authentication provider for Openfire

### 5.5.1 Converse.js

The latest version of Converse.js<sup>3</sup> was released on March 2015 under the MPL v2.0 license. The client is well-documented and offers a great list of features, such as multi-user chat rooms, vCard<sup>4</sup> support, off-the-record encryption and is translated into 15 languages. The client is built on top of the Strophe.js<sup>5</sup> library, a widely used XMPP library for JavaScript. The client appeared to have great potential for seamlessly blending in with DHIS 2, as it is designed to discreetly fill a small space of the bottom right corner of the browser, allowing the users to browse the content of the web page while simultaneously having an overview of the IM activities. The client also offers the possibility to maintain the IM session across page loads, which is very important for offering the users uninterrupted browsing while working with DHIS 2.

### 5.5.2 JSXc

JSXC<sup>6</sup> was latest released in July 2014 under the MIT license. The client offers features like end-to-end encryption, user verification and end-to-end encrypted audio and video calls. In terms of design, JSXc looks very similar to Converse.js. And like Converse.js, JSXc also

<sup>3</sup>[www.conversejs.org](http://www.conversejs.org)

<sup>4</sup>[www.wikipedia.org/wiki/VCard](http://www.wikipedia.org/wiki/VCard)

<sup>5</sup>[www.strophe.im](http://www.strophe.im)

<sup>6</sup>[www.jsxc.org](http://www.jsxc.org)

offers uninterrupted browsing, but only among web pages enhanced particularly for JSX. A drawback with JSX is its static list of XMPP contacts filling up approximately 20% of the browser window, which could potentially interfere with the users while performing their tasks in DHIS 2 due to the reduced window size.

### 5.5.3 Candy

The latest version of Candy<sup>7</sup> was released in July 2014 under the MIT license. Candy is well-documented and highly customizable as it offers variety of plugins and event hooks. However, the client is designed for multi-user chatting and therefore fill the entire browser window, which is undesirable as the user should be able to work in DHIS 2 while simultaneously using the IM client.

### 5.5.4 TrophyIM

TrophyIM<sup>8</sup> was released in November 2008 under the MIT license. TrophyIM, like Converse.js, is built on top of the Strophe.js JavaScript library. The client has not been updated in seven years. In addition, the client is not designed in a manner which allows the user to view the contents of DHIS 2 while using it, as the client fills the entire browser window alone.

### 5.5.5 SparkWeb

The latest version of SparkWeb<sup>9</sup> was released in April 2008 by Ignite Realtime, the same open source community that built Openfire. The client is optimized for businesses and organizations, with built-in support for group chat and strong security. However, the client is developed for Adobe Flash<sup>10</sup>, which is major drawback in terms of potential for implementation with DHIS 2. In addition, this client also fills an entire browser window.

### 5.5.6 Final Selection

Looking into the different XMPP clients it became evident that Converse.js was the best candidate for implementation with DHIS 2. It was the client with the most recent release, highest frequency of updates and most elaborate documentation. In addition, the client appeared to be highly customizable with great potential for blending in with DHIS 2.

## 5.6 HTTP Binding

Converse.js uses HTTP as protocol for communicating with the XMPP server. HTTP connections are normally short-lived and stateless. On the other hand, XMPP connections are stateful and has traditionally used long-lived TCP connections at the transport layer[63]. This approach has several advantages, such as application of a single parser body and particularly efficient compression of XMPP traffic due to recurrence of different XML elements and attribute names during a XML stream. However, a major drawback with this

---

<sup>7</sup>[www.candy-chat.github.io/candy](http://www.candy-chat.github.io/candy)

<sup>8</sup>[www.code.google.com/p/trophyim](http://www.code.google.com/p/trophyim)

<sup>9</sup>[www.igniterealtime.org/projects/sparkweb](http://www.igniterealtime.org/projects/sparkweb)

<sup>10</sup>[www.adobe.com/products/flashplayer.html](http://www.adobe.com/products/flashplayer.html)

approach appears with irregular or unstable network connections, such as in certain places in Rwanda, as the cost of resuming a long-lived TCP connection can be high due to the abundant round trips necessary for negotiating, encrypting and authenticating the XML stream[63]. To accommodate this issue, the XMPP Standards Foundation developed an HTTP binding for XMPP in 2004 named bidirectional-streams-over-synchronous HTTP (BOSH)[55]. The BOSH technique adds an HTTP connection manager to the client-server interactions in the standard XMPP architecture. BOSH enables the XMPP client to communicate with the connection manager via various synchronous HTTP request and response pairs without the need of using asynchronous chunking or polling. As a consequence, many of the characteristics of TCP are mimicked and streamed data is transported with minimal latency[63]. BOSH is now broadly adapted, especially by browser-based clients such as Converse.js[63].

## 5.7 Server-side Authentication

An important factor with the XMPP browser client Converse.js is its possibility for enabling shared sessions, making it possible to use a single login for both DHIS 2 and the XMPP server. This technique is referred to as prebinding, where a web application sets up an authenticated BOSH session with a BOSH connection manager. Additionally, prebinding enables the possibility to make the IM session persist across page loads. To enable prebinding, a BOSH server and a BOSH client is required. In this case, Openfire acts as a BOSH server simply by being enabled in the server configuration variables. In terms of a BOSH client, no out of the box feature existed, and it therefore had to be developed from scratch with a server-side programming language such as Python, Ruby, PHP or Java. In this case, a prebind web application (the BOSH client) was written in Java as DHIS 2 is already running on a Java application server. The prebind web application was written using Smack, an Open Source XMPP client library by Ignite Realtime, embedded with a library enabling BOSH support written by Eriksson Monteiro<sup>11</sup>. This application is necessary for setting up an authenticated BOSH session for Converse.js to attach to. The process of the prebind web application can be seen in figure 5.2. The communication between the Converse.js, the prebind web application and the BOSH server (Openfire) works in the following manner:

1. The prebind web application receives user credentials via a HTTP POST request from the DHIS 2 login screen.
2. The prebind web application uses the received user credentials to establish a BOSH session between the prebind web application and Openfire.
3. The two tokens RID (request ID) and SID (session ID) are extracted from the session. The SID is a unique identifier for the current XMPP session. This identifier stays constant for the entire life of the session. The Request ID (RID) is a unique identifier for the current request (i.e. page load). Any communication between the XMPP client and XMPP server is considered a new request and therefore requires a new unique RID. The RID in both the XMPP client and the XMPP server needs to be synchronized otherwise the session will be terminated.

---

<sup>11</sup>[www.github.com/eriksson/smack-bosh](http://www.github.com/eriksson/smack-bosh)

4. The prebind web application closes the BOSH connection without killing the session with Openfire.
5. The prebind web application responds to the user's HTTP POST request by putting the extracted RID, SID and JID in cookies in the browser of the user. The JID is generated using the username of the user.

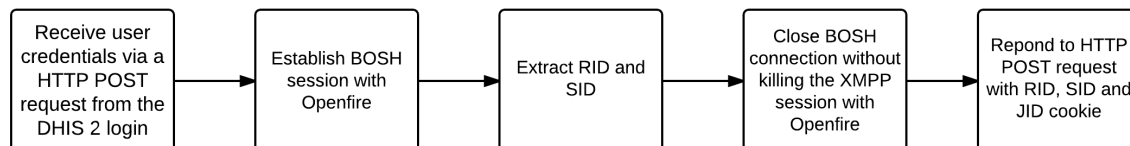


Figure 5.2: The process of the prebind web application

The cookies set by the prebind web application are fetched with JavaScript later on and used in the initialisation of Converse.js for picking up the XMPP connection where it was left by the prebind web application.

## 5.8 Developing and Implementing a Log In Script

The prebind web application needs to receive user credentials via a HTTP POST request from the DHIS 2 login screen in order to authenticate with Openfire. A client-side script was developed for fetching the user credentials from the DHIS 2 log in screen and sending them to the prebind web application. The script was written in JavaScript using Ajax<sup>12</sup> and the JavaScript library jQuery<sup>13</sup>. Ajax was used for exchanging data with the server, and jQurey was used as it simplifies the HTML document traversal, event handling and Ajax.

VelocityView documents, which are typically used for structuring the view layer of Java web applications, are the primary building blocks of view layer of DHIS 2. The script was embedded in the login VelocityView document of DHIS 2. A HTML script element pointing to the external JavaScript script file through the source attribute was embedded in the head of the VelocityView document to execute on the client's machine when the document loads. The process of the login in script can be viewed in figure 5.3. Step by step, it works in the following manner:

1. The log in form is prevented from submitting.
2. The form is then submitted with a HTTP POST request using Ajax. If the HTTP request returns successfully and the user is authenticated with DHIS 2 it is possible to access the web API of DHIS 2 where information about the user can be acquired.
3. A HTTP GET request using Ajax is sent to the DHIS 2 web API.
4. The request returns the information about the user in JSON format. As mentioned section 4.4, the IM feature should only be exposed to district hospital data manager, the JSON information is therefore used to check if the user is a district hospital

<sup>12</sup>[www.wikipedia.org/wiki/Ajax\\_\(programming\)](http://www.wikipedia.org/wiki/Ajax_(programming))

<sup>13</sup>[www.jquery.com](http://www.jquery.com)

data manager by checking the user role. If the user is not a district hospital data manager, the user is forwarded to the dashboard of DHIS 2.

5. If the user is a district hospital data manager the login credentials are sent to the prebind web application.
6. The prebind web application authenticates with Openfire. If the authentication is successful, the tokens RID, SID og JID (Jabber ID, made up by the DHIS 2 username) are placed in respective cookies in the users browser to be used by Converse.js after log in.
7. The user is finally forwarded to the dashboard of DHIS 2.

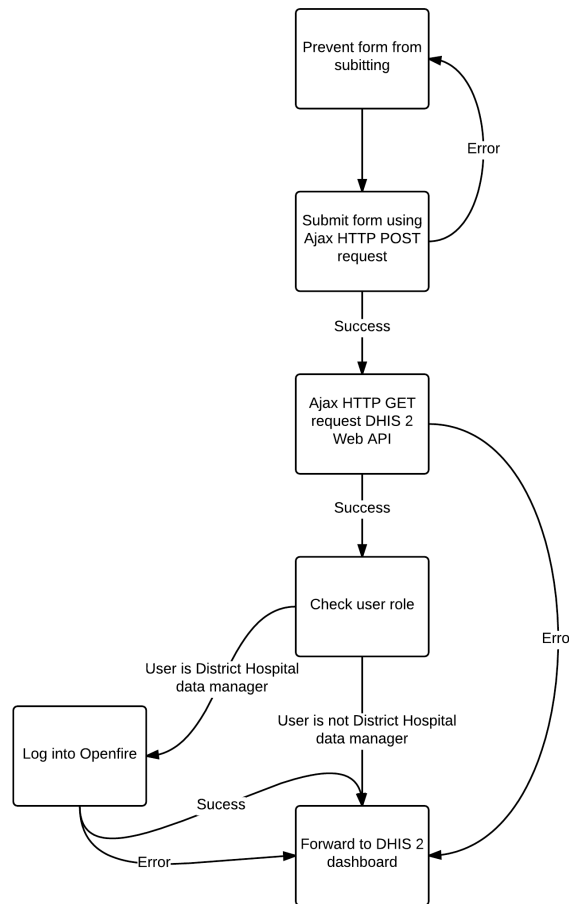


Figure 5.3: Process of the login in script

Fetching the user credentials in this manner is considered a temporary solution and was chosen due to the restricted time frame of this project. In the future this process should take place server-side, as it would not require the abundant authentication round trips.



## 5.9 Implementing Converse.js in DHIS 2

A script was written in JavaScript for initializing Converse.js, and for making the existing log out button in DHIS 2 also log out of Openfire. The script was embedded in the main VelocityView document of DHIS 2 after the closing of the body element<sup>14</sup> using a HTML script element pointing to the external JavaScript script file through the source attribute. The script executes on the client's machine when the document loads. Process of the Converse.js integration in DHIS 2 can be view in figure 5.4. The script works in the following manner:

1. The document is loaded and the script checks if the SID cookie is set before moving on. This is to check if there is an existing XMPP session for the respective client.
2. The original action of the log out button in DHIS 2 is removed and replaced with a custom log out function. The log out function does the following:
  - (a) Clear the Converse.js session and close the XMPP connection.
  - (b) Delete the RID, SID and JID cookies.
  - (c) Log out of DHIS 2.
3. Converse is initialized with configuration settings according to desired requirements. The configuration settings used are explained in the following list.

**prebind: true**

This option is used to attach the existing XMPP BOSH session, which is the BOSH session is set up server-side in by the prebind web application.

**keepalive: true**

This option is used to keep the session alive without having to pass new tokens to the initialization of Converse.js every time the page is reload. This eliminates the need to set up a new BOSH session for every page reload.

**bosh\_service url: "https://hmis.moh.gov.rw/http-bind/"**

This option takes the URL of the BOSH connection manager, which in this a case is Openfire found at /http-bind on the web server.

**jid: getCookie("jid")**

The JID is one of three tokens needed by Converse.js to attach to the BOSH session. The JID is fetched from the cookie set in the user's browser by the prebind web application.

**sid: getCookie("sid")**

The SID is one of three tokens needed by Converse.js to attach to the BOSH session. The JID is fetched from the cookie set in the user's browser by the prebind web application.

**rid: getCookie("rid")**

The RID is one of three tokens needed by Converse.js to attach to the BOSH session. The JID is fetched from the cookie set in the user's browser by the prebind web application.

---

<sup>14</sup>[www.w3schools.com/tags/tag\\_body.asp](http://www.w3schools.com/tags/tag_body.asp)

**allow\_otr: false**

This option provides the user with the option to enable off-the-record encryption of single-user chat messages. This option was disabled as too many options can be disruptive. However, this option could be enabled in the future as the users are more familiar with the IM feature.

**allow\_muc: false**

This option enables multi-user chat in chat rooms. This option was disabled as it is desired to gradually introduce the user to the functions of Converse.js, starting with one-to-one communication.

**animate: false**

This option was used for disabling animations of the buddy list and the conversation windows for every page reload, as the animations can appear disruptive and distracting.

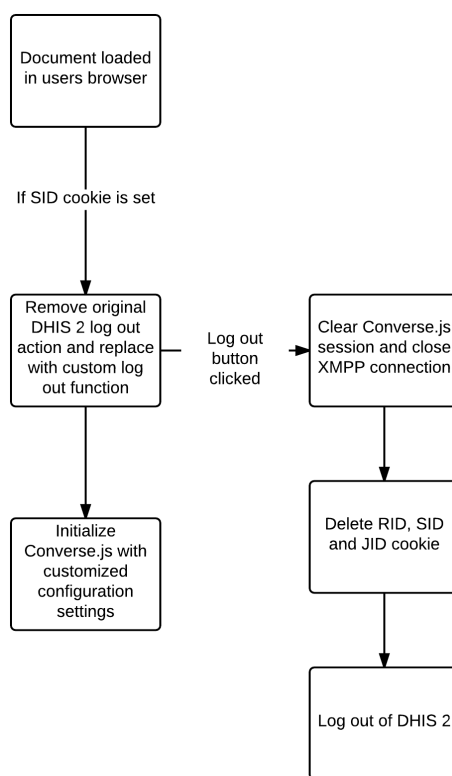


Figure 5.4: Process of the Converse.js integration in DHIS 2

The last step of implementing Converse.js was to include the CSS and JavaScript files of Converse.js inside the head element of main VelocityView document of DHIS 2 via the HTML script and link tags. Further, a minor change to the appearance of Converse.css was made by changing the colors to match the colors used in DHIS 2 in Rwanda. Figure 5.5 shows a screenshot of what Converse.js finally looked like in in DHIS 2.

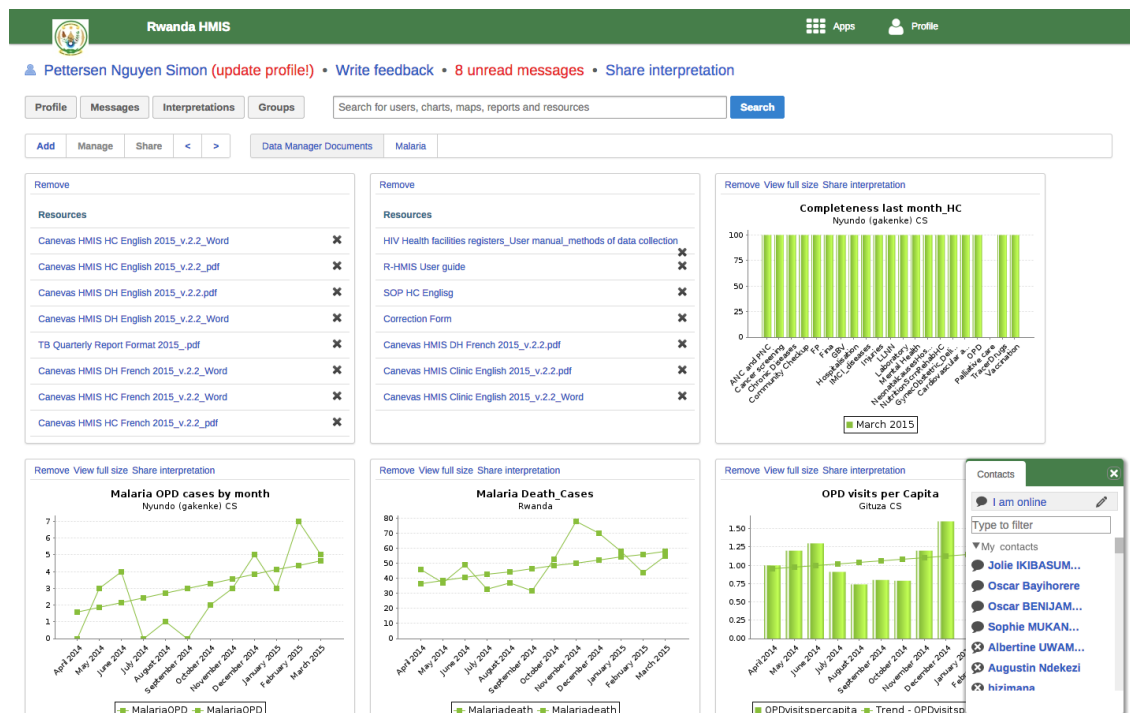


Figure 5.5: Screenshot of the IM feature in DHIS 2

## 5.10 Final Architecture

The final architecture of the implemented IM feature is illustrated in figure 5.6. The figure illustrates the scenario where the user is created for the first time in Openfire and no exceptions are raised. Step by step, the process is described in the following manner:

1. User credentials are sent via HTTP POST request from the DHIS 2 interface to the prebind web application.
2. The prebind web application establishes a BOSH session with Openfire.
3. Openfire authenticates with DHIS 2 using HTTP GET request.
4. DHIS 2 checks if the given user size credentials corresponds with an existing user in the DHIS 2 database.
5. DHIS 2 verifies that the user exists in DHIS 2.
6. DHIS 2 returns authentication success to Openfire.
7. The user is created in the Openfire database.
8. The XMPP connection between is initialised.
9. The RID, SID and JID cookies are set in the browser of the user by the prebind web application.

10. The cookies are used in the initialisation of Converse.js to pick up the XMPP connect where it was left by the prebind web application. All communication now runs directly between Converse.js and Openfire.

The process of XMPP initialisation between Converse.js and Openfire is similar for users already created in Openfire, but without the creation of the user.

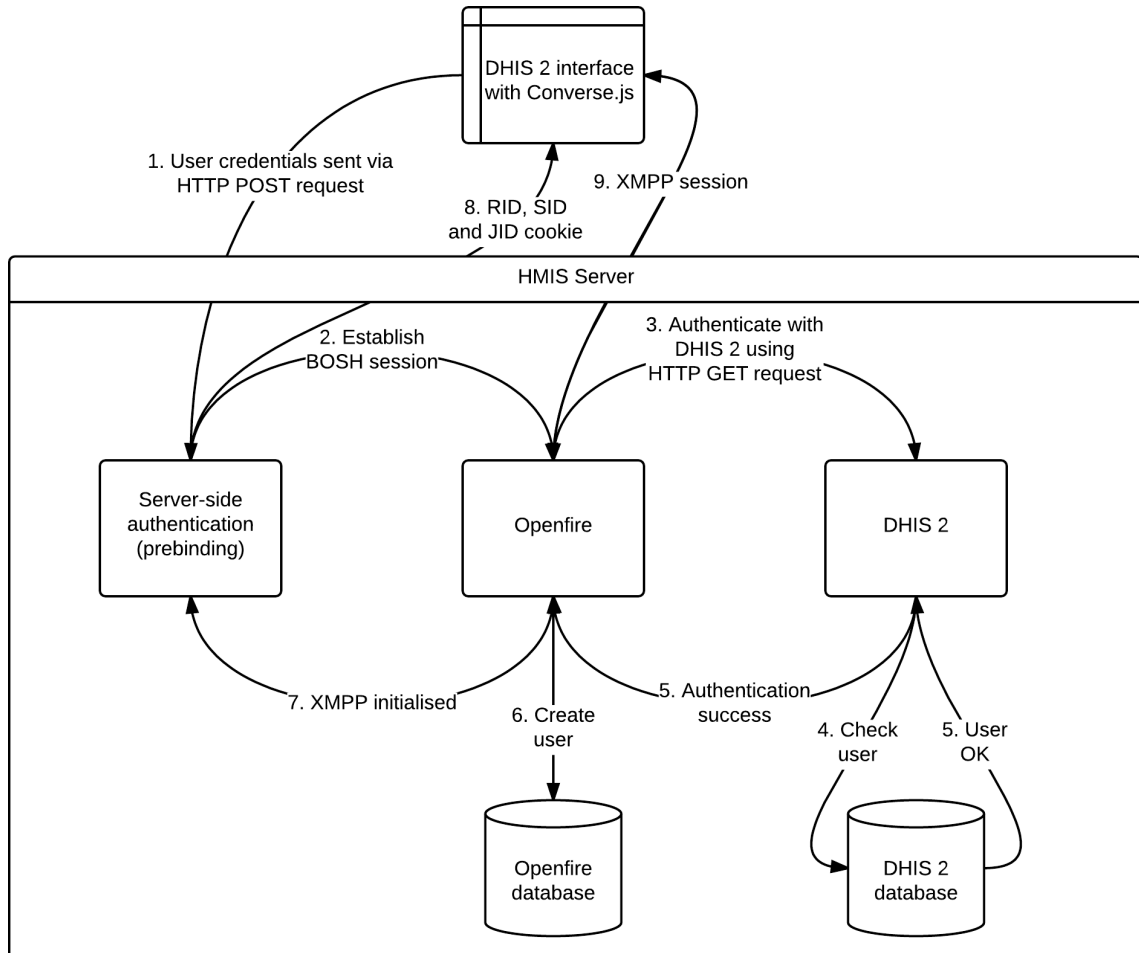


Figure 5.6: Final architecture of the IM feature

# Chapter 6

## Results

### 6.1 Introduction

In this chapter, results from the data collection is presented. The calculated internal consistency of the constructs, and the results from each construct are presented. Furthermore, results from the calculations of the correlations between both perceived usefulness and ease of use, and actual usage will be presented. Finally, I look into the potential differences in the perceived usefulness and ease of use based on how many times the user had used the IM feature.

### 6.2 Data Collection

As the users are spread out throughout Rwanda, the questionnaire was developed as an online survey using Google Forms<sup>1</sup>, rather than as a printed questionnaire as it is easier to distribute. In addition, it is easier to collect data using Google Forms as it automatically collects the responses in an online spreadsheet. The questionnaire was distributed by email on the 9th of April by the HMIS Supervisor at the Ministry of Health in Rwanda to all of the 74 district hospital data managers. The users were given about a week to participate in the survey as the closing of the survey deadline was set to the 17th of April. As the IM feature was up and running on the 24th of March and the survey was started the 9th or April, the participants had the opportunity to use the IM feature for two and a half week to three and a half week depending on when they responded to the survey.

A total of 47 (response rate of 65.28%) of the 74 distributed questionnaires were returned, where 33(70.21%) users responded to the French version, and the remaining 14(29.79%) to the English version. Seventy-two percent of the respondents (34 respondents) were male and 28%(13 respondents) were female. Most of the respondents were between 31 and 35 years old (42.55%). Additional demographics statistics are given in table 6.1.

### 6.3 Internal Consistency of Constructs

In order to examine the internal consistency of the constructs actual usage, perceived usefulness and perceived ease of use, their Cronbach alpha values were calculated. The alpha

---

<sup>1</sup>[www.google.com/forms/about](http://www.google.com/forms/about)

Characteristics	Option	Count	Percentage (%)
Age	Less than 24 years old	0	0
	25–30 years old	5	10.64
	31–35 years old	20	42.55
	36–40 years old	14	29.79
	More than 40 years old	8	17.02
Gender	Male	34	72.34
	Female	13	27.66

Table 6.1: Demographics statistics of respondents

value of the actual usage construct was 0.71, which according to table 4.1 in section 4.5 indicates individual reliability. For the constructs perceived usefulness and perceived ease of use, the alpha values were 0.96 and 0.94 respectively, which according to table 4.1 indicates that individual reliability for the constructs are excellent. The results from the examination of the internal consistency of the constructs therefore show that items in each construct correlate positively with each other, which indicates that they have something in common, and that they probably measure the same phenomenon, but different aspects of it.

## 6.4 Construct Results

The grand mean and standard deviation of the results from each construct were calculated and can be seen in table 6.2. Overall, the participants did not report to have used the IM feature a lot, with a mean of 2.84, and a somewhat high standard deviation of 0.97. However, the results show that the participants perceived the IM feature as moderately useful with a mean of 5.32 and easy to use mean of 5.58, with the insignificant standard deviations of 0.31 and 0.22.

Construct	Mean	Standard deviation	Cronbach's alpha
Actual Usage	2.84	0.97	0.71
Perceived Usefulness	5.32	0.31	0.96
Perceived Ease of Use	5.58	0.22	0.94

Table 6.2: Construct results

## 6.5 Items Results

The mean, mode, median and standard deviation for all items were calculated, as seen in table 6.3. The results for each construct are be summarized in the following sections.

### 6.5.1 Actual Usage

Viewing the results presented in table 6.3, it is evident that the participants had used the IM feature to some extent, with a times used mean of 3.81 and mode of 4, where 4 on the Likert scale corresponds with the IM feature being used 2-3 times by the user the past

Item	Mean	Mode	Median	Standard deviation
<b>Actual Usage</b>				
Times used	3.81	4	4	1.93
Hours used	1.87	1	1	1.44
Frequency of use	2.83	1	2	1.89
<b>Perceived Usefulness</b>				
Work more quickly	4.75	7	5	2.29
Job performance	5.30	7	6	1.90
Increase productivity	5.38	7	6	1.85
Effectiveness	5.43	7	6	1.95
Makes job easier	5.47	7	6	1.80
Useful	5.62	7	6	1.80
<b>Perceived Ease of Use</b>				
Easy to learn	5.23	6	6	1.76
Controllable	5.38	7	6	1.92
Clear & understandable	5.77	7	6	1.66
Flexible	5.74	7	6	1.50
Easy to become skilful	5.72	7	6	1.66
Easy to use	5.62	7	6	1.74

Table 6.3: Item results

week. However, the IM feature was only used for over short periods of time, with an hours used mean of 1.87 and mode of 1, where 1 on the Likert scale corresponds with the IM feature being used for less than 1 hour the past week. Furthermore, the results show that the participants had used the IM feature slightly infrequent, with a frequency of use mean of 2.83, and the majority of the users had used the IM feature extremely infrequent, with frequency of use mode 1. Results for all items show high standard deviation. The results from the actual usage measurement can additionally be seen in figure 6.1.

### 6.5.2 Perceived Usefulness

The results show that the participants believed that the IM feature could possibly moderately make them work more quickly, increase their job performance, productivity and effectiveness, make their job easier and be useful in their job with means between 4.75 and 5.67. Furthermore, the majority of the participants believed that the IM feature could possibly do so in an exceptional manner, as all the modes are 7 (figure 6.2). Results from the item asking the user if they believe that the IM feature could possibly make them work more quickly differs from the rest of the results from the perceived usefulness examination, with a somewhat lower mean (4.75) and higher standard deviation (2.29) than the other items in the same construct. Furthermore, the result showed that on average, the participants believed the IM feature to be useful more than any other item, with a mean of 5.62. The results further shows high standard deviation for all items in the construct.

### 6.5.3 Perceived Ease of Use

The results show that the participants found the IM feature to be moderately easy to learn, controllable, clear & understandable, flexible, easy to become skilful with and easy

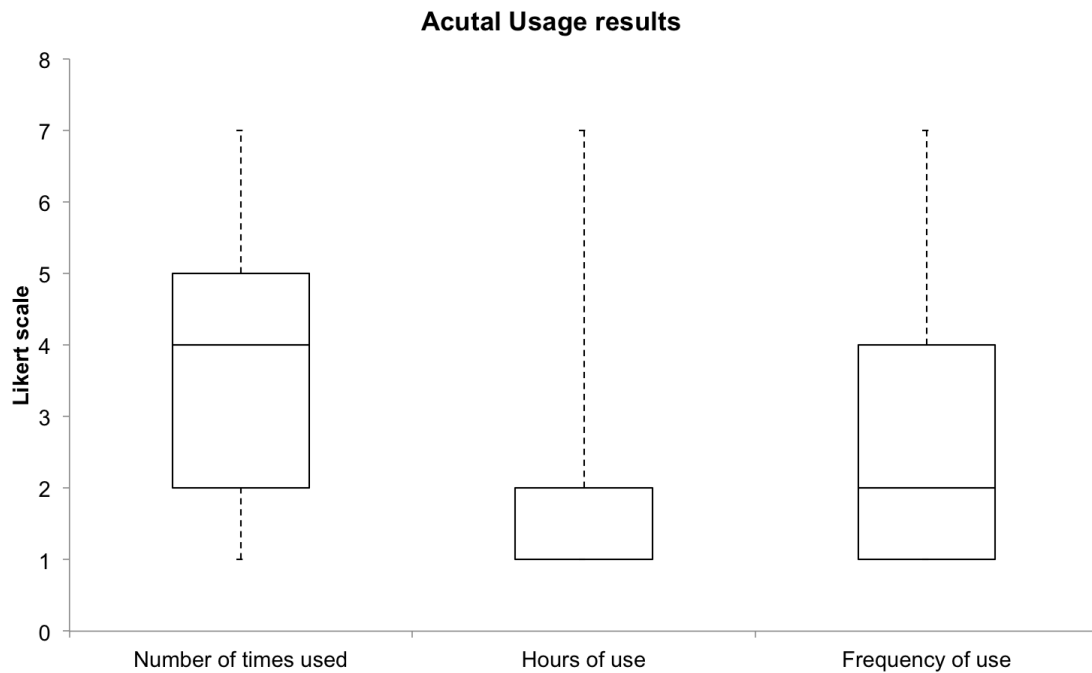


Figure 6.1: Box plot describing the actual usage of the IM feature

to use with means between 5.23 and 5.62. Furthermore, the majority of the participants found the IM feature to be so in an exceptional manner, with the modes of 6 to 7 (figure 6.3). On average, the participants found the IM feature to be somewhat less, but not substantially, easy to learn (5.23) and controllable (5.38) than the other items in the same construct. The results further shows high standard deviation for all items in the construct.

## 6.6 Correlation Between Perceived Usefulness and Actual Usage

Pearson correlation coefficient,  $r$ , and the respective significance values,  $p$ , were calculated for the results from all items in the perceived usefulness and actual usage constructs and can be viewed the correlation matrix showed in table 6.4.

Item	Times used	Hours used	Frequency of use
Work more quickly	$r = .22, p = .14$	$r = .24, p = .10$	$r = .06, p = .67$
Job performance	$r = .24, p = .10$	$r = .25, p = .09$	$r = .08, p = .59$
Increase productivity	$r = .25, p = .09$	$r = .22, p = .13$	$r = -.01, p = .94$
Effectiveness	$r = .20, p = .19$	$r = .24, p = .10$	$r = .18, p = .23$
Make job easier	$r = .15, p = .31$	$r = .17, p = .26$	$r = .04, p = .77$
Useful	$r = .24, p = .10$	$r = .22, p = .13$	$r = .10, p = .52$

Table 6.4: Matrix showing the correlation between perceived usefulness and actual usage

As can be seen in table 6.4, none of the calculated correlations exceeds the threshold value of 0.3 which is an indication of a moderate correlation, which means that all the



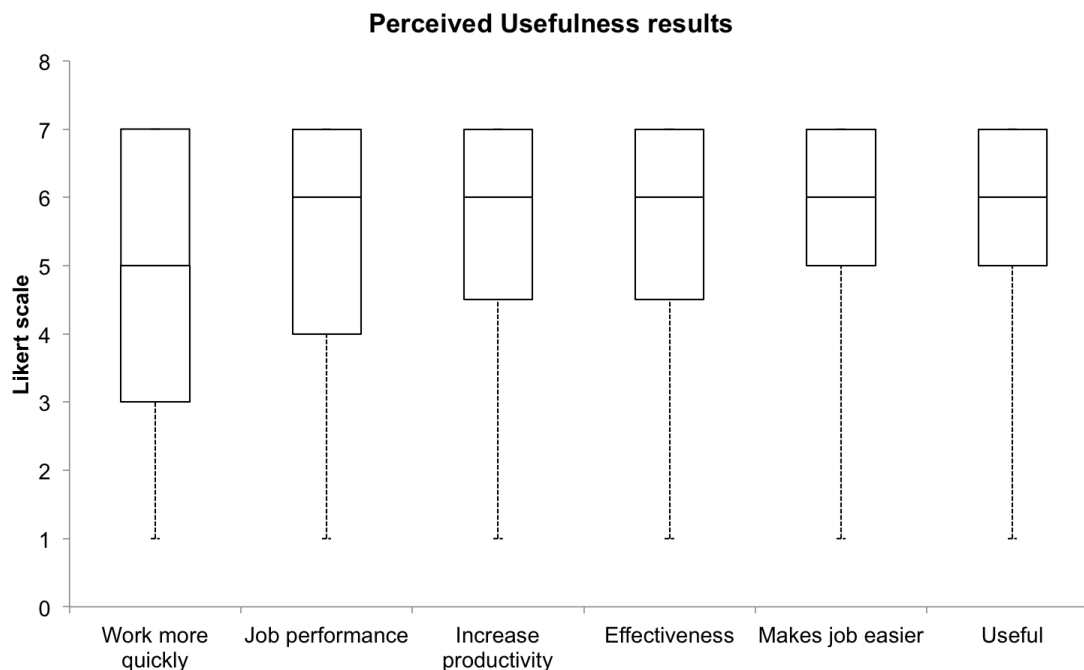


Figure 6.2: Box plot describing the perceived usefulness of the IM feature

correlations are considered as weak to non-existent. In addition, all the significance values are above the 0.05 significance level, which means that none of these results can be considered as statistically significant. However, looking at the calculated coefficients with a significance level of 0.10 or less, there are indications that correlations to some extent do in fact exist, as seen highlighted in table 6.4. Viewing the highlighted correlation coefficients in table 6.4, it can be seen that the correlation coefficients are still under the 0.3 mark for moderate correlation. However, the correlation coefficients are not very far from the threshold with values of 0.24-0.25. There is therefore a possibility that there is some correlation. Furthermore, there are no indications of any correlations between perceived usefulness and frequency of use.

## 6.7 Correlation Between Perceived Ease of Use and Actual Usage

Pearson correlation coefficient,  $r$ , and the respective significance values,  $p$ , were also calculated for the results from all items in the perceived ease of use and actual usage constructs, and can be viewed in the correlation matrix showed in table 6.5.

As can be seen in table 6.5, all the calculated correlations coefficient values, except for for three items, are below the 0.3 the threshold. Furthermore, the significance values are mostly above the 0.05 significance level. However, there is a moderate positive relationship between how the participants perceived the IM as controllable and the amount of times they had used it,  $r(45)=0.37$ ,  $p<0.05$ . In addition, there is also moderate positive relationship between how the participants perceived the IM as clear and understandable

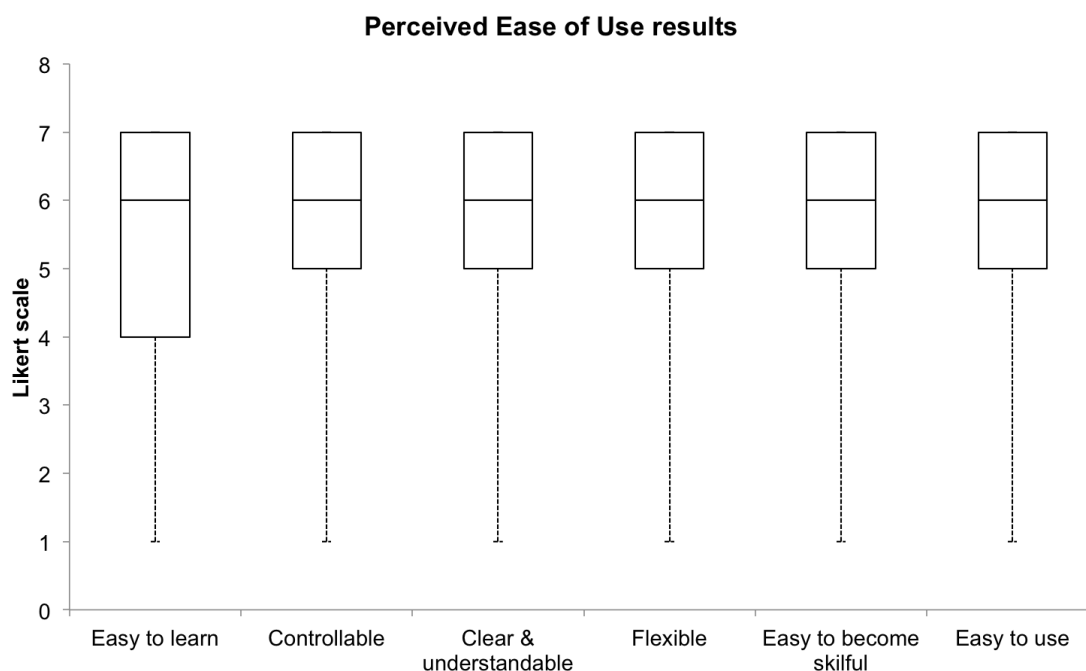


Figure 6.3: Box plot describing the perceived ease of use of the IM feature

Item	Times used	Hours used	Frequency of use
Easy to learn	$r = .27, p = .07$	$r = .11, p = .47$	$r = .20, p = .19$
Controllable	$r = .37, p = .01$	$r = .16, p = .28$	$r = .23, p = .13$
Clear & understandable	$r = .36, p = .01$	$r = .21, p = .16$	$r = .20, p = .18$
Flexible	$r = .28, p = .06$	$r = .16, p = .29$	$r = .20, p = .18$
Easy to become skilful	$r = .26, p = .08$	$r = .11, p = .45$	$r = .05, p = .75$
Easy to use	$r = .26, p = .08$	$r = .05, p = .74$	$r = .02, p = .90$

Table 6.5: Matrix showing the correlation between perceived ease of use and actual Usage

and the amount times they used it,  $r(45) = .36, p < 0.05$ . Furthermore, looking at the correlation coefficient with a significance level of 0.10 instead of 0.05, there are indications that there are correlations between all the perceived ease of use items and times used, as the correlation values are between 0.26 and 0.37. However, it does not seem to be any correlations between perceived ease of use and both hours used and frequency of use. The potential reason to this will be further discussed in the next chapter.

## 6.8 Difference Perceived Usefulness and Ease of Use Based on Times Used

It is interesting to see if there is a difference in how the participants responded to the perceived usefulness and perceived ease of use constructs based on how many times they reported to have used the IM feature in DHIS 2. To do this, results were split into two samples: those who had tried the IM feature once, and those who had tried it more than

once. The correlation between both perceived usefulness and ease of use and number of times the IM feature was then calculated for the two samples. Furthermore, the results from the two different samples were compared, and statistical hypothesis testes were conducted on the two samples in order to identify potential differences in the calculated means.

### 6.8.1 Correlation with Perceived Usefulness Based on Times Used

To see if there was a higher correlation between the perceived usefulness and the amount of times they had used the IM feature for those who had used it more than once, the Pearson correlation coefficient,  $r$ , and the respective significance values,  $p$ , were calculated for the two samples. The results can be viewed in the table 6.6.

Item	Once	More than once
Work more quickly	$r = .17, p = .25$	$r = .36, p = .01$
Job performance	$r = .11, p = .47$	$r = .42, p = .00$
Increase productivity	$r = .23, p = .13$	$r = .25, p = .09$
Effectiveness	$r = .13, p = .38$	$r = .39, p = .01$
Make job easier	$r = .18, p = .23$	$r = .28, p = .06$
Useful	$r = .20, p = .18$	$r = .41, p = .00$

Table 6.6: Correlation with perceived usefulness based on times used

The results show that for the users who reported to have used the IM feature only once, none of the calculated correlations were significant as all the  $p$  values are below the 0.05 significance level. However, for the participants who had use the IM feature more than once, four out of six of the calculated correlations between perceived usefulness and actual usage were significant, while the remaining two were close to significant with  $p$  values of 0.09 and 0.6. Further, the results show moderate correlations between the amount of times the IM feature was used and the questions regarding the IM features ability to make them work more quickly, enhance their job performance, increase their effectiveness and its usefulness with  $r$  values of 0.36, 0.42, 0.39 and 0.41 respectively. The remaining two items regarding increased productivity and making the job easier are close to the 0.3 threshold for moderate correlation with values of 0.25 and 0.28. Compared to the earlier calculated correlations where for all users were included, there are significantly more indications of correlations between the perceived usefulness and number of times the IM feature was used for those who had used it more than once.

### 6.8.2 Correlation with Perceived Ease of Use Based on Times Used

The correlation between the perceived ease of use and number of times used for the different samples was also calculated, as seen in table 6.7.

For the sample who had only used the IM feature once, the results show moderate correlations for the IM feature being perceived as controllable( $r=0.44, p=0$ ), clear & understandable( $r=0.3, p =0.04$ ), easy to become skilful with ( $r=0.46, p=0.02$ ) and easy to use( $r=0.36, p=0.02$ ). For the sample who had used the IM feature more than once, four out of the six of the calculated correlations were close to the 0.3 threshold for moderate

Item	Once	More than once
Easy to learn	$r = .17, p = .25$	$r = .24, p = .10$
Controllable	$r = .44, p = .00$	$r = .29, p = .04$
Clear & understandable	$r = .30, p = .04$	$r = .28, p = .06$
Flexible	$r = .20, p = .17$	$r = .29, p = .04$
Easy to become skilful	$r = .36, p = .02$	$r = .29, p = .05$
Easy to use	$r = .34, p = .02$	$r = .21, p = .14$

Table 6.7: Correlation with perceived ease of use based on times used

correlations with significance values below or close to 0.05. Compared to the earlier calculated correlations where for all users were included, the calculated correlations based on the sample who had used the IM feature more than once were somewhat weaker.

### 6.8.3 Comparison of the Results From the Two Samples

A comparison of the two samples can be viewed in figure 6.4 and figure 6.5, where S1 is the sample of users who had used IM feature more than once, S2 is the sample of users who had used the IM feature only once. The results show that the participants who had used the IM feature more than once perceived the it to be more useful and easier to use than those had used it only once, as the the first quartiles in the box plots are generally higher. Additionally, results from those who had used the IM feature only once show higher variation, as the differences from the first quartiles to the thirds are generally higher.

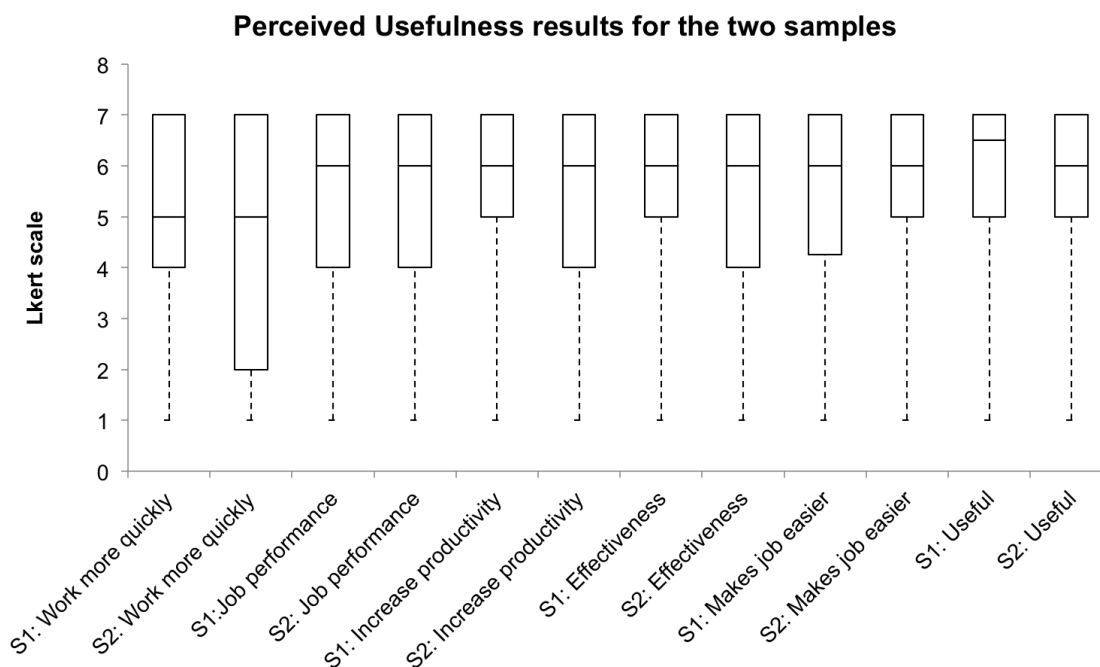


Figure 6.4: Box plot comparing the perceived usefulness of the two samples

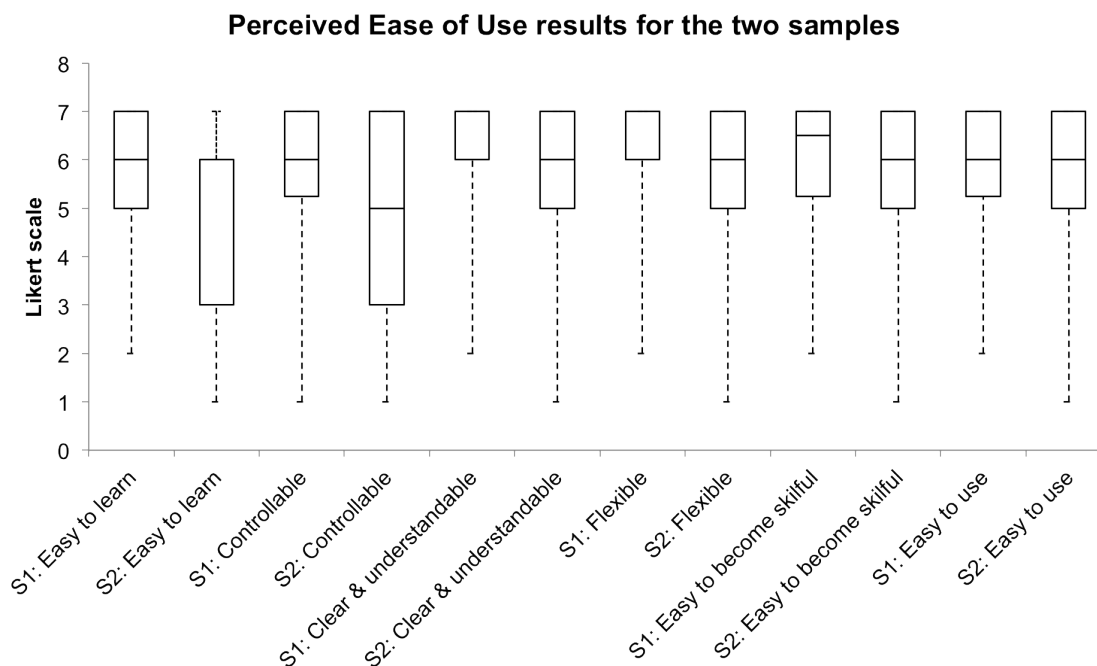


Figure 6.5: Box plot comparing the perceived ease of use of the two samples

#### 6.8.4 Statistical Hypothesis Testing

Students *t*-tests were used to test the hypotheses to see if there was significant difference between the means of two samples. The *t* values obtained from the *t*-test can be viewed in table 6.8. Furthermore, the *p* values for each *t*-test was computed in order to investigate the probability that the differences between the means of the two samples was due to chance, assuming that the null hypothesis were true. The closer the *p* value is to zero, the higher the probability for the null hypothesis being false. The computed *p* values are also shown in table 6.8.

Comparing the *p* values to an acceptable significance level such as 0.05, it is evident that only the computed *p* value for the hypothesis concerning the IM feature being perceived as clear and understandable was under the significance level with a *p* value of 0.04. It is therefore possible to state that the observed effect is statistically significant, which means that the null hypothesis is therefore reject, and the alternative hypothesis accepted. Accepting the alternative hypothesis, the following statement with 4% chance of error can be made: “the participants who had used the IM feature more than once perceived it as more clear and understandable than those who had only used it once”. Three of the computed *p* values were in the interval of 0.05-.0.10: controllable ( $p=0.06$ ), easy to learn ( $p=0.09$ ) and flexible( $p=0.10$ ). Therefore, the following statement, with a 6-10% chance of making an incorrect statement, can be made: “The users who had used the IM feature more than once perceive it to be more controllable, easy to learn and flexible than those who had used it once”.

Item	t-value	p-value
Perceived Usefulness		
Work more quickly	0.53	0.30
Job performance	0.64	0.26
Increase productivity	0.96	0.17
Effectiveness	0.29	0.39
Makes job easier	0.13	0.45
Useful	0.48	0.32
Perceived Ease of Use		
Easy to learn	1.33	0.09
Controllable	1.56	0.06
Clear & understandable	1.83	0.04
Flexible	1.31	0.10
Easy to become skilful	0.74	0.23
Easy to use	0.99	0.16

Table 6.8:  $t$  values and  $p$  values from the students  $t$  tests for the given hypotheses

# Chapter 7

## Discussion

### 7.1 Introduction

In this chapter the results will be discussed, how they relate to the research questions and how they differ from or correspond with the results from some of the studies described in chapter 2. It is important to note that the IM feature had only been available to the users for only 2-3 weeks at the moment of data collection, and that only 47 users participated in the survey. This might, and most probably have, had a greater impact on the results obtained in this study. As a consequence, a potential follow-up study is suggested in section 8.4. In this chapter, I discuss the statistical material that had the opportunity to obtain, and try to look into some of the factors that might have led to the given results.

### 7.2 Initial Reception of IM in DHIS 2

The first research question raised in this study was “How is Instant Messaging in DHIS 2 initially received?”. As means for answering this research question, a survey for determining the actual IM usage of the users was conducted. The actual usage was measured using items adapted from a study by Moon and Kim[50], which measured three extends of actual usage: times per week, hours per week and frequency of usage. The internal consistency of the adapted measures were examined by calculating the Cronbach’s alpha. Results from the calculation showed that the construct measuring the actual usage had a Cronbach’s alpha of 0.71, which is a indication of good internal consistency. However, the Cronbach’s alpha value obtained from this study is noticeably lower than the alpha value obtained from a study by Lu et al.[46], where the same measures for measuring IM usage was used, and an alpha value of 0.90 was obtained. Lu et al.[46] most likely obtained a greater Cronbach’s alpha than the one obtained from this study due to a higher number of participants, as the number of participants plays a crucial role in the equation for calculating Cronbach’s alpha. The study by Lu et al.[46] had 250 participants whereas this study had 47.

The grand mean of the actual usage measuring construct was calculated in order to give an overview of the actual usage, and the result from the calculation was 2.84. On a scale from 1-7, this indicates that the users did not use the IM feature a lot. To compare, the study by Lu et al.[46] used the same measurements to measure the actual IM usage in the everyday life of 250 high school students, undergraduate students, and working professionals in a high school in China, and their mean result was 4.05. Lu et al.[46]

used a 7 point Likert scale with labels identical to the one used in this study. Thus, the participants of this study reported to on average have used the IM feature more than 1 point (on a 7 point scale) less than the reported by the users in the study by Lu et al.[46]. There may be several reasons why the participants had not used the IM feature to a greater extent. One reason could be that the IM feature had only been available for two to three weeks when the data was collected, and it is possible that the usage has increased or decreased since then. Another reason could be that the context of this study is entirely different from the context of the study by Lu et al.[46]: while this study examined the IM usage in work context among users in Rwanda, the study Lu et al.[46] measured the IM usage on a day-to-day basis amongst Chinese users. The last imaginable reason, which is the reason that I suspect might have had greatest impact on the usage of the IM feature of them all, is the failure to reach critical mass, which is further reflected on in the conclusion.

Viewing the results it was evident that the users had used the IM feature to some extent, but for only over short periods of times and quite infrequently. It can be assumed that the users used the IM feature for rapid exchanges addressing a single purposes, such as quick question clarifications or for scheduling meetings, in the same manner as the they use DHIS 2 Messaging, as presented by examples in section 3.4.1. This could be the reason to why the users reported to have used the IM feature several times but not for longer periods. However, based on the methodology used in this project, it is not possible to know what the user have used the IM feature for, and in the future it could be interesting to look into this. Furthermore, as the users had only been able to use the feature for 2-3 weeks at the moment the responses were collected, it is possible that usage pattern may have changed since then.

### 7.3 Perceived Usefulness of Instant Messaging in DHIS 2

The second research question raised in this study was "How is Instant Messaging in DHIS 2 perceived as useful, and how does the perceived usefulness correlate with the actual usage?". To begin with, the first part of this research question regarding how the IM feature was perceived as useful by the users will be discussed.

The individual reliability of the construct measuring the perceived usefulness was calculated using Cronbach's alpha, the results from the calculation proved excellent individual reliability of the construct with an alpha value of 0.96. The studies by Wang et al.[75] and Lu[46] et al., presented in section 2.8.2, also measured the perceived usefulness of IM and obtained Cronbach's alpha's of 0.89 and 0.87. Thus, the Cronbach's alpha for the perceived usefulness construct obtained from this study was considerably higher than the ones obtained from the studies by Wang et al.[75] and Lu[46].

The results showed that the users perceived the IM feature as moderately useful, with a mean of 5.32 on a scale from 1 to 7. Compared to the results from some of the studies mentioned in section 2.8.2, the results from this study do not differ much. The study by Lu et al.[46] used the same measures to measure the perceived usefulness of IM and the results showed a mean of 5.88. The study by Li et al. [41] measured the perceived usefulness of IM by 273 US undergraduate students and 341 Chinese graduate students obtained a mean of 5.58 for the US students, and 5.48 for the Chinese students. Lou et al.[45] applied the perceived usefulness measures to study the perceived usefulness of IM by 331 US undergraduate students, and obtained a mean of 5.88. Thus, the mean obtained from this study was higher than the one from the study by Lu et al.[46] and slightly below



the means obtained from studies by Li et al. [41] and Lou et al.[45]. However, there are major differences between these studies and this study, as the aforementioned studies measured the perceived usefulness of IM in daily life, whereas this study measured the perceived usefulness of an IM feature in work context. In addition, the aforementioned studies had 5-7 times as many participants.

Furthermore, the results show that the users believed that the IM feature could possibly moderately make them work more quickly, increase their job performance, productivity and effectiveness, make their job easier and be useful in their job. The majority of the users believed that it could possibly do so in an exceptional manner. The mean of the results from the question asking the use if they believed that the IM feature could possibly make them work more quickly was lower than the means of all the other results, in addition to having a higher standard deviation. It is difficult to know why the results from this question differs from the rest of them without asking the users themselves. However, a reason could be that this question differs from the others, as to which extent the user is able to work more quickly be can measured externally by someone else, whereas all the other questions are based on the users own perception and assumed measures. Furthermore, the high standard deviation may be caused by the question being interpreted in different ways by the users.

Viewing the results it was further discovered that the user who had used the IM feature more than once perceived it to be, on average, more useful than those had used it only once. It can be assumed that this may be the result of one of two things: the perceived usefulness of the IM feature increased as the users used the it, or, the user used the IM feature more as a consequence of perceiving it as more useful. The results further showed higher standard deviation for all results of the perceived usefulness construct for those who had used the IM feature only once compared to the results of those who had use it more than once. The higher standard deviations may have been caused by a higher uncertainty in the perceived usefulness of the IM feature due to only using it once.

## 7.4 Correlation Between Perceived Usefulness and Actual Usage

The second research question raised in this study was “How is Instant Messaging in DHIS 2 perceived as useful, and how does the perceived usefulness correlate with the actual usage?”. The second part of this research question regarding the correlation between perceived usefulness and actual usage will be discussed.

The correlations between perceived usefulness and actual usage were calculated using Pearson’s correlation coefficient and the results showed that none of the correlation coefficients were significant at the 0.05 level. Looking at the calculated coefficients with a significance level of 0.10 or less, there were some indications of correlations between almost all items in the perceived usefulness construct and either the amount of times used or the amount of hours used. It can therefore be said that there are some weak indications correlations between the perceived usefulness of the IM feature and amount of times and hours it was used. However, there were no signs of any correlation between the user perceiving the IM feature as able to make their job easier and their actual usage of it. This does not necessarily mean that the users did not think the IM feature could make their job easier, it means that their thoughts about the IM feature making their jobs easier was not a reflection of their actual usage of it. Furthermore, the results showed no correlation

between perceived usefulness and frequency of use, without knowing a potential reason behind this.

These calculated correlations included the users who had used the IM feature only once. It was therefore of interest to exclude these users from the calculations and look into the correlations between perceived usefulness and actual usage for those who had used the IM feature more than once. The results from the new calculations were completely different from the initial ones. Now, four out of six of the calculated correlations indicated significant moderate positive relationships between perceived usefulness and actual usage. The two remaining calculated correlations were close to significant with  $p$  values of 0.09 and 0.6, and they were close to the 0.3 threshold for moderate correlation with  $p$  values of 0.25 and 0.28. It is therefore fair to say that for the users who had used the IM feature more than once, the perceived usefulness of the IM feature did in fact, to some extent, correlate their actual usage of it.

While none of the studies mentioned in chapter 2 looked into the relationship between perceived usefulness and actual usage of IM, Lu et al.[46] found that the perceived usefulness remarkably affected the users attitude towards using IM. Furthermore, Lou et al.[45] found that the behavioural intention to continue using IM can be predicted by its perceived usefulness. Assuming that there is some relationship between attitude towards using and actual usage, the findings from this study can be said to be consistent with the studies of Lu et al.[46] and Lou et al.[45]. Furthermore, the findings from this study is in agreement with the studies[2, 23, 31, 69, 70] mentioned in the section 4.2.1, verifying the presence of a relationship between perceived usefulness and actual usage of information technology.

## 7.5 Perceived Ease of Use of Instant Messaging in DHIS 2

The third research question raised in this study was “How is Instant Messaging in DHIS 2 perceived as easy to use, and how does the perceived ease of use correlate with the actual usage?”. The first part of this research question regarding how the IM feature was perceived useful by the users, will now be discussed.

The individual reliability of the construct measuring the perceived ease of use was calculated using Cronbach’s alpha, the results from the calculation proved excellent individual reliability of the construct with an alpha value of 0.94. The studies by Wang et al.[75] and Lu et al.[46] et al., also measuring the perceived ease of use of IM, obtained Cronbach’s alpha’s of 0.91 and 0.86. Thus, the Cronbach’s alpha for the perceived ease of use construct obtained from this study was higher than the ones obtained from the studies by Wang et. al[75] and Lu et. al[46].

The results showed that the used perceived the IM feature as moderately easy to use, with a mean of 5.58 on a scale from 1 to 7. Compared to the study by Lu et al.[46] which used the same measures to measure the perceived ease of use of IM, a mean of 5.34 was obtained. Thus, the users from this study perceived the IM feature as more useful than the ones from the study by Lu et al.[46]. However, as mentioned earlier, there is major difference between the study of Lu et al.[46] and this study, as Lu et al.[46] studied the perceived ease of use of IM systems used in daily life whereas this study measured the perceived usefulness of an IM feature in work context.

The results further showed that the users found the IM feature to be moderately easy to learn, controllable, clear & understandable, flexible, easy to become skilful with and easy to use. The majority of the users believed it to be so in an exceptional manner. However,

the users found the IM feature to be somewhat less easy to learn and controllable than the other items in the same construct. These items might be related to each other: the more controllable, the easier to learn. Furthermore, the users perceived it to be easier to become skilful with the IM feature, than learning how to use it. According to Davis[22], both the items concerns the ease of learning, but he does not discuss the difference between these two items. It can be assumed that the difference in results for these items was a consequence of the questions being interpreted different ways by the users.

Viewing the results it is evident that the users who had used the IM feature more than once perceived it to be easier to use than those who had used it only once. It can be assumed that this may be results of one of two things: the more the users used the IM feature, the more they perceived it as easy to use, or, the users who perceived it to be more easy use consequently used it more. The results further showed higher standard deviation for all results from the perceived ease of use construct of those who had used the IM feature only once compared to the results for those who had use it more than once. The higher standard deviations may have been caused by a higher uncertainty in the perceived usefulness IM feature due to only using it once.

## 7.6 Correlation Between Perceived Ease of Use and Actual Usage

The third research question raised in this study was "How is Instant Messaging in DHIS 2 perceived as easy to use, and how does the perceived ease of use correlate with the actual usage?". The second part of this research question regarding the correlation between perceived ease of use and actual usage will now be discussed.

The correlations between perceived ease of use and actual usage was calculated using Pearson's correlation coefficient. Result from the calculation showed there was a moderate positive relationship between how the users perceived the IM as controllable and the amount of times they had used it, which means that the amount of times the user used the IM feature somewhat correlated on how controllable they perceived it to be. In addition, there was also a moderate positive relationship between how the users perceived the IM as clear and understandable and the amount times they used it. Looking at the correlation coefficient with a significance level of 0.10 or less, there were indications of correlations between all the perceived ease of use items and times used. It is therefore possible to state with some uncertainty that the perceived ease of use of the IM feature to some extent correlated with the amount of times they used it, and that the perceived controllability and understandability were the most important factors of the correlations with the amount of times it was used. However, there were no signs of any correlations between perceived ease of use and both hours used and frequency of use, and is not possible to know the reason to this based on the given results.

These calculated correlation included the users who had used the IM feature only once. It was of interest to exclude these users from the calculations. The results from the new calculations were different from the initial ones, as the indications of correlations were now somewhat weaker. However, the correlations were not weaker to the extent that there was a significant difference. Noticeably, there was no indication of a correlation between the IM feature being perceived as easy to use and the amount of times it was used, without knowing any possible reason behind this.

None of the studies mentioned in the chapter 2 looked into the correlation between the

perceived ease of use of IM on its actual usage. However, as this study found indications that the perceived ease of use of the IM correlates its actual usage, it is in agreement with the studies[2, 23, 31, 69, 70] mentioned in section 4.2.1, verifying the presence of a relationship between perceived ease of use and actual usage of information technology.

# Chapter 8

## Conclusion

In this chapter, a summary of the discussion is given, and the results from this study and the method used is reflected upon. As the data material obtained from this study was somewhat sparse due the chosen method, leaving the discussion affected by much uncertainty, this study is finished by the proposal of a potential follow-up study.

### 8.1 Summary of Discussion

The internal consistency of the constructs measuring the actual usage, perceived usefulness and ease of use of the IM feature was calculated using Cronbach's alpha, and the results from the calculation proved good individual reliability of all the constructs.

The results from the survey measuring the actual usage of the IM feature showed that the users did not use the IM feature a lot. This might be due to the IM feature only being available for two to three weeks at the time the data was collected, and it is possible that the usage has increased or decreased since then. Another reason might be due to a potential failure to reach critical mass, which will be reflected on in the next section.

The results further showed that even though the users had used the IM feature to some extent, it was only used only over short periods of times and quite infrequently. The reason to this is unknown, but it can be assumed that the users used the IM feature for quick question clarifications or for scheduling meetings in the same manner as the they use the already established messaging feature in DHIS 2.

It was further found that the users perceived the IM feature as moderately useful, and that they believed that the IM feature could possibly moderately make them work more quickly, increase their job performance, productivity and effectiveness, make their job easier and be useful in their job. It was also discovered that the user who had used the IM feature more than once perceived it to be, on average, more useful than those had used it only once. Results from the calculations for the Pearson correlation coefficients between perceived usefulness and the actual usage showed indications of week correlations. However, results from the calculated correlation coefficients for those who had used the IM feature more than once showed stronger indications that the perceived usefulness did in fact correlate with their actual usage of it.

Results from the part of the questionnaire measuring the perceived ease of use of the IM feature showed that the users perceived the IM feature as overall moderately easy to use. It was further found that the users thought that the IM feature was moderately easy to learn, controllable, clear & understandable, flexible and easy to become skilful with. In

addition, it was found that the users who had used the IM feature more than once perceived it to be easier to use than those who had used it only once. Results from the calculations for the Pearson correlation coefficients between perceived ease of use and the actual usage showed the perceived ease of use of the IM feature to some extent correlated with user's actual usage of it, and that the perceived controllability and understandability were the most important factors in the correlation. For those who had used the IM feature more than once, the indications of correlations were somewhat weaker, but not significantly.

To summarize, results showed that the users had used the IM feature to some extent, but only over short periods of times and quite infrequently. The users perceived the IM feature to be moderately both useful and easy to use. Furthermore, there were indications that the perceived usefulness and ease of use of the IM featured correlated with the user's actual usage of it. This is in agreement with past research[2, 23, 31, 69, 70], which has verified the presence of a relationship between perceived usefulness and actual usage of information technology.

## 8.2 Reflection

In this study, an IM feature based on XMPP technology was assembled and implemented in the Health Management Information System DHIS 2 in Rwanda. The research objective of this study was to examine how the implemented IM feature was initially received, how it was perceived as useful and easy to use, and how these perceptions potentially correlated with the actual usage of it. As means to examine the questions raised, a survey measuring the actual usage, perceived usefulness and ease of use of the IM feature was conducted.

As the results from the survey measuring the actual usage of the IM feature showed that the users did not use the IM feature a lot, it is suspected that there has been a potential failure to reach critical mass. As a user, using IM without other users is meaningless, and there has therefore been a focus on trying to select the most highly connected pairs of users who resided at different sites for exposing the IM feature to, in other words, trying to pinpoint the group of users who most frequently communicate electronically with each other. The idea behind this strategy was to try to achieve a critical mass of users, as critical mass is of crucial importance when it comes to technology acceptance by the users. The importance of achieving a critical mass for IM adoption was reinforced by the study by Lou et al.[45] which found that the IM usage was driven by the number of employees using it. According to the Head of Integrated HMISs, the district hospital data managers were assumed to be the group of users who most frequently communicate with each, and they were therefore chosen to be the participants in this study. However, as these users might frequently communicate with each other, it does not mean that they are using DHIS 2 simultaneously. This became evident after the IM feature was implemented, as it became possible to observe who was actually logged into DHIS 2 by seeing if they were online in the IM feature. While there was usually no more than 4-5 users online at the same time, it was always a different combination of users. Through these observations it became evident that the district hospital data managers in fact use DHIS 2 frequently, but although in sporadic sessions and at different times. Before implementing the IM feature I was under the impression these users used DHIS 2 throughout their day at work. After asking the Head of Integrated HMIS about this, he confirmed that these users in fact usually worked at different times, and it seem to have been a misunderstanding between me and the Head of Integrated HMIS. As a consequence, the users had limited possibilities for using the IM

feature as the different co-workers were only occasionally online and available for chatting. This, in combination with the IM feature being available for only 2-3 weeks, may have caused the potential failure to reach critical mass. Ideally, a user group who frequently communicate and are simultaneously logged into DHIS 2 should have been chosen for the implementation.

In terms of choice of method, using a TAM adapted questionnaire has limited explanatory power of the study in terms of determining the perceived usefulness and ease of use of the users. As the questionnaire asked only a limited amount of information without explanation, it has not been possible to obtain in-depth insight to why or why not the users perceive the IM feature to be useful and easy to use. In addition, collecting data through a questionnaire there is no way to tell how truthful the participant is being, and how much thought he or she has put into the answers. Furthermore, as the participants replied to the questions based on their own interpretations, and as each question can be interpreted in many different ways, there is a level of subjectivity which is not accounted for. Ideally, the questionnaire should have been supplemented with interviews as means to address the aforementioned disadvantages. As interviews were not conducted due to the given circumstances making it difficult and impractical, a potential follow-up study is purposed in section 8.4.

Another factor which have had a greater impact on ability of this study to draw conclusions, is the limited number of participants in the conducted survey. With only 47 participants, related studies[46, 41, 45] have had several times as many participants. As the number of participants plays a crucial role the the calculation of the correlation between two variables, the limited number of participants in this study is most probably the reason behind the lack of results with high significance value. As a consequence, it has been difficult to identify any potential correlation between the actual usage of the IM feature and its perceived usefulness and ease of use.

### 8.3 Future Work

In terms of the technical aspects of the IM implementation, there are a few things that could be further developed. The temporary solution of fetching the user credentials via JavaScript from the login screen of DHIS 2 of should be addressed. This process should take place server-side, which could be done by developing it as a module in the DHIS 2 core, as it would remove the abundant authentication round trips of the current solution. In addition, the integration between DHIS 2 and Openfire should be further developed to handle the deletion of users. Furthermore, the Converse.js JavaScript library used in the current implementation in Rwanda should be updated to the latest release, and the group chat feature of Converse.js should be enabled and tested. Most importantly, the IM feature is ready to be released to all users in the HMIS in Rwanda, which can simply be done by doing a minor configuration in the login script. Ideally, all the aforementioned suggestions for further development should addressed before doing so.

### 8.4 Proposed Follow-up Study

As circumstances outside of my control prevented me from applying the methods which I desired, I propose a follow-up study. A potential follow-up study could be conducted in a six months time, and the same survey could be conducted as the users have had

more time to use the IM feature. As the IM feature have proven to be stable, it is now possible to expose it to every user in the HMIS. All these users, about 1000, could be invited to participate in the new survey, which would create a more solid basis for drawing conclusions. It should also be possible to record the actual usage of the IM feature by the users, as the self-reported usage does not necessarily accurately reflect their actual usage. In addition, the survey could be supplemented with interviews in order to give in in-depth insights to why or why not the users perceive the IM feature to be useful and easy to use. As the IM feature could be made available for all users for a potential follow-up study, five or six user could be interviewed, preferably one of from each user group at the different levels in the health system. By conducting interviews in a potential follow up-study, it is possible to raise new interesting questions. This study looked into the correlation between the IM feature actual usage and its perceived usefulness and ease of use. However, correlation does not imply causation, meaning that a correlation between two variables does not necessarily imply that one causes the other. By asking the users through interviews, it is possible to examine how the perceived usefulness and ease of use of the IM feature have, or have not, a causal relationship with the actual usage of it. I therefore propose the following research question for a potential follow-up study:

**RQ 1** *How does the perceived usefulness and actual usage of Instant Messaging in DHIS 2 have a causal relationship?*

**RQ 2** *How does the perceived ease of use and actual usage of Instant Messaging in DHIS 2 have a causal relationship?*

A follow-up study could also be used in conjunction with this study, to see if the actual usage, perceived usefulness and ease of use changes over time. Furthermore, it could be of interest to see if the communication pattern of the users have changed as a new medium has been introduced in DHIS 2. For example, one could investigate if some of the communication has move from other mediums, such as DHIS 2 Messaging, to the newly introduced IM feature. It could also be interesting to investigate what type of communication that takes place in each medium, as well as identify who the users are communication with using which medium.



# Bibliography

- [1] Carla AbouZahr and Ties Boerma. Health information systems: the foundations of public health. *Bulletin of the World Health Organization*, 83(8):578–583.
- [2] Dennis A. Adams, R. Ryan Nelson, and Peter A. Todd. Perceived Usefulness, Ease of Use, and Usage of Information Technology: A Replication. *MIS Quarterly*, 16(2):227, June 1992.
- [3] Ritu Agarwal and Elena Karahanna. Time Flies When You’re Having Fun: Cognitive Absorption and Beliefs about Information Technology Usage. *MIS Quarterly*, 24(4):665, December 2000.
- [4] I Ajzen and M Fishbein. Understanding attitudes and predicting social behaviour. 1980.
- [5] Icek Ajzen. The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2):179–211, December 1991.
- [6] Kwasi Amoako-Gyampah and A.F. Salam. An extension of the technology acceptance model in an ERP implementation environment. *Information & Management*, 41(6):731–745, July 2004.
- [7] Lynda M. Applegate, Clyde W. Holsapple, Ravi Kalakota, Franz J. Radermacher, and Andrew B. Whinston. Electronic commerce: Building blocks of new business opportunity. *Journal of Organizational Computing and Electronic Commerce*, 6(1):1–10, November 2009.
- [8] David W. Bates. Effect of Computerized Physician Order Entry and a Team Intervention on Prevention of Serious Medication Errors. *JAMA*, 280(15):1311, October 1998.
- [9] Sussane Bodker. Creating Conditions for Participation: Conflicts and Resources in Systems Development. *Human–Computer Interaction*, 11(3):215–236, November 2009.
- [10] Jørn Braa, Eric Monteiro, and Sundeep Sahay. Networks of action: sustainable health information systems across developing countries. *Mis Quarterly*, pages 337–362, 2004.
- [11] Jørn Braa and Sundeep Sahay. Participatory Design within the HISP network. *Routledge International Handbook of Participatory Design*, page 235, 2012.

- [12] Julie Carter Allison Cashwell Michael Dubs David Kessel Channing King Jennifer Kur Caryl E. Rusbult, Christopher R. Agnewb. The investment model scale: Measuring commitment level, satisfaction level, quality of alternatives, and investment size.
- [13] Central Intelligence Agency (CIA). The World Factbook. *The World Factbook*, 2014.
- [14] G. W. Cheung. Testing Factorial Invariance across Groups: A Reconceptualization and Proposed New Method. *Journal of Management*, 25(1):1–27, February 1999.
- [15] Lei Chi and Clyde W. Holsapple. Understanding computer mediated interorganizational collaboration: a model and framework. April 2013.
- [16] Wikipedia Contributors. Languages of Rwanda, 2014.
- [17] Wikipedia Contributors. Openfire, 2014.
- [18] Wikipedia Contributors. Economy of Rwanda, 2015.
- [19] Wikipedia Contributors. Rwanda, 2015.
- [20] Lee J. Cronbach. Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3):297–334, September 1951.
- [21] Scott E. Hudson Daniel Avrahami. Balancing Performance and Responsiveness Using an Augmented Instant Messaging Client.
- [22] Fred D. Davis. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13(3):319, September 1989.
- [23] Fred D. Davis, Richard P. Bagozzi, and Paul R. Warshaw. User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. *Management Science*, 35(8):982–1003, August 1989.
- [24] H. de Vos, H. Hofte, and H. de Poot. IM [@work]: adoption of instant messaging in a knowledge worker organisation. In *37th Annual Hawaii International Conference on System Sciences, 2004. Proceedings of the*, page 10 pp. IEEE, 2004.
- [25] Guus der Kinderen. Openfire 3.7.0 has been released!, 2011.
- [26] The XMPP Standards Foundation. About XMPP.
- [27] XMPP Standards Foundation. Jabber Instant Messaging User Base Surpasses ICQ, 2003.
- [28] David Gefen. What Makes an ERP Implementation Relationship Worthwhile: Linking Trust Mechanisms and ERP Usefulness, December 2014.
- [29] David Gefen, Elena Karahanna, and Detmar W. Straub. Trust and TAM in online shopping: an integrated model. *MIS Quarterly*, 27(1):51–90, March 2003.
- [30] Rebecca E. Grinter and Leysia Palen. Instant messaging in teen life. In *Proceedings of the 2002 ACM conference on Computer supported cooperative work - CSCW '02*, page 21, New York, New York, USA, November 2002. ACM Press.

- [31] Anthony R. Hendrickson, Patti D. Massey, and Timothy Paul Cronan. On the Test-Retest Reliability of Perceived Usefulness and Perceived Ease of Use Scales. *MIS Quarterly*, 17(2):227, June 1993.
- [32] James D. Herbsleb, David L. Atkins, David G. Boyer, Mark Handel, and Thomas A. Finholt. Introducing instant messaging and chat in the workplace. In *Proceedings of the SIGCHI conference on Human factors in computing systems Changing our world, changing ourselves - CHI '02*, page 171, New York, New York, USA, April 2002. ACM Press.
- [33] J.D. Herbsleb and A. Mockus. An empirical study of speed and communication in globally distributed software development. *IEEE Transactions on Software Engineering*, 29(6):481–494, June 2003.
- [34] Richard Hillestad, James Bigelow, Anthony Bower, Federico Girosi, Robin Meili, Richard Scoville, and Roger Taylor. Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health affairs (Project Hope)*, 24(5):1103–17, January 2005.
- [35] Clyde W. Holsapple. The Pulse of Multiparticipant Systems. *Journal of Organizational Computing and Electronic Commerce*, October 2008.
- [36] Clyde W. Holsapple and Meenu Singh. Electronic Commerce: From a Definitional Taxonomy Toward a Knowledge-Management View. *Journal of Organizational Computing and Electronic Commerce*, 10(3):149–170, November 2009.
- [37] K. G. Jöreskog and Dag Sörbom. *LISREL 8: User's Reference Guide*. 1996.
- [38] Finn Kensing and Jeanette Blomberg. Participatory Design: Issues and Concerns. *Computer Supported Cooperative Work (CSCW)*, 7(3-4):167–185, September 1998.
- [39] Paul Kline. *Handbook of Psychological Testing*, volume 2013. 2013.
- [40] G. Lawton. Instant messaging puts on a business suit. *Computer*, 36(3):14–16, March 2003.
- [41] Dahui Li, Patrick Chau, and Craig Van Slyke. A Comparative Study of Individual Acceptance of Instant Messaging in the US and China: A Structural Equation Modeling Approach, 2010.
- [42] Theo Lippeveld. Routine Health Information Systems : The Glue of a Unified Health System. In *Keynote address at the Workshop on Issues and Innovation in Routine Health Information in Developing Countries, Potomac, March*, pages 14—16. 2001.
- [43] Theo Lippeveld, R. Sauerborn, and T. Bodart. Design and implementation of health information systems Design and implementation of health information systems. *World Health Organization*, 2000.
- [44] H. Lou, W. Luo, and D. Strong. Perceived critical mass effect on groupware acceptance.
- [45] Hao Lou, Patrick Chau, and Dahui Li. Understanding Individual Adoption of Instant Messaging: An Empirical Investigation, 2005.

- [46] Yaobin Lu, Tao Zhou, and Bin Wang. Exploring Chinese users' acceptance of instant messaging using the theory of planned behavior, the technology acceptance model, and the flow theory. *Computers in Human Behavior*, 25(1):29–39, January 2009.
- [47] Xin Luo, Anil Gurung, and J. P. Shim. Understanding the Determinants of User Acceptance of Enterprise Instant Messaging: An Empirical Study. *Journal of Organizational Computing and Electronic Commerce*, 20(2):155–181, April 2010.
- [48] Ed. Lwanga, S. K., Ed. Tye, Cho-Yook, and Ed. Ayeni, O. Teaching Health Statistics. page 28, November 1999.
- [49] ML Markus. Toward a “critical mass” theory of interactive media universal access, interdependence and diffusion. *Communication research*, 1987.
- [50] Ji-Won Moon and Young-Gul Kim. Extending the TAM for a World-Wide-Web context. *Information & Management*, 38(4):217–230, February 2001.
- [51] Bonnie A Nardi, Steve Whittaker, and Erin Bradner. Interaction and Outeraction : Instant Messaging in Action. 2000.
- [52] P Oliver, G Marwell, and R Teixeira. A theory of the critical mass. I. Interdependence, group heterogeneity, and the production of collective action. *American journal of Sociology*, 1985.
- [53] Osterman Research. Instant messaging: Enterprise market needs and trends.
- [54] Osterman Research. Osterman research enterprise IM tracking survey.
- [55] Ian Paterson, Dave Smith, Peter Saint-Andre, Jack Moffitt, Lance Stout, and Winfried Tilanus. Bidirectional-streams Over Synchronous HTTP (BOSH), April 2014.
- [56] Paul A. Pavlou. Consumer Acceptance of Electronic Commerce: Integrating Trust and Risk with the Technology Acceptance Model, December 2014.
- [57] Jenny Preece. *Interaction design : beyond human-computer interaction*. J. Wiley & Sons, 2002.
- [58] Health Information Systems Program. HISP - About, 2014.
- [59] Ignite Realtime. About Openfire, 2015.
- [60] Julie Rennecker and Lindsey Godwin. Theorizing the Unintended Consequences of Instant Messaging for Worker Productivity, July 2003.
- [61] Everett M. Rogers. *Diffusion of Innovations, 4th Edition*. 2010.
- [62] David S. Marshak. Instant Messaging at Work. Key Policies and Practices for Leveraging IM in Business. *Patricia Seybold Group*, 2004.
- [63] P. Saint-Andre. XMPP: lessons learned from ten years of XML messaging. *IEEE Communications Magazine*, 47(4):92–96, April 2009.
- [64] Peter Saint-Andre. Extensible Messaging and Presence Protocol (XMPP): Core. *Internet Engineering Task Force (IETF)*, 2011.

- [65] Peter Saint-Andre. Extensible Messaging and Presence Protocol (XMPP): Instant Messaging and Presence. *Internet Engineering Task Force (IETF)*, 2011.
- [66] Ben Shneiderman. *Designing the user interface : strategies for effective human-computer interaction*. Addison-Wesley, 2010.
- [67] Jive Software. Openfire Scalability, 2007.
- [68] Jan-Benedict E M Steenkamp and Hans Baumgartner. Assessing Measurement Invariance in Cross-National Consumer Research. *Journal of Consumer Research*, 25(1):78–90, 1998.
- [69] Girish H. Subramanian. A Replication of Perceived Usefulness and Perceived Ease of Use Measurement. *Decision Sciences*, 25(5-6):863–874, September 1994.
- [70] Bernadette Szajna. Software Evaluation and Choice: Predictive Validation of the Technology Acceptance Instrument. *MIS Quarterly*, 18(3):319, September 1994.
- [71] Dhis Documentation Team. *DHIS 2 End-user Manual*. 2014.
- [72] Matt Tucker. Openfire Under Apache 2.0 License, 2009.
- [73] Ofir Turel, Alexander Serenko, and Nick Bontis. User acceptance of wireless short messaging services: Deconstructing perceived value. *Information & Management*, 44(1):63–73, January 2007.
- [74] Johannes Wagener, Ola Spjuth, Egon L Willighagen, and Jarl ES Wikberg. XMPP for cloud computing in bioinformatics supporting discovery and invocation of asynchronous web services. *BMC Bioinformatics*, 10(1):279, 2009.
- [75] Chih-Chien Wang, YaHui Hsu, and Wenchang Fang. Acceptance of Technology with Network Externalities: An Empirical Study of Internet Instant Messaging Services, 2005.



# Appendix A

## Questionnaire - English

### A.1 Introduction

I am conducting research on the usage and acceptance of the new IM feature introduced in DHIS 2. I would love to hear from you on your usage of the IM feature the past week and how you may or may not find it useful and easy to use.

If you have not already tried the IM feature, please try it before you respond to this questionnaire.

If you have any questions about the survey, please email xxxxxx xxxxxx: xxxxxx@xxxxxx.com

Thanks in advance, I really appreciate your input!

### A.2 Demographics

1. What's your age?

Less than 18 years old

18-24 years old

25-30 years old

31-35 years old

36-40 years old

More than 40 years old

2. What's your gender?

Male

Female

### A.3 Actual Usage of the IM Feature in DHIS 2

3. How many times did you use the IM feature in DHIS 2 the past week?

1	2	3	4	5	6	7
Not at all	Less than once	About once	2-3 times	4-5 times	About once	Several times a day

4. How many hours did you use the IM feature in DHIS 2 the past week?

1	2	3	4	5	6	7
Less than 1 hour	1-5 hours	5-10 hours	10-15 hours	15-20 hours	20-25 hours	More than 25 hours

5. How frequently did you use the IM feature in DHIS 2 the past week?

1	2	3	4	5	6	7
Extremely infrequent	Quite infrequent	Slightly infrequent	Neither	Slightly frequent	Quite frequent	Several times each day

#### A.4 Perceived Usefulness of the IM Feature in DHIS 2

6. Using the IM feature in DHIS 2 in my job would enable me to accomplish tasks more quickly

1	2	3	4	5	6	7
Unlikely						Likely

7. Using the IM feature in DHIS 2 would improve my job performance

1	2	3	4	5	6	7
Unlikely						Likely

8. Using the IM feature in DHIS 2 in my job would increase my productivity

1	2	3	4	5	6	7
Unlikely						Likely

9. Using the IM feature in DHIS 2 would enhance my effectiveness on the job

1	2	3	4	5	6	7
Unlikely						Likely

10. Using the IM feature in DHIS 2 would make it easier to do my job

1	2	3	4	5	6	7
Unlikely						Likely

11. I would find the IM feature in DHIS 2 useful in my job

1	2	3	4	5	6	7
Unlikely						Likely



## A.5 Perceived Ease of Use of the IM Feature in DHIS 2

12. Learning to operate the IM feature in DHIS 2 would be easy for me

1	2	3	4	5	6	7
Unlikely						Likely

13. I would find it easy to get the IM feature in DHIS 2 to do what I want it to do

1	2	3	4	5	6	7
Unlikely						Likely

14. My interaction with the IM feature in DHIS 2 would be clear and understandable

1	2	3	4	5	6	7
Unlikely						Likely

15. I would find the IM feature in DHIS 2 to be flexible to interact with

1	2	3	4	5	6	7
Unlikely						Likely

16. It would be easy for me to become skilful at using the IM feature in DHIS 2

1	2	3	4	5	6	7
Unlikely						Likely

17. I would find the IM feature in DHIS 2 easy to use

1	2	3	4	5	6	7
Unlikely						Likely



## Appendix B

# Questionnaire - French

### B.1 Introduction

Je mène une recherche sur l'usage et l'acceptation de la nouvelle fonction chat présentée sur DHIS 2. J'aimerais recueillir des informations à propos de votre usage du chat au cours des dernières semaines et si vous le trouvez utile et facile d'utilisation ou non.

Important : Si vous n'avez pas déjà essayé le chat, s'il vous plaît essayez-le avant de répondre à ce questionnaire.

Le sondage ne devrait vous prendre que cinq minutes et vos réponses sont totalement anonymes.

Si vous avez des questions à propos du sondage, envoyez un e-mail à xxxxxx xxxxxx : xxxxxx@xxxxxx.com

Je vous remercie par avance de votre contribution, j'apprécie énormément !

### B.2 Données Démographiques

1. Quel est votre âge ?

Moins de 18 ans

18-24 ans

25-30 ans

31-35 ans

36-40 ans

Plus de 40 ans

2. De quel sexe êtes-vous ?

Homme

Femme

### B.3 Usage Courant de la Fonction Chat sur DHIS 2

3. Combien de fois avez-vous utilisé le chat sur DHIS 2 la semaine dernière ?

1	2	3	4	5	6	7
Pas du tout	Moins d'une fois	Environ une fois	2-3 fois	4-5 fois	Environ une fois par jour	Plusieurs fois chaque jour

4. Combien d'heures avez-vous utilisé le chat sur DHIS 2 la semaine dernière ?

1	2	3	4	5	6	7
Moins d'une heure	Entre 1 et 5 heures	Entre 5 et 10 heures	Entre 10 et 15 heures	Entre 15 et 20 heures	Entre 20 et 25 heures	Plusieurs fois chaque jour

5. À quelle fréquence avez-vous utilisé le chat sur DHIS 2 la semaine dernière ?

1	2	3	4	5	6	7
Très occasionnelle	Relativement occasionnelle	Légèrement occasionnelle	Aucune	Légèrement fréquente	Relativement fréquente	Très fréquente

### B.4 Perception de L'utilité de L'application Chat sur DHIS 2

6. L'utilisation du chat sur DHIS 2 au sein de mon travail me permettrait de réaliser mes tâches plus rapidement

1	2	3	4	5	6	7
Peu probable						Probable

7. L'utilisation du chat sur DHIS 2 améliorerait mes performances au travail

1	2	3	4	5	6	7
Peu probable						Probable

8. L'utilisation du chat sur DHIS au sein de mon travail augmenterait ma productivité

1	2	3	4	5	6	7
Peu probable						Probable

9. L'utilisation du chat sur DHIS 2 augmenterait mon efficacité au travail

1	2	3	4	5	6	7
Peu probable						Probable

10. L'utilisation du chat sur DHIS 2 me rendrait la vie plus facile au travail

1	2	3	4	5	6	7
Peu probable						Probable

11. Je trouve le chat sur DHIS 2 utile dans mon travail

1	2	3	4	5	6	7
Peu probable						Probable

## B.5 Perception de la Facilité D'usage de la Fonction Chat sur DHIS 2

12. Apprendre à faire marcher le chat sur DHIS 2 serait facile pour moi

1	2	3	4	5	6	7
Peu probable						Probable

13. Je trouve facile d'avoir le chat sur DHIS 2 pour faire ce que je veux faire

1	2	3	4	5	6	7
Peu probable						Probable

14. Mon interaction sur le chat de DHIS 2 serait claire et compréhensible

1	2	3	4	5	6	7
Peu probable						Probable

15. Je trouve le chat sur DHIS 2 être souple d'utilisation

1	2	3	4	5	6	7
Peu probable						Probable

16. Il serait aisé pour moi devenir compétent dans l'utilisation du chat sur DHIS 2

1	2	3	4	5	6	7
Peu probable						Probable

17. Je trouve le chat sur DHIS 2 facile à utiliser

1	2	3	4	5	6	7
Peu probable						Probable





