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Collaboration Between Distributed Teams In Development of Software

A Case Study of DHIS2

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Kunnskap for en bedre verden

Abstract

Technology has revolutionized how the majority of all industries perform their work. Workers no longer have to be situated in the same place and time to collaborate and coordinate, allowing for large and complex projects spanning all over the world.

This study aims to contribute with strategies when scaling up a system that has geographically distributed teams collaborating in the development process. It attempts to disclose which resources are beneficial in the development work and the potential negative impact these resources might have.

The case described in this paper is the development of a health information management system that currently has teams dispersed throughout the globe and that requires groupware to collaborate. The research was based on multiple methods for data collection, including qualitative interviews with several ecosystem actors and analysis of the available groupware and online resources. The study analyses the socio-technical perspective. It is based on the CSCW field, the relevance of groupware in collaboration work where physical meetings are not feasible, and the importance of dedicated teams situated close to the end users.

The discoveries imply that several distinct arenas are necessary to maintain a collaborative environment and that close collaboration between development teams and end users is vital regarding the success of the system. It also implies that introducing local teams that are situated close to the end users reporting back to the core team introduces the risk of filtering information from end users.

Preface

This thesis was carried out at the Department of Computer Science at the Norwegian University of Science and Technology (NTNU) throughout the Spring of 2021. It concludes a 5-year engineering degree in Computer Science with a specialization in Software Engineering, leading to the degree Master of Technology.

I would first and foremost like to thank my supervisor Eric Monteiro for the constructive and valuable feedback provided by him throughout the project. I would also like to thank the DHIS2 core team at the University of Oslo (UiO) for their collaboration and contribution to this thesis. Lastly, I would like to thank the HISP groups that contributed to the research for taking the time to provide insight into their development processes and day-to-day work life.

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Contents

List of Figures

1   Introduction

Technology is changing how we do business [37]. Companies are no longer dependent on their workers to be situated in the same geographical area in order to collaborate and work together. Technology has facilitated for teams to be physically separated while still being able to collaborate and effectively reach goals. This is not only the case for software development, but for countless other industries as well. And the technologies keep developing to become more advanced and useful.

The possibilities of working remotely and in distributed teams has become especially apparent during the ongoing pandemic that took place amid this research. The use of groupware to replace physical meetings in all industries has skyrocketed and has accelerated the utilization and facilitation of technology in industries that might not earlier have facilitated for it. Furthermore, the availability to technology that aid in collaborative work will only become more relevant in the future, hence it will most likely play an even more significant role in the workplace. Collaboration and coordination between physically separated teams is therefore a current topic to investigate.

Software engineering is one field where the development takes place in collaborative efforts within large ecosystems of networked communities of stakeholder organizations [28]. It is also a field where the geographical separation of personnel is becoming a more and more inherent characteristic [30]. Some of the largest and most successful software companies today have geographically distributed teams that are collaborating to reach a common goal.

One way of developing solutions where geographically separated teams are essential is to scale up a system that was initially developed for a local context to become useful for a large global market. These systems can emerge successfully, but requires the teams to communicate with each other as well as with the end users in order to capture user needs. New user groups might emerge with different needs than the initial user groups had and several arenas might be necessary to successfully capture these needs. *Local teams*

are can be a necessary resource in order to succeed in this. Local teams are teams that are situated relatively close to certain end user groups and can function as an intermediary link between the core team and the end users. Furthermore, in the case of software solutions, they can contribute in the development processes and aid in customization work to.

In the process of scaling up a software solution, the developers potentially end up with being geographically distributed in different teams. This can lead to several issues, for instance a lack of a mutual understanding of the project [36]. Furthermore, this geographical separation of teams makes it more difficult to manage task dependencies and coordinate them, which can increase the development time [16]. Consequently, it is crucial to maintain continued communication to prevent the project from becoming separate and uncoordinated, and avoid misunderstandings and inappropriate design and implementation decisions [30].

This means that the success of these projects heavily relies on the interaction and information exchange between the team members involved [3]. Effective collaboration demands that people share information [14]. In short, the definition of collaboration is according to Patel et al. [31] as follows: "Collaboration involves two or more people engaged in interaction with each other, within a single episode or series of episodes, working towards common goals."

When solutions are to be scaled up to a larger scope than what they were first intended for, the need for CSCW becomes apparent. CSCW is a research field that tries to understand the impact that technology has on group interaction and how it can assist in the work [14]. Groupware can be conceptualized as systems that support teams to engage to achieve a common goal and that assist distributed groups in their work and collaboration [9]. To which extent one is able to communicate to achieve common goals is imperative [31], implying that CSCW and groupware are crucial aspects in facilitating for collaboration and coordination when developing a software with distributed teams.

The main objective of the research is to understand how geographically distributed

global and local teams communicate and coordinate in order to develop generic systems, specifically how groupware aid to achieve good collaboration. It explores the different aspects of using local teams as intermediaries between the core team and the end users in the development processes. Moreover, it investigates how the core development team of a generic software project manage to capture the relevant use cases and develop a generic core that meet the requirements of the end user groups.In order to understand this, it is interesting to evaluate the processes that the teams are involved in. Therefore, an overview of the development process is useful and will be presented.

The research that has been conducted and described in this article aims to answer the research questions (RQ) that will be introduced below. Considering that the main RQ is somewhat broad, two sub-questions are also proposed.

The research questions proposed for this research are the following:

- **RQ 1: How do geographically distributed teams coordinate and communicate when developing generic software?**

    - *RQ 1.1: How do arenas facilitate the stakeholders to collaborate?*

    - *RQ 1.2: How do the local teams affect the development process?*

To answer the questions presented, the research has been focused around the case of DHIS2, more specifically the DHIS2 core team situated in Norway and the HISP groups that are involved. Researching DHIS2 is feasible in order to answer the research questions considering it is a large project with teams located in different parts of the world, with a wide spread of end users with varying needs and requirements. The DHIS2 platform architecture consists of a configurable core service with tools and documentation to support both development and customization by a range of users.

Certain local HISP groups and the core team has been interviewed for this research due to the fact that they are the major developers of the system. They have great insight as to how the development processes go about today. Talking to these teams will reveal

3

potential strengths and weaknesses that will be useful for projects attempting to achieve analogous goals in the future. Hence, this study contributes to valuable insight to and discoveries about collaboration in these environments. It will also give insight as to where research is missing.

The paper is structured as follows. Section 2 describes the relevant literature for the research questions. Section 3 explains the relevant background for the work. The next section, Section 4 explains the research methodology used for this paper. The case is represented in the following two sections, Section 5 and Section 6. Lastly, a discussion and a conclusion is presented in Sections 7 and 8.

2 Literature

This section explains concepts that are relevant for the case that is presented and is based on existing literature.

2.1 The Socio-Technical Perspective

A socio-technical outlook highlights the dependencies and the links between people (the sociological systems), and ICTs (the technological systems) [5]. Socio-technical networks help with the understanding of human society, nature, and technology together [20].

To make effective tools that are used by users, systems are necessary. It is also vital to make sure that desired outcomes are a consequence of the use [5]. A socio-technical system is composed of two components, namely a social and a technical component [38]. Making sure that the systems produce the desired outcomes requires both the social and the technical elements to be considered together. Hence, these two aspects cannot be examined as two separate strands, but rather as one integrated whole [5].

Socio-technical perspectives can help identify and understand the complexity associated with standardization. There are several perspectives to study when it comes to the

socio-technical complexity of IS standards. One of these perspectives is the complexity of local varieties, for example in work practices and organizational structures, and the process of including these into one standard. Another perspective address the increased diversity of the actors involved in the standardization, as well as the pace of the technical modifications, and the challenges that this contributes to when a standard is being developed [21].

The links between the people and the ICTs are important to understand, especially in large distributed software projects. The impact that technology has on group interaction is interesting to identify, and computer-supported cooperative work (CSCW), which will be the next topic, is a research field encompassing this.

2.2 Computer-Supported Cooperative Work (CSCW) and Groupware

Computer-supported cooperative work (CSCW) is an interdisciplinary research field that tries to understand cooperative work practices [34] and the impact of technology on group interaction and how it can help in the work [14]. The hope and aims of CSCW is to design systems that fit the work practices and enhance the workers' competencies and responsibilities [6]. Understanding the cooperative work practices can contribute to the development of "collaborative computing" or groupware [34]. Groupware and CSCW are correlated, but groupware refers to the technology itself [9].

The study of CSCW involves a deeper understanding of how work is accomplished in groups in addition to the study of the application of the software. The group's work should be properly understood and different technologies should be evaluated in correlation with the needs that the groups have [17].

Figure 1 shows the CSCW matrix which represents how to imagine where the groupware can be applied. The groups that are involved in the activity may be separated by place and/or time, and this influences how they can interact. It is this interaction that the matrix attempts to illustrate [17].

- **Same time/same place** - represents face to face interactions

- **Same time/different place** - represents remote interactions

- **Different time/same place** - represents continuous tasks and includes information that needs to be maintained to support several shifts of staff working on issues

- **Different time/different place** - represents communication with coordination
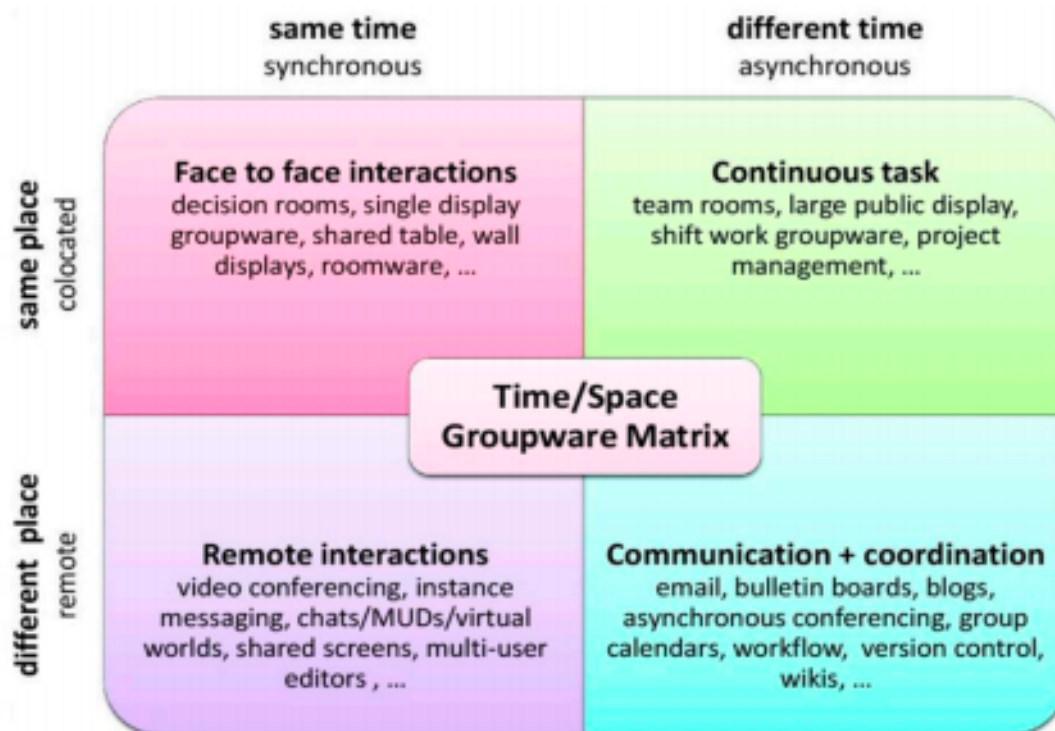

Figure 1: The CSCW Matrix [17].

Collaborative environments involve not only people with different backgrounds and skills, but also several communication, coordination, and production mechanisms, which are used depending on the users' location, activities, and available resources. These factors make collaborative environments highly dynamic [12]. International projects occasionally

have an additional layer of complexity as the projects are split across national boundaries with potential differences in culture, language, time zones, and regulations [30].

According to a study of distributed software engineering teams and how the collaboration is supported within the projects by Layzell et al. [30], there are several advantages and disadvantages in distributed working. One advantage is that distributed work requires more discipline where processes are clearly defined and understood. This leads to a more stable project environment. Another apparent advantage was the reduction in walk-in questions, which minimize interruptions in the core work. Some disadvantages were also discovered during the study. For instance, hosting meetings using video-conference tools was regarded as challenging work considering it required concentration to include all sides of the meetings in the discussions. Long meetings were also considered unfit [30].

Having a personal interest in a project can also provide more enthusiastic project members, which often is a side effect of project members knowing and liking each other. This can be achieved by allowing the members to socialize through face-to-face meetings, although this can be difficult and costly to enforce [30].

Communication and collaboration in especially large distributed projects do not necessarily happen automatically and require coordination. According to Layzell et al. [30], "participants on larger projects found it helpful to have a strong, highly organized, proactive coordinator to solicit suggestions for improvements, receive opinions, draw conclusions and present them for discussion. This ensures that plans, designs, technical aspects, and budgets are adhered to.

CSCW supports a range of applications, but that the reality is that these applications are usually closed and limited to registered users. They do not take advantage of each other as they work in isolation [23]. As Andriessen [2] notes in his book, many advanced systems are "sets of more or less integrated modules and functionalities, that can be tailored to specific usage." With this, he indicates that the work that is performed in groups often requires many applications simultaneously to cover all functionalities that the teams need

the applications to cover. Therefore, several applications might be necessary to perform all tasks. These applications can be groupware.

Groupware is conceptualized as "computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment" to empower human interaction [9]. It is designed to support geographically or temporally distributed workgroups to assist them in their work and collaboration [29]. More specifically it is computing technologies that facilitate, mediate, or regulate workers' interdependent activities [34]. A primary benefit of groupware is that it allows people to work together, in real-time, even when separated by great physical distances [14] as it creates a shared space for cooperation and enables awareness among the group members [9].

Groupware should support collaboration towards a common goal, solution of a common problem, data sharing, idea generation, conflict resolution, decision making, or system analysis and design [29].

Some examples of groupware include video conferencing, email, application sharing, electronic calendars, workflow systems, and websites. There exist numerous software vendors providing groupware and each of these types has specific functions that it is important to take advantage of, but the software also comes with particular limitations [17].

Groupware technology supports distributed requirements engineering and organizations are offered sophisticated multimedia meeting systems with video, audio, and computer support for remotely specifying requirements. It is important to understand how these communication media facilitate social processes in requirements engineering. Generally, most theories have argued that face-to-face meetings are the richest communication medium and are best suited for tasks that require group negotiations. Other media, including computer conferencing, are believed by several theories to restrict communication and thus being less rich, leading to a decrease in the group performance [11].

But, Damian et al. [11] compared face-to-face interaction with four different dis-

tributed communication settings and did not support this assumption. One of the conclusions was that using groupware makes the participants remote and therefore less emotional than a local partner. Electronic mediation might emphasize task-related matters over interpersonal aspects of interaction and did enhance the performance for certain of the test groups in the studies. The reduced ability to perceive emotional cues might aid in attaining a level of impartiality in the negotiation of requirements [11].

Gorton et al. [19] explained that in the trial they performed, they managed to demonstrate the value of employing groupware technology in distributed teams. They showed that the team members in a smaller team can communicate, synchronize activities and accomplish reasonable complex tasks asynchronously, with a minimum of direct communication. They further referenced to quantitative data that indicated that, at least for small groups, asynchronous problem-solving does not seem to introduce significant interaction overheads. For larger groups, this is not necessarily the case. Developing generic systems with the possibility of tailoring often involves a large number of geographically separated teams and these ecosystems can be complex, making coordination of the work challenging.

2.3   Generic Systems and Tailorability

A global information infrastructure should be a uniform and standardized solution in order to reduce complexity and risk while also maintaining control. At the same time, another argument is convinced that the information system has to be a local, situated and a contextual work setting. For a solution that is supposed to support globally dispersed and independent work, the two arguments both have to be balanced [33].

As opposed to custom systems, generic systems are designed for general use. For the system to become successful in the market the design should be of interest to as many user groups as possible, supporting as many applications as possible. Consequently, the focus when developing the system should be on the generic aspects that as many user groups as possible has interest in [4].

Being able to communicate with the end users in the software arena might require the establishment of one or more customer-developer links. These links are defined as the channels that allow the customers and the developers to exchange information. Intermediaries are entities situated between customers and developers, meaning that the developers communicate with the intermediary instead of the customer directly [25].

There exist different approaches to developing generic software, one of which is to seek out a representative user organization. A first version of the system can be developed for this organization, but the product developers have to recognize the generic features of the design and get rid of specialized features to generalize the solution. This redesign of the system can potentially be risky and difficult [4].

Another approach separates the user from the designers and developers by having two separate processes. The system is developed based on general models of the application area [4]. Disembedding is the process where the supplier aims to establish a standardized set of requirements. Once common requirements are established, standard software development practices follow that works towards a generic software package where the design process, content, and output are dictated by the vendor.The customer is responsible for the configuration, implementation, and operation of the system [4].

Open generification focuses on the local practices, as opposed to Pollock's generification perspective. Open generification is a design strategy for developing software packages that satisfy different user needs. The components in open generification are global developers as well as local developers, and the processes of embed or not embed features. Open generification is about establishing a generic core, provide design guidelines, training, and communicate platforms and other building mechanisms for the local developers. The global developers strive for a broad perspective and design globally relevant software packages. It is the local developers' responsibility to satisfy the local needs in the software solution. This allows for local innovations that can be included in the software core. The global developers should enable the local developers to perform local innovations [18].

But developing generic systems introduce the need of tailorability. According to Kjær et al. [26] "tailorability concerns the modification and adaptation of systems after they have been put into use". To make tailorable systems sustainable, several aspects concerning user knowledge, technical issues, and business organization have to be satisfied. Additionally, considering that the end users can be regarded as codesigners of the system, it is important to maintain collaboration between developers and users [15].

A study performed by Keil et al. [25] suggested that based on their results, the projects that had both a low (zero or one) number of links and that had a low number of direct links, between the developers and the customers, were the less successful projects. It was also pointed out that the problems associated with less successful projects resulted in part from the over-reliance on intermediaries. It was explained that the intermediaries can, either intentionally or unintentionally, filter and distort messages. Another point was that the intermediaries may not have a complete understanding of the customer's needs.

Johannessen et al. [24] explored how systems that are developed for local practices can be adapted to larger markets, hence making the system more generic. As the market for the software grew, the number of users also grew. The initial user group that was involved in the development process had to start fighting to be heard and reported that they felt like the responsiveness dropped when the number of users grew. Furthermore, the end users were not in direct contact with the developers to the same degree anymore, as intermediaries represented the end users when the user base grew. The requests were passed on to intermediaries from the end users, the requirements were then redefined and worked on before the intermediaries decided which requirements to pass on to the developers. In this way, the intermediaries replaced the developers' close contact with the end users. For the vendor, this meant that the user base was easier to handle, but it also introduced the risk of filtering and distortion of information.

Local initiatives should be able to tailor the generic systems to maximize the usefulness. This is especially the case in the development of software for large markets. When

the local initiatives are varied with a high degree of dynamics or diversity in user requirements [35], the need for tailorability is crucial. Simply put, tailoring can be regarded as an adaptation of generic software [15].

3   Case Background

In the following section, relevant background on the case of DHIS2 is provided. This includes the history and motivation behind the initiative together with the necessary background and information on the Health Information System Program (HISP).

3.1   District Health Information Software (DHIS)

In South Africa in the 1990s, segregation was an immense issue as it created a division between racial groups and consequently had a great impact on health care. The DHIS aimed to provide a tool for integrated and decentralized information support for district health management, more specifically provide health care workers with basic information to deliver better health services. The aspiration at that time was to provide improved health services in the impoverished parts of the country, as several communities suffered under apartheid and discrimination. Today, DHIS2 is the national standard in South Africa. It provides local-level management, easy access to data and analytical tools, and also supports national data requirements [8].

The first version of DHIS was based on the Microsoft Office platform as a free and open source database application. In 2004, however, the development of the second version of DHIS started, DHIS2, with a core team based in the Department of Informatics at the University of Oslo (UiO). This version was triggered by designers that wanted to shift from a traditional and centralized system development practice to an open and distributed free open source software [8].

DHIS2 is a software for reporting, analyzing, and disseminating data. It has grown

to become one of the world's largest health management information systems. It is the national health information system in more than 67 countries, as well as it is used by many non-governmental organizations to manage their data. Today, the core of the initiative is to strengthen the health information systems in especially developing countries [22].

Figure 2 represents the DHIS2 innovation ecosystem. An innovation ecosystem in this context refers to the network of action surrounding the development and implementation of DHIS2 instances around the world. These include groups that are involved in the network, such as developers, HISP groups, Ministries of Health, universities, Non-Governmental Organization (NGO), and so on [7].

Some key actor groups represented in this figure are:

The core DHIS2 platform developers: The global team that develops the software that makes up the platform. They are constantly interacting with the use context through the DHIS2 implementers and designers and they are developing the innovations that are shaped as technical artifacts.

The DHIS2 implementers and designers: The facilitators and developers of the DHIS2 instances that are being implemented in countries. They mediate ideas and requirements for new functionalities and feedback on the software between the users and the developers. They are the innovation mediators between users and core developers. They are also innovators in terms of developing new ways of applying and using information.

Potential and actual users of the range of information and services: They range from the individual users in the field to the health managers at district and higher levels, policy makers, international organization, to the general public. This is both the context and driver of innovations. Innovations are generated in direct interaction with the DHIS2 platform, resulting in its further reconfiguration, extension, and development. Key innovations are linked to new ways of doing things with the help of technology.

Third party developers: These are targeting actual and potential users and use cases as a market for their particular innovations, which may take shape as new modules or plug-ins,
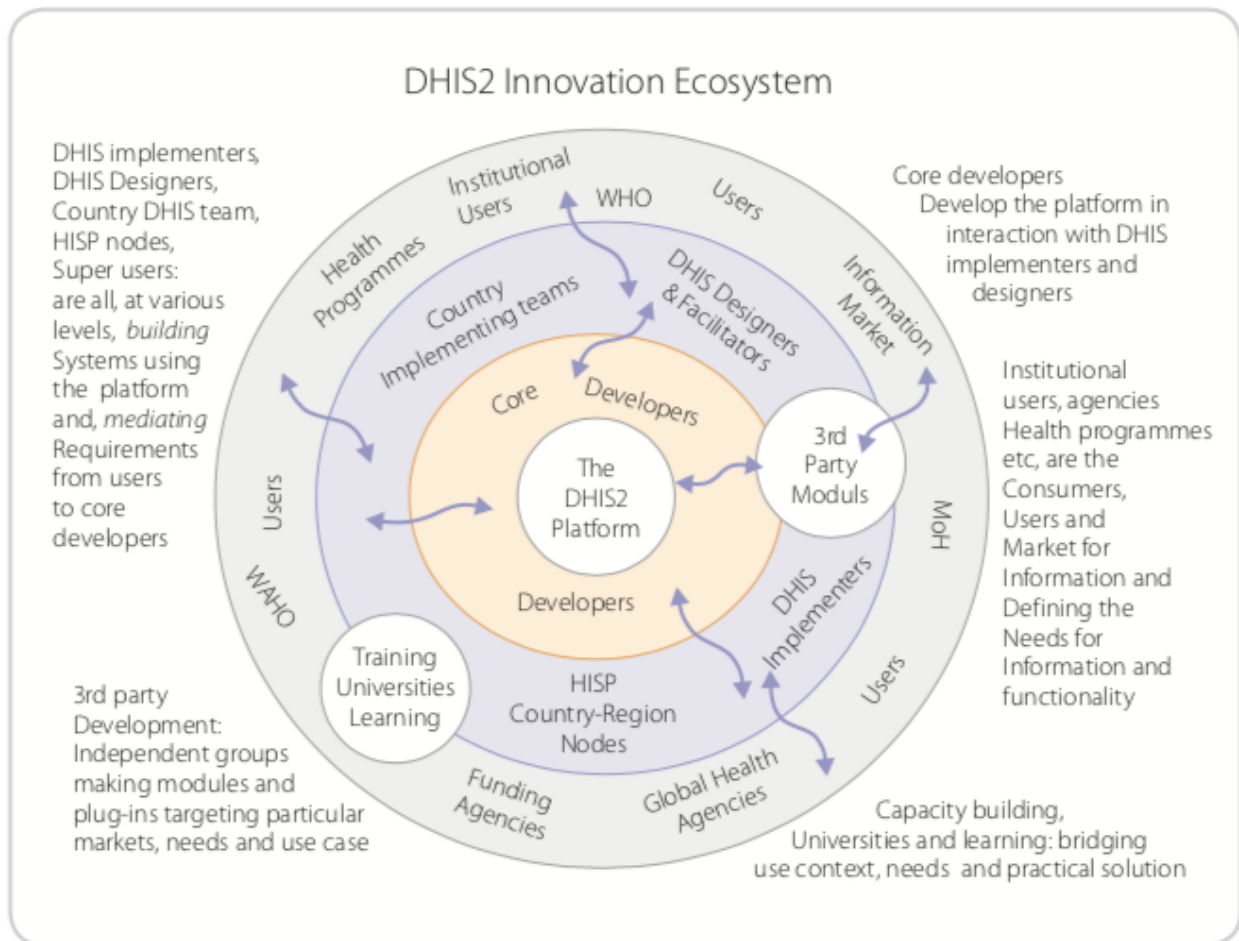
DHIS2 Innovation Ecosystem

DHIS implementers, DHIS Designers, Country DHIS team, HISP nodes, Super users: are all, at various levels, *building* Systems using the platform and, *mediating* Requirements from users to core developers

Institutional Users

WHO

Users

Core developers
Develop the platform in interaction with DHIS implementers and designers

Health Programmes

Country Implementing teams

DHIS Designers & Facilitators

Information Market

Core Developers

The DHIS2 Platform

3rd Party Moduls

Institutional users, agencies Health programmes etc, are the Consumers, Users and Market for Information and Defining the Needs for Information and functionality

Users

WAHO

Developers

MoH

Training Universities Learning

HISP Country-Region Nodes

DHIS Implementers

Users

3rd party Development: Independent groups making modules and plug-ins targeting particular markets, needs and use case

Funding Agencies

Global Health Agencies

Capacity building, Universities and learning: bridging use context, needs and practical solution

Figure 2: The DHIS2 Innovation Ecosystem [7]

but also as new configurations of the platform, without new add-ons.

Educational schemes, training, and universities: Make up the institutional glue, which enables innovations to actually materialize through the cycles of use-ideas for an improvements-trial-workable module or work practice. While 'learning through use' as a first step in a process of innovation and 'conceptualizing new ways of doing things' as the second, the following steps of bringing ideas all the way to technologies and implementations will require a range of skills where universities and wider training schemes are key components. Masters and Ph.D. programs and now also the DHIS2 Academy have been important build-

ing blocks in the innovative DHIS processes since the start in the 1990s.

It is HISP at the Department of Informatics at the UiO that coordinates DHIS2. As the number of users increased, and as the requirements became more specific and in a larger quantity than earlier, it became increasingly difficult to keep the generic solution updated [8]. The core team consequently collaborates with HISP groups, which are located in developing countries, and contributes to development work, research, and implementation support, to name a few [22].

3.2 The Health Information System Program (HISP)

The overall goal of HISP is to enable and support countries to strengthen their health systems [22]. The vision of the program is to develop and implement sustainable, and integrated HISs that will empower the communities, healthcare workers and decision-makers. They strive to improve the coverage, quality, and efficiency of health services [32]. According to the HISP website [32], HISP collaborates with Ministries of Health, universities, NGOs, and private companies. The HISP groups are the long and trusted partners of HISP UiO [22].

HISP UiO is one of the leading organizations and contributes to include in-country capacity building and implementation support, research, a Ph.D. program, and hosting the core DHIS2 software development team. The main objective of the HISP UiO is 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 [22].

The UiO HISP group works in collaboration with other HISP groups all over the world. This collaboration facilitates the DHIS2 implementation to provide local customization and configuration, and in-country and regional capacity building and makes DHIS2 a global and public good. Regional HISP groups can contribute with requirements gathered from these regions, provide feedback, and also generate local configurations that potentially can

be integrated into the core platform to be used worldwide [22].

Furthermore, it is this close and continuing collaboration between HISP groups resident in different countries that have been a huge part of the DHIS2 success. This also facilitates DHIS2 consultancy and support in the respective countries that the HISP group is located at [22].

Below is a list of the HISP Groups around the world:

- HISP-VN (Vietnam)

- HISP Bangladesh Foundation

- Health Information Systems Program - Uganda

- HISP India - Society for Health Information Systems Programmes

- HISP Tanzania

- HISP Nigeria

- HISP West and Central Africa

- HISP (Sri Lanka)

- HISP Rwanda

- HISP Mozambique (SAUDIGITUS)

One of these groups is HISP-South Africa (SA), a global action research network founded in the Western Cape in 1994 and was funded by Norad. The main objective was to develop and pilot the DHIS for managing routine health information. In 2003 it was registered as a non-profit organization [22]. For instance, HISP-SA provides HIM training and offers courses in topics like computer literacy, data quality improvement, data analysis, and training in DHIS2. The HISP-SA has trained over 20 000 health care staff, managers,

and partners since 2014 in various aspects of HIM. They claim to obtain in-depth knowledge on how the routine health information systems work, which is important to support the workers in all levels of the health systems at both district levels and national levels [32].

Generally, the HISP groups vary greatly. Some are large with up to 150 members, while others are rather small. The HISP groups have different interests, strategies, and competencies. It also varies what background the members of the different HISP groups have, which play a role in their understanding of the software and the use cases that their countries face.

As mentioned earlier, the HISP groups function as a mediator between the end users and the core team. But the term "end users" can be confusing in the case of DHIS2. There are many levels of users. To which degree the software is used at the different levels varies. Hence, the next section attempts to clarify the term in the case of DHIS2.

3.3   End Users of DHIS2

There are end users on different levels of the countries that are using DHIS2, ranging from the end users at the health facilities to the end users at the central level. In order to characterize the users of DHIS2, the HISP groups explain it by dividing the end users into levels. The end user groups of DHIS2 are mainly the following:

- Health Managers that are in charge of planning the local health services and that use information available through DHIS2 to support their decisions

- Health Clinicians, including doctors and nurses that use DHIS2 in their work with patients, both for supporting decisions when working with a patient and for reporting practices.

- Data Entry Clerks/Collectors/Managers that enter data into DHIS2

The lowest level of the end users of DHIS2 is the data entry clerks, data managers, or data collectors at the health facilities. Their primary responsibility is to capture and enter

data into the system. Who performs this work depends on the size of the health facilities. In small-scale health facilities there might not exist separate data managers, meaning that the clinicians are also responsible for the data collection.

For a medium-sized health facility, there can be health clinicians (nurses and doctors, etc.) that actually provide the health services. In addition to these, there are separate data managers that are responsible for recording the services, either directly into DHIS2 and is the one interacting with the software, or manually by pen and paper. If the system is a paper-based system, then end users of DHIS2 does not exist at the lowest level. The paper-based reports are forwarded to the next level where the data is then entered electronically into DHIS2. The end users are therefore not on the facility levels, only on the district level.

The local health facilities are therefore the lowest level of the reporting system hierarchy and contain the facility users where the health services are being provided. The data managers and data collectors have received training. These use DHIS2 daily in the health facilities and either work closely with the clinicians or have a medical education themselves.

The next level is the sub-national/regional levels where the main focus is data capturing and collection, in addition to some basic data quality analysis. At this level, there are different types of managers, like program managers, health program managers, and data managers. These evaluate and analyze the data that has been reported by the lower health facility levels.

The top-level is the national scale system, which is the largest implementation of DHIS2. The ones working with DHIS2 use it actively for their data needs and demands. Some of the users at this level are involved with the basic maintenance or the customization of the system and might deal with basic configurations, troubleshooting, user administration, and user support. The users at this level might have the access to administer the system to solve diverse issues. These users perform their actions in DHIS2, accessing and analyzing data, but they have some extra privileges to maintain and administer DHIS2.

At which levels DHIS2 is implemented vary from country to country. The end users can consequently be everything from workers at health facilities, like medical doctors, to trained data managers, to partners at the central levels, depending on the implementation levels of DHIS2.

Some of the HISP group members characterize themselves as end users as well. Many of the members of the HISP groups are educated medical doctors and have worked in the field with DHIS2 for many years before becoming a part of the HISP network. This gives a great understanding of how the system is used, what it is used for and what the users emphasize and focus on when using the system.

Other HISP groups do not characterize their members as end users. These HISP groups are external entities with a primary role of supporting ministries etc. These HISP groups, which might be especially the more integrated and larger HISP groups, only support the users and the health programs. Their main responsibilities include implementation and customization, making sure that the system is as useful for the end users in their day-to-day work and tasks as possible. Other responsibilities include support with high technical requirements, dashboard development, supporting technical issues, troubleshooting, and providing support for the end users using the system. Also, they educate the end users through the DHIS2 Academy program.

It is also important to note that the ministries of health are end users of DHIS2. These are predominantly end users at the higher levels. Collaboration and communication between HISP groups and their respective ministries of health are highly relevant for most HISP groups. The involvement and structure of the ministries of health can vary between the countries and HISP groups.

4 Research Method

In order to answer the research question presented in Section 1, the case of DHIS2 is researched. By trying to understand how the large distributed teams of DHIS2 collaborate and work together to develop a generic system that is tailorable for the local developers and end users, it can disclose the success factors of DHIS2, as well as potential improvement.

4.1 Research Approach

The empirical evidence that is presented in this thesis is collected from relevant groupware used in the DHIS2 project and through interviews with diverse people employed in the DHIS2 initiative. The research and data collection took place in the Spring of 2021. Due to the ongoing Covid-19 pandemic, all the interviews, meetings, and research had to be performed remotely.

To answer the research questions proposed for this paper, qualitative research was deemed most applicable. This was because the data obtained through the interviews would be non-numerical data used to understand the interview objects' experiences and opinions. This insight into the problem can contribute to new ideas for research. This is opposed to quantitative research where quantifiable data is collected that can be further analyzed using statistical or computation techniques.

Considering the sheer volume of people involved in the development of the DHIS2 software and the large number of functionalities and features that are available, there exist several different branches working on varying tasks within the DHIS2 project. These branches are called product streams that have product managers. The product managers can almost underhandedly decide which methods and processes that are suitable to the respective product stream. This means that the development processes in one product stream might differ from the development processes in another.

Due to this variation between the different product streams, the research related to this

paper has been focused on mainly one product. stream. The processes and communication that relate to the development process for this particular product stream were considered. This allows the research to go more in-depth on certain topics, compared to only scratching the surface of the entire platform and all the product streams. Although the research is focused on just one particular product stream, a lot of the information that was gathered applies to the entire DHIS2 platform.

4.2   Case Access

The access to the case was unfortunately heavily influenced by the ongoing Covid-19 pandemic.

For once, the plan was to spend time at the UiO with the core team. This would give insight into how work was performed, what their workday looked like and who they interacted with, and how this interaction took place. This was unfortunately not possible during the pandemic. Not being able to meet with the involved people eliminates not only the chance to observe and interact with the employees, but it also eliminates the chances to have informal conversations and discussions that can potentially reveal useful information that otherwise will not be discovered.

Furthermore, ideally, the interviews would have been conducted face-to-face. Instead, all communication had to take place through groupware, dominantly through video-conferencing tools. Only being able to talk to people during scheduled times during the day will remove the casualness of a conversation that can be informal during research. The threshold for scheduling a casual talk or conversation is large through groupware and consequently did not take place. Therefore, only scheduled interviews were held, where the agenda is clear, the time is set, and often relatively short. It also induces time pressure, where the little time that is scheduled for an interview has to be well spent to get the information needed, again risking losing out on casual conversation or discussions where useful information can be revealed.

It was also challenging to find times that were suitable for some of the interview objects, especially the ones situated in Africa. They explained that during the pandemic it was extra hectic for them as there was a lot of pressure related to the DHIS2 work around Covid-19. This challenge was further enhanced with the time difference between Norway and the respective countries.

Despite the challenges related to the pandemic, the involved people were still happy to talk and the times that were scheduled were well spent. The interview objects shared their experiences, explained challenges, and appeared genuine and honest. The information revealed in this paper is consequently still valuable and gives, to the extent that was possible under the current circumcises, a valid representation of the situation.

4.3 Data Collection

The following qualitative data collection methods were used during the research:

- Semi-structured interviews with certain core team members. Open-ended questions were asked about their experiences with the development process and their collaboration with the HISP groups and the end users

- Semi-structured interviews with certain HISP group members about their experiences with the development process and their collaboration with the core team and the end users

- Observing the core development teams based at the UiO, in particular one product stream, by participating in project meetings

- Seminars arranged by the UiO where core team members were invited to talk about their work

- Observing the communication between core team and the HISP groups through groupware

- Observing the behavior of the core team, HISP groups, and end users on platforms like Jira and DHIS2 Community website

The interview objects can be divided into two groups based on where they are working at the time of this research.
The two groups are as follows:

- **Group 1: HISP group members**

- **Group 2: Core team members**

Throughout the paper, quotes from these two groups are disclosed. For Group 1, interviews have been conducted with five members from four different HISP groups. From Group 2 interviews have been conducted with seven members, where some of the interview objects were interviewed more than once. These are all based in Oslo working from the UiO and is part of the product stream that is in focus for this paper.

Note that some of the members from the core team could have worked someplace else at a different time, for instance, they could have worked in a particular HISP group. Furthermore, the interview objects from the core team have had different roles and could provide valuable information from distinct parts of the product stream. The experience levels of the interview objects also ranged from decades to just a couple of years.

The selected interview objects from the HISP groups were the ones that were in regular contact with the core team members and were for the most part the field ambassadors for their HISP group. Considering that these are expected to be in routine contact with the core team members, it was deemed most important to talk to them to gain their perspectives on how communication and collaboration work between them.

Although these two groups have a lot of valuable information, this study still lacks information from a very important group, namely the end users at the lower levels. It would have interesting and useful to talk to this group additionally, considering that they might expose issues and difficulties that would be useful for further analysis. This was not

doable for this research due to the traveling restrictions in conjunction with the Covid-19 pandemic.

The interviews were conducted one on one over Google Meet[1] or Zoom[2]. The idea behind interviewing only one HISP group member at the time was that they might be more willing to talk freely when no one else was listening. This ensured that the topics that might be hard to talk about were also discussed and that the interview objects could share unpopular opinions as well. The interviews lasted about one hour each, and in addition to questions, the interview objects were also free to take the word and talk about what he/she considered relevant for the research topic.

In addition to the one-on-one interviews, seminars were arranged by the UiO where all of the master students researching DHIS2 could join. These seminars were also conducted using Zoom and allowed students to ask questions to the guest. The guests varied, but they were all part of the DHIS2 core team. The topics consequently also varied based on the guests and their responsibilities within the DHIS2 project, giving different perspectives on the issues. Questions to be asked could be submitted in advance or asked directly during the seminars. These seminars were a great way for students to get answers to questions they might have and questions they did not even know that they had.

Furthermore, the weekly design meetings were attended during the semester where notes were taken. These notes are a part of the data collection for this research. In affiliation with these meetings, the Slack channel for the group has also been used to collect information and data. These meetings and the Slack channel gave insight and understanding of how the HISP groups and the core team work together even though they are physically separated in different countries and even continents, and consequently also different time zones.

Additionally, Jira and the DHIS2 Community have been evaluated and information extracted from these platforms has been interpreted throughout the research period to un-

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[1]https://meet.google.com/
[2]https://zoom.us/

24

derstand the different environments. Turning on notifications and receiving weekly emails on the happenings within the community gave updates on what was posted and how the response times were. It made it easy to pay attention to the community and what questions were being asked, if the questions were answered and who provided these answers.

4.4   Data Analysis

Considering that the case is dependent on information provided by individuals and their perspectives and perceptions, it was important to interpret and compare the information provided by one individual to the other individuals' perspectives and perceptions. Hence, inductive reasoning was appropriate. The approach was to analyze the specific observations and draw some general principles. The experiences and observations attained from one interview with one individual were synthesized while trying to discover a general truth.

It was crucial to not draw any conclusions based on one interview, but instead, take the time to listen to and evaluate the information provided by several individuals regarding the same topics. This gives a more accurate representation of the issue. However, it was still important to take the individuals' thoughts and opinions into consideration. This was a balance that is was important to keep during the analysis of the data, and the fact that opinions and experiences can vary between individuals has been attempted acknowledged where relevant.

Consequently, the analysis of all the collected information and data follows a heurmeneutic approach where the complex whole is assembled "from preconceptions about the independent meanings of its parts and their interrelationships" [27]. This means that all the different sources of field data are utilized and considered when interpreting the findings of this research.

The next sections represents the discoveries from the data collection, followed by the analysis.

5 DHIS2 Development Processes

This section contains information about a selection of the development processes that the DHIS2 features go through. The main focus is on the processes that require communication between the core team, the HISP groups, and the end users. This includes the process of collecting the requirements, prioritizing requirements, developing mockups, and sending them to the HISP groups for feedback. Finally, a short section gives an overview of the release of the new implementations in DHIS2.

5.1 Collecting Requirements

The first step before developing a new feature is to collect requirements from all of the stakeholders involved. Requirements can come from end users at all levels, the HISP groups themselves, NGOs, and the core team. Involving all stakeholders in this process contributes to discovering areas for improvement in the software. In addition, when all the stakeholders are involved, it is easier to paint an accurate picture of the state of the software. If the same requirements are coming from many of the stakeholders, it can indicate that this is a pressing issue.

5.1.1 HISP groups

Capturing requirements from the end users mainly go through the HISP groups as the HISP groups are closer to the end users than what the core team is. The HISP groups are the main link between the end users and the core team and can be considered an intermediary between the two. It is therefore important that the HISP groups get the full picture of the end users' needs and use cases. Communicating with the end users and visiting the end users to see them work with the software in their usual environment are important measures to take to get the necessary level of understanding.

The HISP groups mainly receive feedback from the end users through the field visits

and the available groupware.

> *"Requested features are collected from the field and compiled."*
> - HISP group member 3

> *"Most of the time requirements are collected through field visits and engagement meetings that is done in conjunction with workshops that are organized now and then. This is a good way to communicate with regards to requirements, but also get feedback on new features that has been implemented."*
> - HISP group member 5

Some of the HISP groups also communicate with certain groups of end users through online communication channels like WhatsApp and consequently collect requirements through these in addition to field visits.

> *"We have a WhatsApp group for data managers from the health facilities. The first data correction points is the health facilities. They might have challenges and might find that it is important for them to add certain functionalities to DHIS2. They will then share the feedback with us in the HISP group through the WhatsApp group, which a couple of Oslo guys are members of as well."*
> - HISP group member 3

Additionally, the end users are often unsure as to what it is that they want. The HISP groups will then work with the end users, trying to figure out where the issue lies and what feature would solve the problem that the end user has. Writing down the use cases that are relevant for the requirements is also important for the requirements to be easy to understand for outsiders that might not be familiar with the situation.

The HISP groups often do not utilize the full scope of functionalities that DHIS2 has to offer, but particular functionalities that cover the needs of the countries that have implemented it. The requirements that come in consequently reflect how DHIS2 is used in the country.

In addition to receiving requirements through field visits and the WhatsApp groups, the requirements can also come from Jira and the DHIS2 Community. The HISP groups also have to pay attention to these posts to not miss out on important requirements and compile them into one document that is sent to the core team for further processing.

5.1.2 Core team

The core team has several ways of capturing requirements from the field. Their interaction with the HISP groups is the dominant way of capturing requirements. The interaction with the HISP groups takes place through several arenas and will be the topic of the next section. In addition to this interaction, Jira and DHIS2 Community are regularly checked to capture requirements or issues. It is therefore important that the core team spends time on these platforms and be updated on new posts.

However, the core team has a desire to be closer to the end users themselves, having a direct dialogue with them. Therefore, they do arrange some field visits. They also have workshops where requirements can be collected directly from the end users themselves.

5.2 The Prioritization Process

A prioritization of requirements is performed by both the HISP groups and the core team. The HISP groups have to prioritize the requirements that they get from the end users. The prioritized list is then shared with the core team. The core team receives prioritized lists from many HISP groups and have to prioritize these themselves. How the prioritization process is executed varies.

5.2.1 HISP groups

One important first step when the HISP groups receive requirements from the end users is to make sure that the desired features do not already exist in an application or function that is available through DHIS2. If a feature does exist that will meet the requirements of

the user, then the requirement should not be included in the excel sheet to be forwarded to the core team.

The HISP groups all have different approaches to how they prioritize the requirements that are collected from the end users and that is forwarded to the product managers.

> In the prioritization process we use ranking and voting because we cannot go through with all the requests that we receive. The HISP group is asked to vote for which requirements should be prioritized. They get time to discuss the features, why it is needed and where it is used. They also have time to explain to the rest of the group why the features are important. After this we have about one month to vote, but this depends on the DHIS2 roadmap and where they are in the process."
> - HISP group member 3

Ranking the requirements and vote for the most important ones seems to be a repeating process within the HISP groups. Considering that many of the requirements that are provided to the HISP groups are not doable in practice or might be too specific, going over them and properly document them is an important part of the HISP groups' job before forwarding it to the core team.

It is also useful to investigate if the requirement or issue has already been posted on Jira or the DHIS2 Community website before prioritizing. If the feature has been requested by other HISP groups, it could already have been evaluated by the core team. But if the feature is missing and there doesn't seem to be anyone else requesting it, the requirement can be added to the excel sheet for further evaluation and prioritization.

5.2.2 Core team

The core team has apparently tried several ways of capturing and prioritizing requirements from the HISP groups in the past. What is of preference clearly varies.

The user stories that the core team receives from the HISP groups can often conflict

with one another. For instance, one user story can focus on speed, while another focus on something completely different, for instance asking for a lot of functionality.

> *"Those [user stories] are opposed - the two interfaces cannot exist side by side. We have two approaches to these situations. One is a softer approach where we say that we are trying to make something in the middle and find a compromise. The other approach is where the product manager makes a decision of what they want to support. This is a hard part of the job."*
> - Core team member 6

But being transparent and honest in the design process is something that the core team values. A lack of resources is an issue that most of the HISP groups are aware of and that the core team acknowledges as well.

> *"We are very tight on resources, we don't have many designers and developers. So we have to be honest and say that "this is not covered in this application". But ideally, I would like to stay in the first approach where you can configure it to make it fit your needs. We are trying to build adaptable components and interfaces."*
> - Core team member 6

Furthermore, NGOs and other projects all over the world have implemented DHIS2 and consequently, user stories can come from NGOs and donors as well. Generally, the product manager explained that the NGOs are less prioritized compared to for instance the ministries of health.

> *"But I give fairly little attention to the NGOs."*
> - Core team member 2

The explanation behind this is that the NGOs might not ask for features that are relevant and a high priority throughout the country. The ministries of health, on the other

hand, asks for things that are the principles from the users and not the governments, which possibly is the case of the NGOs. Instead, the NGOs are told to communicate and present their needs to the ministries of health. If the ministries of health can stand behind the request, they can instead request it from the core team. This is also an advantage as it makes the NGOs and the ministries of health communicate with each other.

> *"But this is a gap that needs to be filled - how can we engage the NGOs in the development process?"*
> - Core team member 2

5.3 Mockups and Prototypes

The mockups or prototypes are created by the core team and sequentially sent to the HISP groups for feedback.

5.3.1 Core team

A library with standards relevant to DHIS2 is used when creating mockups or prototypes. The core team has dedicated workers with experience within the field for creating the mockups and all new features that are developed are passed through these experienced designers. From there on, the process is an agile-inspired process where the mockups are created, sent to the field ambassadors maybe once or twice giving them a chance to provide feedback before the development process starts. Even though all the field ambassadors get a chance to provide feedback on the mockups, it does occur that they do not take advantage of this opportunity.

Sharing the mockups or prototypes with the HISP groups and for them to provide feedback is appreciated by the core team. Furthermore, sharing it before too much work is put into it is beneficial for the core team. It makes it easier to discover features that are not useful early in the process, when changing it is very time-consuming, and when too much effort has not been put into the feature already.

"I like to build fast rough prototypes that can be shared. This is where I make ideas for interfacing and how things can work and I share it internally with the team [the product managers and the implementers] and also with the HISP community. This is a great place to get a quick sense if it can work or not. I try to not put too much work in it before testing the ideas."
- Core team member 6

Furthermore, trying to understand the motivation behind the feedback can be beneficial in the further design process. When the NGOs, HISP groups, or other users then provide feedback, investigating why they are requesting a particular feature can help the core team. It can aid in understanding what they actually need while also using their expertise to develop features that benefit as many users as possible.

"I try to take it back to the motivation, so "What are you actually trying to achieve here? We can make that possible in another way that works for everybody else as well." A lot of the feedback I get, or when I go out and ask people, it kind of takes 2-3 deeper questions to get the deeper motivation. The work that I do is kind of the digging. Because I get a lot of feedback, but then my job is digging into it to get to the motivation."
- Core team member 6

5.3.2 HISP groups

As mentioned, the product manager sends mockups of features to the field ambassadors in the HISP groups. Some mockups are discussed in weekly or monthly meetings, like the weekly design meetings. But other features are not discussed in these meetings and are sent through email for review and feedback.

But regardless of how the HISP groups receive the mockups, the question is what is done after they receive the mockups. Often, there are two rounds where the HISP groups can provide feedback on the mockups, but usually not more considering that it delays the

release time. Most HISP groups do not send the mockups to the end users for feedback, especially not the lower levels of end users.

> *"We do not send the mockups to end users. But I think that it would be helpful to send the mockup to the person who suggested it for feedback though, but we haven't tried this."*
> - HISP group member 3

One HISP group explained that the members look at the mockups individually and provide feedback and eventual improvements. Unless the feature comes from the respective HISP groups' area of the profession, they do not spend time discussing the features together as a group. Discussing the features as a group is mostly done when the HISP groups know what the client wants and the relevant use cases. The feedback from the HISP members is then collected, reviewed, and compiled before it is sent back to the product manager.

Another HISP group explained that they systematically share the mockups with the countries DHIS2 Technical Teams when they receive them.

> *"We send the mockups to the DHIS2 Technical Teams in the countries. They are the ones implementing the system etc. So we share it with them for their feedback because they are end users themselves."*
> - HISP group member 2

But this might be a cumbersome process for the country DHIS2 Technical Teams. They mentioned that they wanted to change their approach.

> *"But sometimes when we send it to them, they just say that it is fine and don't really take the time to give proper feedback."*
> - HISP group member 2

Considering the size of DHIS2 and the number of features, all HISP groups might not use all features that are available on DHIS2. Consequently, providing feedback on a feature where you are not familiar with the use case can be challenging and might not be very productive and useful for the core team.

> *"DHIS2 is getting big with a lot of features and we do not even use all of the features.*
> *If you do not know the use case, it is hard to provide feedback."*
> - HISP group member 3

5.4   New Release

Due to the nature of DHIS2 and the fact that the core team struggles to communicate with all user groups before new features are developed, a lot of the feedback on features comes first after it has been implemented. This is not ideal for the core team. Ideally, the feedback would come before the design, development, and implementation are completed.

> *"Often we do not get feedback until 1-2 years after the release. It might take 1-2 years*
> *before the countries are updating to the new version. That can be a challenge."*
> - Core team member 6

This is partly why it is important to keep the developed features flexible.

> *"Designing for flexibility is essential because it is a kind of rolling design process in*
> *a way. It is not about building an application, release it and moving on to the next. I*
> *think most of the core DHIS2 applications has the rolling and building minimum viable*
> *products, but then build upon it as you get more experience of how it is actually used."*
> - Core team member 6

Certain HISP group members that the core team works with are pushy and vocal. Consequently, when prioritizing and developing new features, these might be considered

more important. After the release, they might realize that there were other groups that weren't heard, but that had great input for the development process.

> *"But then when we build the application and release it, we sometimes find out that there are all these other user stories that we didn't hear about until they came to us with it. That is a challenge which doesn't have an easy solution. That requires us to try to release something that in the first instance is flexible and have a base that can be built upon."*
>
> - Core team member 6

6 Arenas

There are several ways for the core team, HISP groups and end users to communicate with each other. Based on interviews and groupware analysis this sections tries to explain how the communication generally takes place. Figure 3 is an attempt to visualize the different how the arenas are utilized between the core team, HISP groups and end users. These communication links will be further elaborated during this section.
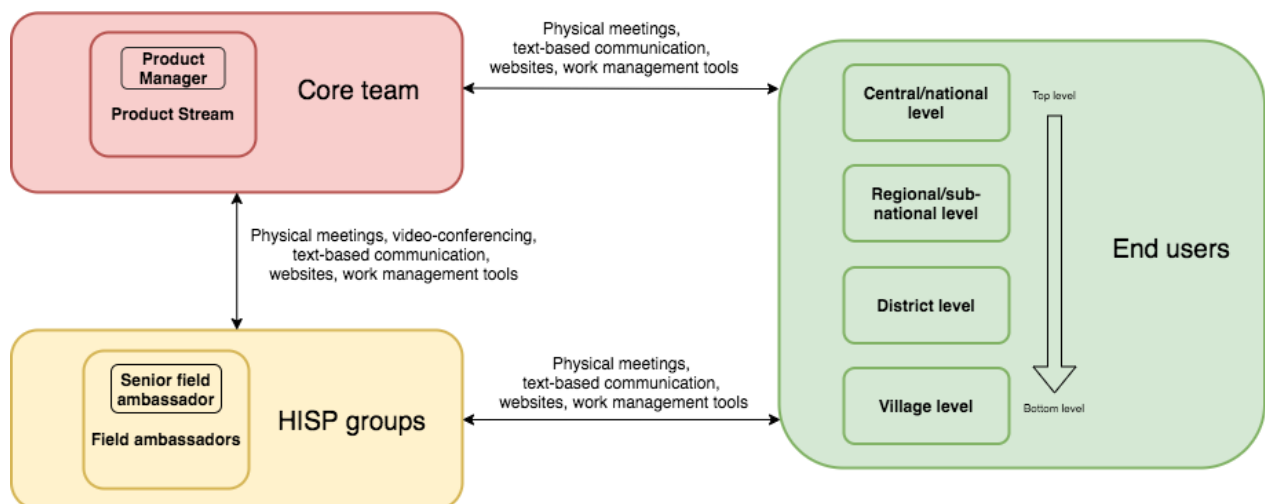
Figure 3: Communication links between core team, HISP groups and end users engaged with DHIS2.

A majority of the following subsections are divided into subsections again. One of these discuss how the core team predominantly communicates with the HISP groups, but also the end users, through the arenas. The other focus on how the HISP groups use these arenas to communicate with predominantly the end users. The last subsection discuss how the video-conferencing tools are utilized. This is based on two meetings where these tools are vital.

6.1 Physical Face-to-face Meetings

One form of face-to-face meetings that are regularly used within the DHIS2 ecosystem is field visits. The definition of field visits in this context is when an individual or a group, either from the core team or from the HISP groups, travels to and seeks out end users of the software to communicate with them directly.

6.1.1 HISP groups

Certain HISP groups expressed the importance of field visits for capturing everyday issues the end users interacting with DHIS2 face in their activities. The field visits have different structures. Some are planned by the HISP groups themselves and usually take place a couple of times a year. Additionally, the HISP groups regularly conduct workshops and perform DHIS2 training with end users in the field, through for example the DHIS2 Academy. These function as a point of communication where the HISP groups can interact with end users to get input and feedback.

The DHIS2 Academy enables the HISP groups to go out in the field, giving the end users a chance to discuss issues and come with ideas or concerns, and also share their general experiences with the usability of the product. The HISP groups can help the user with functionality issues or customization. If the end users want something that is not doable with the resources that the HISP group has or the feature is not available on DHIS2, then the HISP group can report it on Jira or bring it directly to the core team.

The fieldwork can be initiated by the ministries of health that the HISP groups are in close collaboration with. The ministries of health can arrange fieldwork where they are visiting districts and occasionally the HISP groups are invited to join these to arrange workshops or provide training or have routine meetings and presentations with the regions and districts. This is a great way for the HISP groups to communicate directly with the end users.

> *"Usually we have someone every month going out for training and field visits. The training topics varies, but we also use these opportunities to expand into other DHIS2 core functionality discussions as well. So in terms of going into the field, we do go quite often. Occasionally planned by us, but more often from invitations from the ministries of health."*
> - HISP group member 5

If the challenges that are faced by the end users during these visits can be fixed by the HISP representative directly, for example, if the issue is a configuration issue, then it is addressed then and there. If the issues are design issues, on the other hand, those have to be addressed by the core team. The requirement is then properly documented by the HISP group and included in the requirements list as a suggestion for the next release. Therefore, field visits are useful for requirements collection.

During the interviews, it became clear that certain HISP groups that have the resources can choose to spend time in the field individually.

> *"I decided to spend two years in [the country] to get a better understanding of what was going on in the field and to get the best image of the country context. I worked with them for two years, and during these years, I had regular contact with the end users at the lower levels. But since I left, I haven't had the same contact with the lower level users. Now I have contact with end users at the central level, but less contact with those at the facilities."*
> - HISP group member 2

There are certain obstacles that some HISP groups face regarding field visits. Some of the HISP groups are rather small and do not have the resources to send personnel into the field. Another obstacle that some face is permission for doing field visits. A mandate from the ministries of health can possibly be required in order for the HISP groups to visit the health facilities.

6.1.2 Core team

Interviews with core team members revealed that there is a desire to expand the teams for increasing resources and to use some of these resources to spend more time in the field. This allows the core developers to get a better understanding of the end users and the use cases of the software that they will be developing. Not only is this both time and resource-demanding, but the case of Covid-19 has slowed down this process significantly.

However, due to the vast majority of end users and the large differences between these end user groups, it will regardless be too big of a responsibility for the core team to travel to all of them. It is not realistic to think that the core team developers will have the opportunity to do this. Regardless, it was expressed that it is considered useful by the core team for the developers to travel to the field and get insight into the situation. The product managers have therefore arranged field visits with developers in the past and have a goal to continue with this in the future.

Field visits have also been arranged in the past by partnering up with other research opportunities. By running research projects in collaboration with other organizations the product stream will receive funding for the travels, and the findings from these research projects can often be brought back into the roadmap process of DHIS2.

The product streams also arrange field visits where they invite the HISP groups to join. As mentioned earlier, this is a great opportunity for the HISP groups to travel to the field and make them interact with the end users directly. By providing them with training on how this can be done and why it is useful, it can encourage the HISP groups to continue

doing it by their own initiative.

> *"My favorite part [about field visits] is to make the HISP groups talk to the end users."*
>
> - Core team member 3

6.2 Websites

The online community forums for DHIS2 are examples of social boundary resources that help and enable stakeholders to understand the ecosystem and the software. The DHIS2 Community website [13] is an example of such a community. Anyone can sign up for the DHIS2 community to be involved in discussions. It is a place to share knowledge, skills, and interests through ongoing conversations. The DHIS2 Community website has a lot of daily activity all over the world.

6.2.1 Core team

The product managers occasionally use the DHIS2 Community website to receive feedback on mockups that are created for core features. Considering that anyone can become a user of the DHIS2 Community and has the opportunity to provide feedback on mockups, participate in discussions and post issues or bugs, etc., it appears to be a great channel to communicate with users all over the world and include anyone who wants to be involved in the design process.

After researching the posts where mockups are included and feedback is requested on the community website, it, unfortunately, looks like the participation and engagement are somewhat limited. A screenshot of one post asking for feedback on a specific feature is shown in Figure 4. As indicated at the bottom of the figure, the post was viewed over 500 times. But the number of users providing feedback is only 4. This is a low number compared to the number of users which are obviously reached. Why this is the case is not easy to say and will only be speculations.

Figure 4: Post asking for feedback from the DHIS2 community in January 2019.

Figure 5 shows another post asking for feedback from the DHIS2 community. It is noticeable that the reach of this post was significantly lower than that of the post in Figure 4 with only 46 views. It was arguably posted during the Covid-19 pandemic, which potentially can influence the reach as many countries are busy with features that are related to the pandemic. However, from looking into the website, it became clear that how many people one post reaches varies greatly.

The ones that are posting these mockups have mentioned themselves that the feedback on these posts is limited and does not in practice reach as many as it could do in theory. Unfortunately it seems like the willingness or the time and resources for users to go through mockups that are posted on the website is minimal.

Figure 5: Post asking for feedback from the DHIS2 community in February 2021.

6.2.2 HISP Groups

During the interviews, the DHIS2 Community website did not appear to be a huge part of the HISP groups' workday. When mentioned, they did explain that the website was useful, but they did not provide a lot of insight as to how the website was used or why they considered it useful. However, when asked about the mockups and their perspectives on why the feedback on these posts is low, they did have some plausible explanations.

The HISP groups often receive the mockups through meetings and get the chance to provide feedback before they are posted on the DHIS2 Community website. Posting these mockups on the website was from the HISP groups' perspective considered to be more for the public and end users that are not a part of the HISP groups, as they do not get the chance to join the meetings where the mockups are discussed.

Another point that was mentioned during the interviews that can be considered as an argument not to post mockups or designs of a specific feature on the DHIS2 Community website is that there is a risk attached to being too transparent as well. HISP group members or other stakeholders that see these mockups might believe that this is going into production and can potentially start planning based on these features or designs. For instance, they might include the features when asking for funding or talking to governments regarding future development. Everyone engaged on the website might not have an understanding of the design process. The mockups might change drastically during the development process due to for instance technological constraints or changes in the user stories.

6.3   Work Management Tools

Jira is a work management tool used in conjunction with DHIS2. It is a globally open communication platform where those who are interested can sign up. On the platform users can follow the development process or get an overview of what is included in the next release. The platform also enables users to provide direct feedback and requirements to the decision-makers, participate in discussions, provide their own requirements, or report bugs and issues [1]. Jira has grown to become a very large community with thousands of users and posts. The number of posts on Jira has reached 10 000 and are generally about DHIS2 development topics.

6.3.1   HISP Groups

The sheer volume of posts indicate that users are active on the platform, reporting issues and bugs etc. But it also offers some challenges. Due to the large volume of posts on Jira, not everything is assigned to someone that deals with the post.

> *"Some issues might fall through the cracks and then you realize that the issue that you posted a couple of months ago still hasn't been attended to or responded to at all."*
> - HISP group member 5

Figure 6 shows an example of a post that presumably fell through the cracks. The post is from 2016 and was updated in 2019, but it is still unassigned and unresolved. The post is asking for an update where the user is provided with a notification when the session has expired.
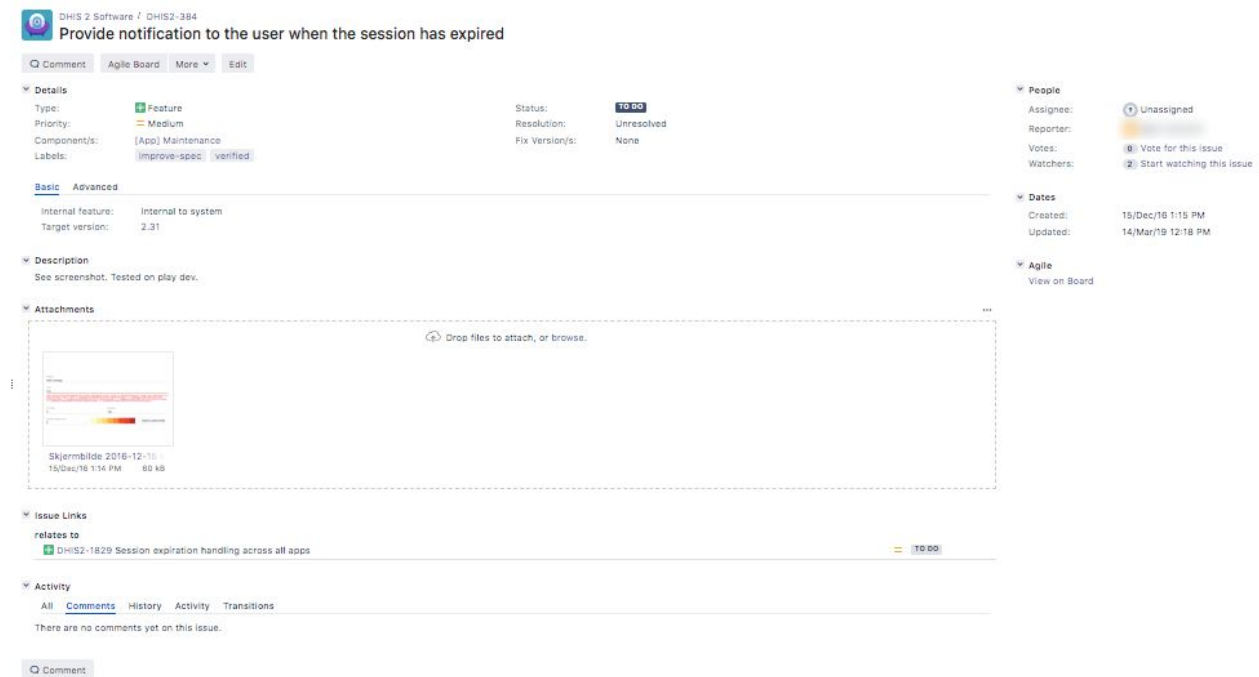
Figure 6: Post asking for a feature in 2016 that was never assigned to anyone and that is still unresolved.

Figure 7 shows another example of a post that has passed unassigned and unresolved. This post is newer as it was first posted in 2019. The comments on this post indicates that the issues is of interest to be resolved, but it has still not been assigned to anyone.

Figure 7: Post asking for an update in 2019 that was never assigned to anyone and that is still unresolved.

The HISP group members explained that posting something on Jira often is not sufficient in order for an issue to be attended to. This is unfortunate, but also understandable with the number of end users being myriad compared to the number of core team members.

> *"It is very easy for things to fall through the cracks on Jira if you don't make sure that it is noticed and followed up and prioritized. If an issue is critical, the best practice will be to register it on Jira, but in addition to this also contact the core team through WhatsApp or Slack or other channels, making the responsible people aware of the issues."*
> - HISP group member 5

But if users actually post issues on Jira, then they should be updated on the process. If their post cannot be considered and solved, they deserve an explanation as to why. Not providing an explanation and for the issues to remain unresolved and unassigned can be a demotivating experience for the ones writing the posts. They can be left with a feeling of not being taken seriously. This in turn can lead to users not seeing the benefit in posting issues on Jira in the future.

It was explained that certain HISP groups do not see the use in encouraging users to post issues on Jira themselves, both due to the sheer volume of issues, but also that it might not be assigned to those who actually knows how to effectively solve the issue. Consequently, many HISP groups tell end users to send it to them instead to be forwarded to the responsible product manager.

> *"I do not encourage users to put requirements on the community themselves - it is like swimming in the middle of an ocean where there are no rescue people near by. People might think that they know what they are doing and don't need assistance."*
> - HISP group member 1

Forwarding issues or making responsible people aware of the issues that has been posted on Jira might be something that the experienced and larger HISP groups are capable of. The more integrated HISP groups might have developed relationships with the core team and they know which people to contact that is responsible for the issue that arise. It is therefore easier for them to push their issues onto the core team, making sure that the issue is being heard. For the smaller and less experienced HISP groups, or non-HISP groups and other end users, this might not be the case. It is also important for those posting on Jira to make sure that the issue or bug report hasn't been reported already to avoid duplicated posts. This therefore requires some effort from the users of Jira on staying updated on what has been posted earlier.

6.3.2 Core team

Jira is a great way for the core team to receive bug reports, issues, and other reports from all over the world. But the ability to recognize important requirements, bug reports, and issues on Jira and assign them to qualified developers is important and necessary, but also challenging. One feature on Jira that simplifies the process of keeping up with important issues is to look at the number of votes or followers on an issue.

The core team has to constantly monitor Jira, looking at posts and which posts are rising to the top regarding votes and followers. This indicates the importance and scope of an issue. The issues also have to be assigned to the relevant people to be resolved.

> *"It is a massive effort for us trying to be responsive. The reality is that we will always fail - it is too big of a global community for us to make everybody happy. But as long as the process attempts to be democratic and we believe in the inputs that we are receiving, then that meets our vision as to what we are trying to do."*
> - Core team member 3

Another interesting point that was mentioned during one of the seminars is the fact that Jira is extremely time consuming.

> *"I actually spend more time on Jira these days than I do on DHIS2."*
> - Core team member 2

Furthermore, it was explained that Jira has turned into a forum for tech support where a lot of the questions are not answered. He expressed that there was a bigger aspiration for the posts to be more about registering use cases, as well as sharing different successes and best practices that other users can learn from. It would be an advantage if Jira could be extensively used for knowledge sharing.

6.4 Text-Based Communication through Groupware

A lot of different communication platforms are used between the core team, the HISP groups, and the end users. For instance, Slack[3] and WhatsApp[4] are often used to chat in larger groups and where the response time is usually relatively short. Chat systems, like Slack and WhatsApp, enable two or more people to have online real-time text conversations [10]. The messaging feature on DHIS2 platform is another way to communicate with groups and people where the topics are mostly concerning the features that already exist in DHIS2.

6.4.1 HISP groups

WhatsApp is common groupware used in the HISP communities. Certain HISP groups explained that this was a great tool for communicating directly with the end users in the field, for instance with data managers from health facilities. Issues and requirements can be described by the end users on WhatsApp and these can then be attended to by the HISP groups. If the issues or requirements are something that should be forwarded to the core team for them to work on it, then it can be correctly and thoroughly documented by the HISP groups and forwarded officially to product managers. The general feedback that the end users might have can also be shared on the WhatsApp group.

Certain HISP groups did however explain that they communicated with the ministries of health using WhatsApp, but did not directly communicate with the end users at lower levels. The ministries of health worked as their intermediaries and were the ones that were directly linked to the end users instead.

"There isn't really any communication with the end users directly from the HISP group, there are some steps in between."

- HISP group member 5

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[3]https://slack.com
[4]www.whatsapp.com

Consequently, the ministries of health in this case have a lot closer contact with the end users compared to the HISP groups. The HISP groups instead communicate and collaborate closely with the ministries of health to get feedback from the end users through them and forwards this to the core team.

6.4.2 Core team

Occasionally, core team members are also invited to join the WhatsApp groups between the HISP groups and the end users, providing the core team with a direct link to the end users. They get to listen to the end users' day-to-day issues with the software and get direct feedback and requirements from the field.

Slack is another communication channel that is used to link the core team to the HISP groups. Slack is for the most part used to report issues or requirements where the response time is expected to be moderately low. Furthermore, Slack is used for workgroups that communicate and collaborate with each other, like for the participants of the weekly design meetings. There is a Slack channel for the participants of these meetings where thoughts and concerns can be shared with others. It is a great way to link the participants together, creating a small community where the participants can engage in conversations and discussions with each other.

Figure 8 shows a post on Slack by one of the members. Considering that the mockups are posted on the Slack channel, the members can provide written feedback on them when they have the time. For instance, in the following post, it appears that one of the members did not have the opportunity to join the meeting. Feedback on the mockups was therefore provided in the post on Slack beforehand. Posting the mockups on Slack allows for everyone to be included in the discussions even if they do not have the opportunity to join the meetings.

Posting the meeting agendas on Slack before the meetings lets the attendees know in advance what the topics of the meetings are and these posts also work as a reminder
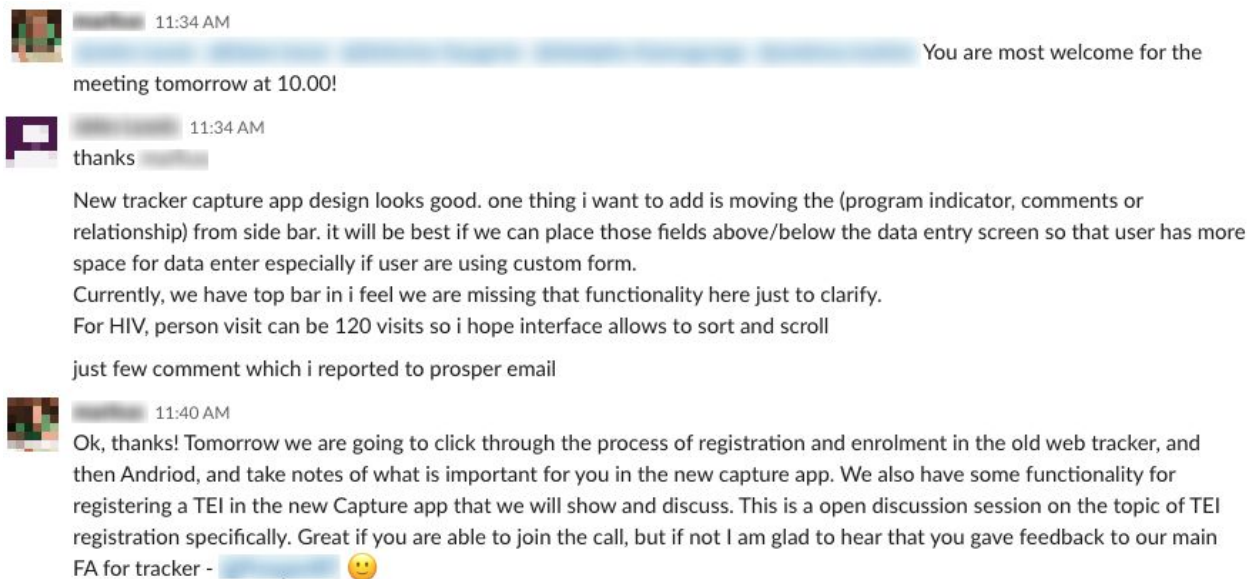
Figure 8: Post providing feedback on mockup.

of the meetings. Links to the mockups are posted here as well, giving the participants easy access to them to evaluate them once again and look at the updates from last week's meeting. Figure 9 shows an example of such a post.

The Slack channel is also great for questions, which again can initiate discussions. Figure 10 shows a post asking questions about a certain label that was unclear. Other members can join the discussion and come with their expertise in the area. Slack is great for involving a large group of people and as noticeable the response time is relatively short.

In addition to the external groupware used, there also exists an integrated messaging feature available in DHIS2. This allows users to send messages to other users, user groups, and organizational units. The messages will only appear on DHIS2 and are not sent to an email address in addition. It was mentioned during the interviews that the DHIS2 messaging feature is used for feedback and general messages. The messaging module is used by several of the HISP groups to create groups to communicate with countries that they work with. It allows for the HISP groups to both receive and share issues and to provide support to end users in a fast and efficient way. It creates a direct channel between
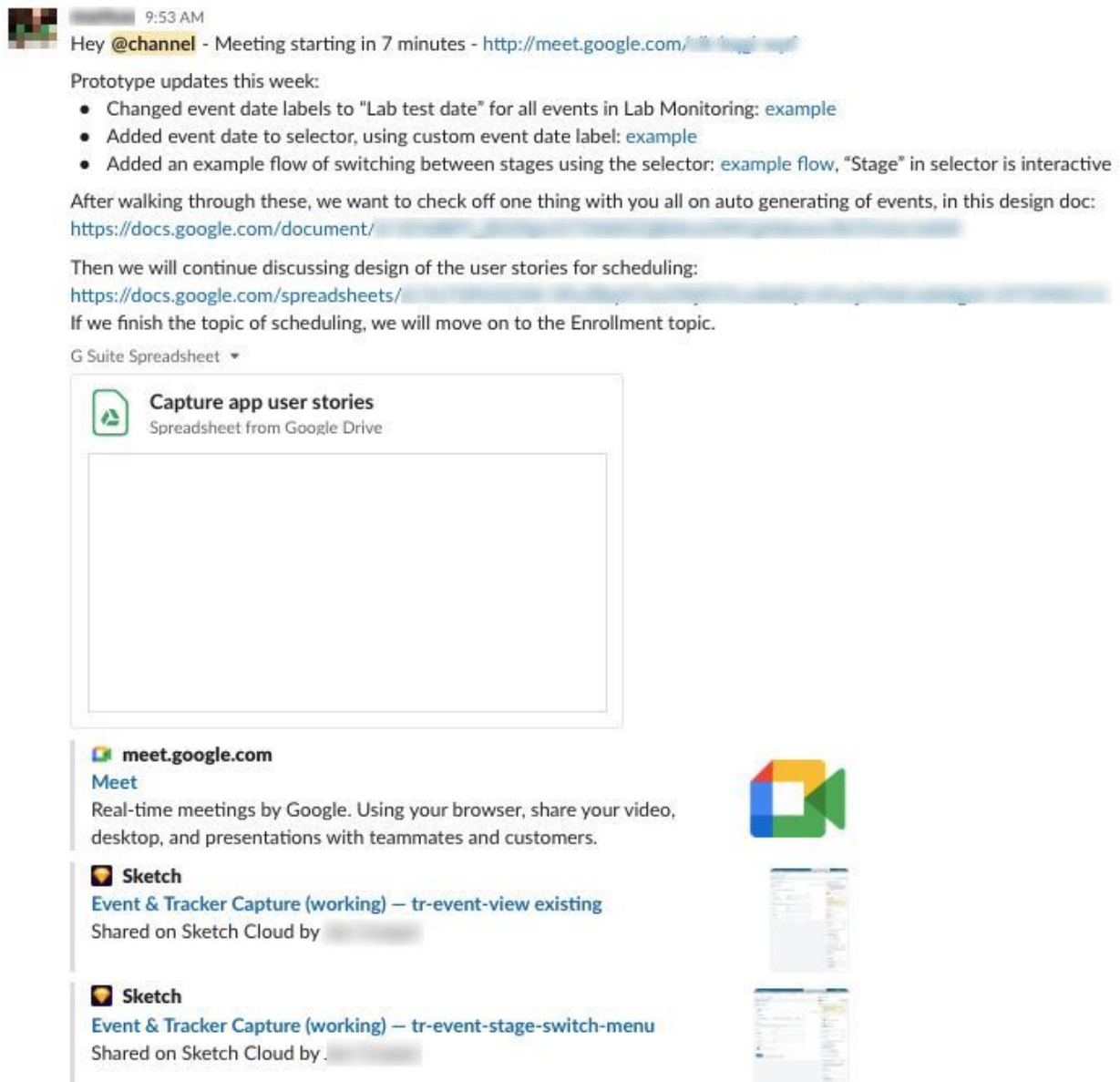
Figure 9: Post on Slack reminding the members about the weekly design meeting and with a meeting agenda. Links to the mockups and updates since the last meeting are included.

the HISP groups, end users in the countries that they work with, or works as a direct communication channel to the individual end users everywhere.
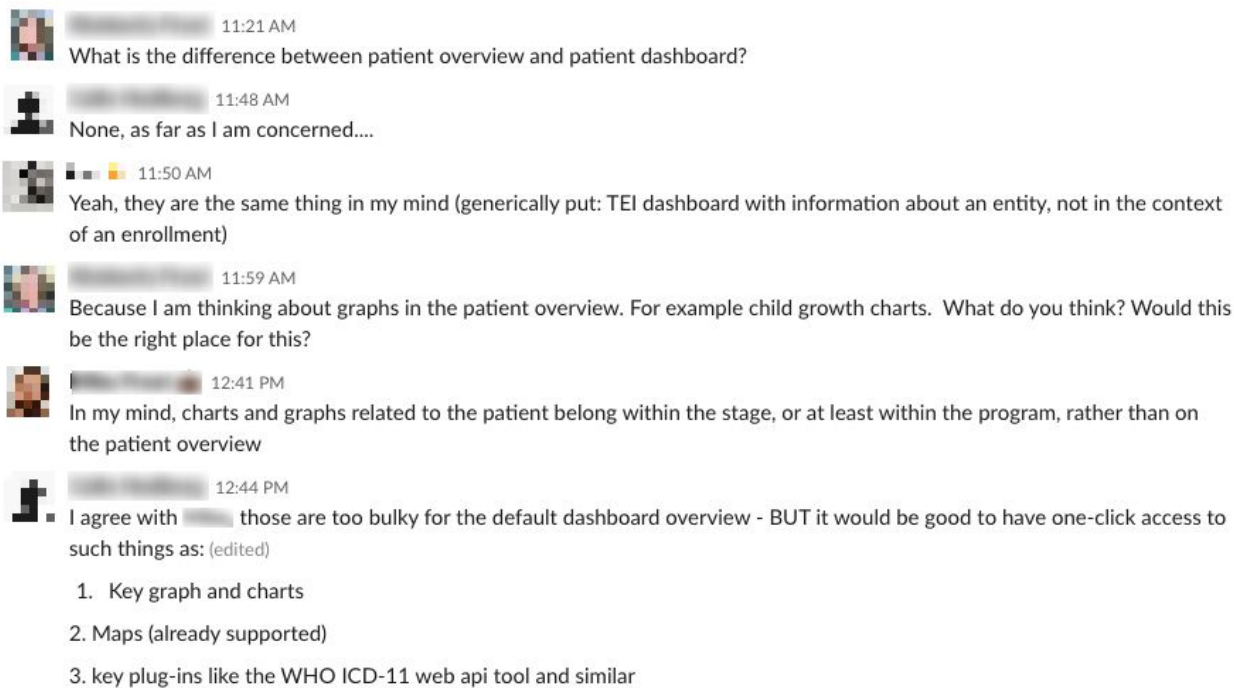
Figure 10: Member asking a question and getting answers from several different other members.

6.5 Video-Conferencing

Video-conferencing tools allow teams to communicate in real-time with each other and were particularly useful and extensively during the pandemic. Meetings are hosted using these tools and directly link the core team and the HISP groups together. It does, however, not appear as if the video-conferencing tools are used to tie the core team or the HISP groups to especially the low-level end users, which potentially is due to lack of resources and access to such tools for these groups. Considering that the end users are not a part of the following meetings discussed that utilize these tools, this section is structured differently than the previous sections. This section focuses on two meetings where video-conferencing tools are essential and where the attendees are members of the core team and the HISP groups.

6.5.1   Weekly Design Meetings

One arena that facilitates collaboration between the HISP group members and the core team members is the weekly design meeting that takes place every week at a certain time over the video-conferencing tool Google Meet. This meeting gathers HISP group members from different parts of the world, which consequently places participants in different time zones.

Prior to having these weekly design meetings, the relationship between the core team and the HISP groups was ambivalent. There was a lot of frustration from the HISP groups' side affiliated with difficulties regarding communication. The miscommunication made it difficult for the core team to receive feedback from the HISP groups.

> *"The weekly design meeting was a deliberate effort to try to change the feeling [from the HISP groups] about not being heard and not being included in the design processes. The goal was to create a dedicated forum where the core team could receive feedback from the HISP groups and understand their priorities."*
> - Core team member 3

The main objective of the meetings is to work together to build specific applications. In short, the attendants go through functionalities, gather user stories from the respective HISP groups, before moving on to functional requirements and design. The last step is a new release where the new applications and features are included.

The members from the HISP groups that usually attend these meetings are the field ambassadors for the relevant product stream. However, other members of the HISP groups can also attend as the invite to the meetings is not restricted to the field ambassadors. If the group members prioritize attending the meetings or not is up to them.

> *"Who joins the meetings depend on the HISP groups. The field ambassadors from all HISP groups are invited, but it is up to them if they want to prioritize to join the*

meetings or not."

\- Core team member 3

The meetings usually have a decent cross-section representation of HISP groups. Allegedly, the number of different HISP groups that are usually represented in these meetings is three or four. A diverse representation is valuable for the core development, considering that the variation between the HISP groups can be large when it comes to requirements and necessary functionalities.

Nonetheless, the number of attendants should not be too large either. Usually, about 14-18 individuals attend the meetings. It is beneficial that the number is kept to a point where the attendants are not hesitant to speak up and express their opinions.

"We try to keep the NGOs and others out of the meetings. We have NGOs that we work on design with, but we prefer to do this separately from the weekly design meeting because we want to keep this meeting like a privileged channel for the HISP groups. The HISP groups are officially a part of the roadmap process, and it has been difficult in the past to get feedback from them, so this is kind of a dedicated forum to get the feedback and understand what the HISP groups prioritize."

\- Core team member 3

The meetings discuss one topic each week. It is a continuous process, starting where last week ended. The first step of the workflow is to collect user stories from the participating HISP groups and write the user stories in a Google spreadsheet.

Generally, the ability to see and recognize requirements, as well as spending a sufficient amount of time thoroughly understanding them and formulate good written user stories, is very important for the HISP groups. The ability to argue for them is also important for them to be included.

There are numerous tabs in the Google spreadsheet that contains user stories provided by the participants. In addition to providing the user stories, the meeting arena allows the

HISP groups to contextualize and provide a description of the relevant use cases to the other attendants. This is an advantage compared to posting the requirements on Jira. The discussions decrease the chances of misunderstandings regarding the user stories and give the participants the chance to argue why the particular user stories should be prioritized. The user stories are then considered and prioritized internally by all the participants during the meeting.

Where in the process the group is will decide what the topic for the week will be. For instance, if the requirements have already been gathered and prioritized and a prototype has been developed, then the group will go through the Google spreadsheet and mark if the user story is covered by the prototype design or not. If not, a discussion about how the user story can be included in the design will take place.

The weekly design meeting is a useful arena for different HISP group members to discuss features and designs directly with the core team and their developers. The participants provide experiences from their regions, explaining why certain design ideas are beneficial or disadvantageous for the use cases they are familiar with. This helps ensure that the decisions that are taken benefit as many end users as possible.

It is obvious that the representatives from the HISP groups attending the meetings are familiar with the experiences from their respective fields and end user groups. The representatives bring up relevant experiences that the developers from the core team based in Norway might not think about when developing the new features.

> *"The majority of the users out in the field work with small screens and therefore has a limited screen surface. For them to be able to filter out what they want to view and not is therefore an advantage."*
> - HISP group member 5

Moreover, the meetings are a great way for the developers to ask if the changes that they have made to a prototype from the meeting last week were actually in line with what was proposed.

> *"I interpreted the use case and the user story that you had written that this is the func-*
>
> *tion that you wanted. Did I interpret it correctly based on what you actually wanted?"*
>
> - Core team member 4

This gave the one that proposed the feature an opportunity to confirm or contradict the interpretations.

> *"Yes. The majority that I have interacted with find this word confusing."*
>
> - Core team member 5

The meetings give the designers and developers the chance to ask questions that are relevant for the further design process as well.

> *"In everyone's experience, what is considered a lot of stages?"*
>
> - Core team member 6

Receiving this information is valuable for the designers when trying to make the best design choices possible. Talking directly with the HISP groups is a fast and secure way to make sure that the choices make sense and are sustainable in the future.

Moreover, the meetings also challenge the designers to think differently. The designs that already exist and that are already in use might not be the best solutions possible. Maybe the design was appropriate a decade ago, but this might have changed. The ones that actually know how the system is being used might have a better chance to comment on this than what the designers do.

> *"It becomes a legacy thing that is more confusing than useful."*
>
> - Core team member 5

6.5.2 Formal Prioritization Meetings

Approximately twice a year a formal process for prioritization of user stories takes place. During these meetings, every HISP group, the project senior management team, and the

core team comes together for two full days of prioritization work. The aim of the meeting is to find linkages between user stories and find a common prioritization for the further development work of the DHIS2 core. How the meetings are conducted varies.

> *"We last had this meeting in fall 2020, and we did indeed meet virtually using Google Meet. Even when travel was possible [before the pandemic], there is probably always at least some portion of the attendees that would be virtual, given that the HISP groups are all over the world. But corona has made it so that we are entirely virtual at this point."*
> - Core team member 3

This indicates that even though some of the attendees meet up physically, video-conferencing tools, more specifically Google Meet in this case, always play a significant role in the meetings in order to connect all the HISP groups together.

The HISP groups all write down their top 10 user stories for the various parts of the software. This means that the HISP groups have to internally prioritize the user stories as a preparation for this meeting.

All of these groups then come together for two days of prioritization work, trying to find linkages between user stories. A sort of voting process then takes place, where everyone has a version of the spreadsheet and can enter their weighted vote. Exactly how the voting takes place has been tweaked several times and is still being customized trying to find the process that is as fair, effective, and as optimal as possible. A weighted algorithm then brings the most popular user stories to the top of the list. Lastly, the core team will consider the requirements and include in the roadmap the ones that can be addressed and that deemed important.

7 Discussion

To answer the main research question about how geographically distributed teams coordinate and communicate when developing generic software, two sub-questions were suggested. The first sub-question looks at how arenas facilitate in communication and coordination between the different stakeholders of the system. It also discusses how requirements are provided and prioritized. The second sub-question entails the involvement of local teams and how these teams affect the development process.

The first part of this section will look at some general findings that can be linked to the main research question and that can help to contextualize Section 5 and 6, before diving deeper into the two sub-questions.

7.1 RQ 1: How do geographically distributed teams coordinate and communicate when developing generic software?

In an attempt to bridge Section 5 and 6 together, two figures are presented. These figures are striving to give a visualization as to which degree the arenas are used in the development processes. Explanation of how and when the arenas are used in the development processes are included.

Figure 11 shows a graph where the different steps of the development process are represented on the x-axis, while the y-axis shows the degree of use for the different arenas.

The figure only has three degrees of usage, namely low, medium, and high. The degree of usage is based on the interviews and the data collection from the online channels and cannot be measured accurately. It is instead an indication of the arenas used during the development process on a general basis. Individuals might have preferences, meaning that certain arenas might be used to a higher degree for some individuals compared to others.

During the process of collecting requirements, Jira, DHIS2 Community and field vis-
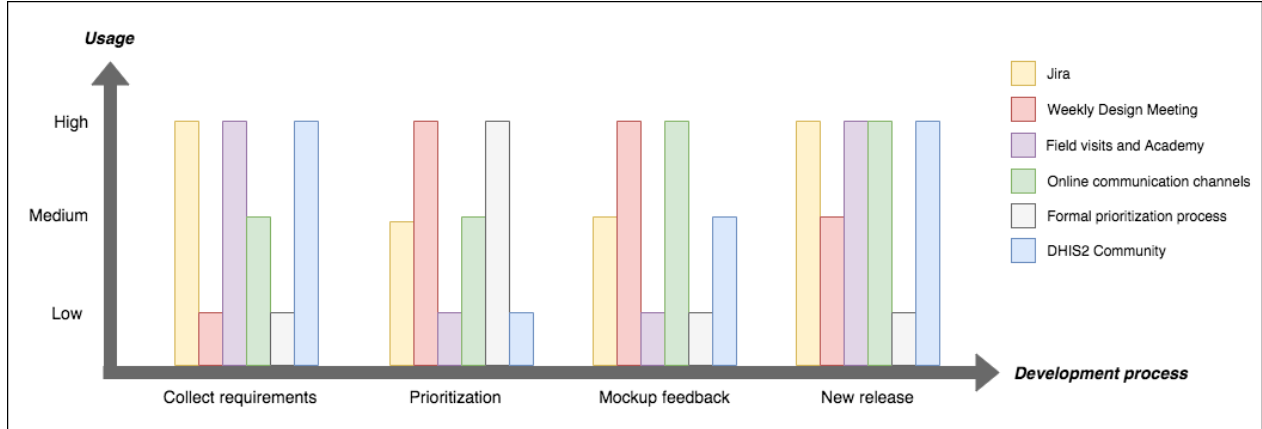
Figure 11: Graph illustrating the degree of usage of the arenas (y-axis) on the different steps of the development process (x-axis). What color represent which arena is shown in the top right corner of the figure.

its, and Academy dominate. Field visits and Academy are for the most part between the HISP groups and the end users. These are dominant during the process due to the importance of interacting directly with the end users and also trying to draw out the users that might not be active on the online communities, but still might have valuable feedback and requirements. By including the users, DHIS2 coincides with open generification. Open generification supports user-centered innovation and recognizes the users as innovators that create a more open and sustainable solution.

Online communication channels are used occasionally. Exactly how much they are used varies a lot between the HISP groups. Some include end users from every level in online communication channels to regularly communicate with them and understand what the requirements are from the field. Other HISP groups do not communicate with end users directly through these channels. The online communication channels are excellent for documenting requirements and making sure that they reach the right people. Discussions and elaborations can be provided in these channels, but the response time is probably longer than with face-to-face meetings.

Lastly, the weekly design meetings and the formal prioritization meetings are not

significant for the process of requirements collection. Those meetings are between HISP groups and the core team, unlike the collection of requirements, which is dominantly between the end users and the HISP groups.

The next step in the figure is the prioritization process. During this process, the weekly design meetings and the formal prioritization meetings are highly used. These meetings invite the HISP groups to elaborate and explain the requirements in more detail and are great arenas for real-time discussions. Jira and online communication channels are also frequently used. In Jira, the core team can get a sense of the importance of a requirement by looking at the number of watchers on the post and how the voting is for the requirement.

The DHIS2 Community and the field visits and Academy are not used frequently for the prioritization process. The field visits and Academy is more relevant for the collecting of requirements, but the users are predominantly not involved in the prioritization process of the requirements. The DHIS2 Community website is not convenient for the prioritization process as it is a website for all of the users of DHIS2. The prioritization process is more suitable for a group of HISP members that can represent their user groups.

For providing feedback on mockups, the weekly design meetings and online communication channels are efficient and frequently used. The weekly design meetings facilitate real-time discussions between the HISP group members, allowing them to provide feedback and explain the importance of features. It also allows for other members to agree or disagree with the feedback and the different viewpoints can be elucidated during the meetings. Jira and the DHIS2 Community are not as extensively used for this purpose as the mockups might get lost in the crowd on these platforms. It is also more time-consuming to write the feedback in a post and make sure it is understandable. The end users are not active in this process, consequently, the field visits and Academy are not dominant during this process.

The last process is to make a new release available. A lot of feedback on new features is provided after the features are implemented and thoroughly tested in their real envi-

ronment. The feedback on the new release is possible through most of the arenas. For the end users at the lower levels, it is most common to provide feedback through either the field visits and Academy, or through the text-based communication groupware, but also by posting on Jira and DHIS2 Community. The end users at the lower levels are not included in the weekly design meetings, hence this is not an arena for these end users to provide feedback. They can, however, provide the feedback to their respective HISP group which can present the feedback at the meeting. Considering that the feedback is objective and can be formulated in a post or a message without the need of much discussion, the meetings are not strictly necessary for the feedback to be valuable.

The HISP groups provide feedback to the core team through most channels. If the feedback needs to be further explained or use cases have to be presented, the meetings can be a great arena for this purpose. The meetings allow for the core team to ask follow-up questions and a conversation can be had to clarify any uncertainties. This is of course also the case with posts or messages, but here, the response time is often considerably slower.

A second figure demonstrates the steps that a requirement goes through to become a feature in a new release. It is a very important step in the development process for HISP groups to receive requirements from end users, communicate these to the core team and make sure that the important requirements are a part of the new solutions. Figure 12 therefore tries to visualize these steps to provide a better sense of how this usually takes place today. There are several different cycles that can lead to the same goal, as the requirement can go through various steps and be handled differently by the people that are involved. The cycle that is illustrated in Figure 12 is one that became obvious during the interviews as the weekly design meetings were predominantly in focus. But as mentioned, there are other steps possible, which are also made obvious in Figure 11.

The first step of the cycle in Figure 12 is when a HISP group receives requirements from its end users. The end users providing the requirements can be from levels, ranging from the national level to the local level. The requirements in this example are collected from
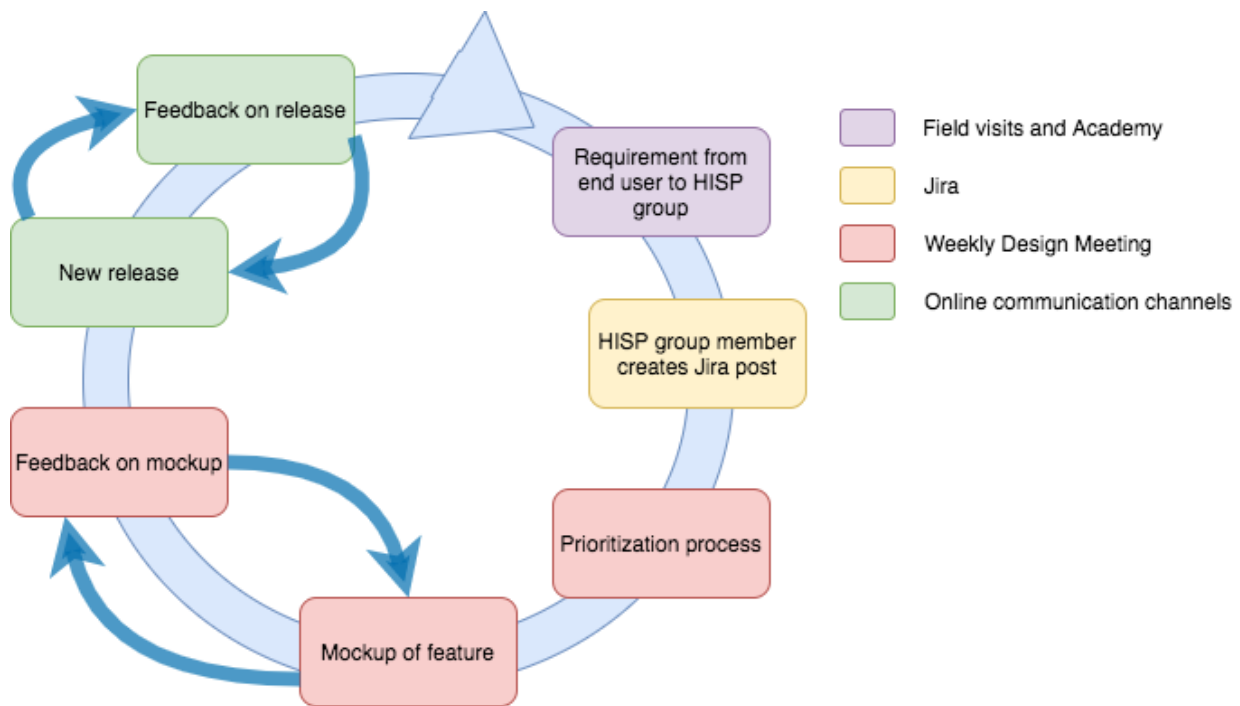
Figure 12: One possible cycle of a requirement from an end user becoming a feature in a new release.

field visits and DHIS2 Academy work. The requirements that are considered important are forwarded to the core team. From there on, the HISP group works on formulating the requirement or issue in a way that is understandable for an outsider that might not be familiar with the use cases. The requirements are finally posted on Jira and are now available for the rest of the DHIS2 community.

The next three steps are in conjunction with the weekly design meetings. All of the requirements that are presented during the weekly design meetings have to be prioritized internally by the members of the meeting. During this process, the ones that presented the requirement get the chance to elaborate and argue for it, as well as provide relevant use cases. The prioritization process can go over several weeks before the full list of requirements that shall be focused on going forward is complete and agreed upon.

After the prioritization process is done and the development team has a clear understanding of which features to work on and what the requirements entail, the process of

creating a mockup of the feature is started. When a version of the mockup is finished, it is usually posted on Slack to the members of the weekly design meetings. The mockup can then be presented during the meetings. The members get a chance to ask questions, clarify uncertainties or misunderstandings, and additionally provide feedback. The feedback can be taken into consideration and the mockups can be changed accordingly. This process of sharing mockups and receive feedback on them can be repeated several times and take place over several weeks. This is illustrated as a small sub-cycle in the figure.

When the mockup has been evaluated and the members are satisfied with the result, the feature can be developed and included in the next release. This is also a cycle of providing feedback for potential changes and performing the changes that are relevant for the next release. The communication in these steps takes for the most part place through online communication channels. Unfortunately, much of the feedback is provided after the feature has been included in the new release.

7.2 RQ 1.1: How do arenas facilitate stakeholders to collaborate?

It was noted by Andriessen [2] that work that is performed in groups often requires many applications simultaneously. This is further backed up by the reality with CSCW, which is that the applications are closed and limited to registered users and often do not take advantage of each other considering that they work in isolation from one another [23]. Another important note is that the numerous software vendors that provide groupware all give rise to their specific functions and limitations, which enhance the need for several groupware as one potentially has limitations restricting to make them sufficient.

During the research for this paper, it appears that research on how large projects use several distinct groupware during development processes is lacking. Therefore, this paper attempts to fill this hole by attempting to explain how a project depends not only one, but on several arenas and groupware systems to achieve effective communication and collaboration.

Section 2.2 describes how groupware is designed to support and assist geographically distributed groups in their collaboration work. In the work with DHIS2, several groupware solutions aid in collaboration towards a common goal, data sharing, conflict resolution, decision making, etc. These are available with the purpose of supporting distributed workgroups and assist them in their work and collaboration.

DHIS2 is a highly dynamic collaborative environment. It involves a variety of people with different backgrounds and skills, in addition to several communication, coordination, and production mechanisms. When and how these are used depends on the users' activities, available resources, and location.

When evaluating DHIS2 against the CSCW matrix in Figure 1, DHIS2 falls under the square of "different place and different time", meaning it is both remote and asynchronous. When ending up in this situation, both communication and coordination are imperative.

Figure 11 demonstrates the many platforms used in the development of DHIS2 for subsidizing communication and coordination. It is clear that during the development of DHIS2, there are several groupware systems that aid in the collaboration between stakeholders. For instance, for the weekly design meetings, several different types of groupware play a dominant role for the meetings to be completed. The platforms that are most extensively used are Slack and Google Meet.

The Slack channel is a great arena for sharing files, communicate directly with the entire group, or to contact individuals that are involved in the meetings. Hence, the Slack group assemble the core team and HISP groups. It also provides and arena for the HISP groups communicate with each other.

Reminders about the meeting, links to the Google Meet arena, mockup links, and general questions and topics are also posted in the Slack group. Hence, for cases that arise outside the hour where the group meets up using Google Meet, Slack is a great communication arena.

"There are also have online channels to write in if there is something that needs imme-

diate attention. Then we usually get in touch with the team through Slack."

\- HISP group member 5

When asked why particularly Google Meet is used as the video conferencing tool, the following explanation was provided:

"Well, we use G suite [Google Workspace [5]] for emails and calendars etc, so it is easier to set up meeting in Google Meet through that."

\- Core team member 7

Consequently, it appears as the arenas that coincide with other arenas are the ones utilized. Slack is easy to use with other arenas, as this platform allows one to connect to the video-conferencing service of choice. This way, the video calls can be set up and invited to using G Suite, which adds the event to the calendar, while concurrently posting reminders about the meetings on Slack.

As mentioned in Section 2.2, face-to-face meetings in environments where the stakeholders are geographically separated can incur substantial meeting costs and also delay the development process compared to using groupware for meetings. With the large physical separation of stakeholders in DHIS2, the meetings would have to be thoroughly planned for them to be feasible. Hence, the coordination and travel costs potentially are considerable. When the stakeholders meet up using groupware, the necessary time for planning is way shorter, as well as the travel costs can be completely disregarded. This speeds up the development process and the resources can be used on the development itself contrary to on travel expenses.

For further studies, it would be interesting to investigate if there is one groupware system that fulfills all the requirements of the development processes of DHIS2, and how using one single groupware system would impact the efficiency and collaboration between the stakeholder groups.

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[5]https://workspace.google.com/

Groupware lead to impartiality

Section 2.2 highlights the study performed by Damian et al. [11] where electronic mediation helped groups emphasize the task-related matters over interpersonal aspects. It also reported that reduced ability to perceive emotional cues leads to impartiality during negotiations of requirements. The same indications are discovered in DHIS2.

Generally, the HISP groups interact with the end users to a larger degree than what the core team does. It was, however, mentioned as a potential improvement for the core team increase the number of field visits. The interaction that the core team has with end users takes place through predominantly the field visits, DHIS2 Community, Jira, and to some degree text-based communication through groupware from Section 6.

However, several challenges can be affiliated with the approach of meeting face-to-face. With a large software like DHIS2, it requires an immense amount of resources for the core team to travel to all user groups. Even though such field visits potentially are useful as it facilitate the developers to experience the use cases, it is most likely not doable due to a lack in resources. This would mean that if the field visits were to be arranged, the core team would have to choose a fraction of the places that have implemented DHIS2 and gain their experiences from this.

> *"The dilemma with any larger development like this is that the key people and their experience and the way that they understand the world, matters a lot to what is prioritized and not."*
> - Core team member 5

If the core team travels to one or two regions to experience how the software is used and by whom, this region does probably not accurately represent how most other regions use the software. The users should be considered in the big picture with all user groups and their needs, and not as a single entity whose needs should be covered. Visiting just a couple of countries can consequently lead to a misleading perception of the full reality.

"I have seen this [in one case] where both the two key people kind of gained their understanding of what [the case] is all about from working on [one particular health system in one particular region]. That is what I call a niche electronic medical record. So when we started using [the case] extensively for [another health system] in [another country], which has different needs and where the thinking is different, it was really hard to get that in it. That has slowly improved. But it is hard to kind of break through these preconceived ideas sometimes, because they have a lot of experience for certain user areas, a lot of interaction with users and so forth, but very little on other areas. And obviously then, what you think is important is the area in which you have expertise from."

- Core team member 5

The interaction between the core team and the end users could with an advantage exclusively take place through groupware to avoid impartial prioritizing of requirements. Having little direct interaction with the users can aid in developing software solutions that are not tied to specific user groups. Groupware can consequently contribute to keeping the core team as impartial as possible when prioritizing requirements. Instead of the core team visiting one or two implementation areas, they can gain their understanding in a more fair way using Jira or DHIS2 Community where all the end users can contribute. This also eliminates the pitfall of the core developers obtaining bias in the prioritization process of requirements.

Damian et al. [11] concluded that groupware makes the participants less emotional as the reduced ability to perceive emotional cues might aid in attaining impartiality in the negotiation of requirement. This study and the attached findings validates and contribute to confirming their findings on how groupware can be as valuable as face-to-face meetings.

Although groupware can lead to impartiality, there are also disadvantages related to video-conferencing tools replacing face-to-face meetings. According to the study performed by Layzell et al. [30], long meetings using video-conferencing tools were consid-

ered unfit. Additionally, it was regarded as challenging work to include all sides of the meeting in the discussions.

It was mentioned as a disadvantage to have too many participants at the weekly design meetings. A large number of participants will reduce the time every individual has to share their opinions. Furthermore, it can be intimidating for the HISP group members to speak. This can in part be because English is not most of the participants' mother tongue. It was also difficult for the core team to coordinate the meeting and keep track of and include every individual in the discussions if the number of participants is large. Hence, an effort is made to keep the number of attendees to a certain number.

Furthermore, the meetings last only one hour every week. Generally, this is a short amount of time to allow for a large group to speak up. Therefore, the attendees must keep it factual. It can also be difficult for people to join the meeting if it is scheduled to last longer than one hour. This is in part due to the time differences, but also because the HISP groups are generally busy.

Keeping meetings short and factual is, therefore, not necessarily a disadvantage in the case of DHIS2. But the study does coincide with the challenge of including all sides of the meeting reported by Layzell et al. [30]. In a face-to-face meeting, it is easier to have an overview of the participants and those who has not gotten the opportunity to talk yet. However, the core team is aware of the challenges of including too many participants in the meetings. They strive to keep the number to the minimum. For instance, the NGOs are not invited to the meetings, a deliberate effort to open up for the HISP groups to communicate with the core team.

7.3   RQ 1.2: How do the local teams affect the development process?

As mentioned, DHIS2 shares a lot of traits with the design strategy of open generification. DHIS2 has global and local developers, has a generic core, and provides guidelines and training. The HISP groups can be considered the local developers in the case of DHIS2.

Furthermore, the HISP groups function as intermediaries between the core team and the end users. The HISP groups themselves and the core team repeatedly stressed the importance of having these groups. They aid in forwarding requirements and are involved in the prioritization process. They also help the end users with the implementation, local innovation, and issues that might arise.

The impact of having intermediaries was one of the topics in the study by Keil et al. [25]. According to this study, the projects that had a low number of links and direct links between the developers and the customers, were less successful. Their reasoning for why the intermediaries are potentially a factor for an unsuccessful project is interesting to consider. The intermediaries can filter and distort messages and lack a complete understanding of the customer needs. This makes it difficult to communicate the needs accurately back to the developers. This also underlines the importance of not having more than one indirect link between developers and customers or end users. If a HISP group uses intermediaries to communicate with the end users, the information goes through another link with potential filtration and concurrently places the HISP groups further away from the use contexts. Having direct links removes these potential obstacles.

It was explained in Section 6 that certain HISP groups discourage the end users to post issues and requirements directly on Jira. This was due to the hazard of the post not being assigned and resolved. Ergo, they discourage the end users to utilize one of the available direct links to the core team.

Nonetheless, certain members of the core team expressed that they do not agree with this discouragement. The core team asserted that they wanted the end users to post directly on Jira and generally communicate with the core team through the direct links that they have made available.

> *"Imagine how much is filtrated and changed on the way from end user and to the core team developers."*
> - Core team member 1

One of the core team members expressed that a clear trail from the users to the core team was lacking. This is potentially considering that the available links are not regularly used by the end users to communicate with the core team. The core team member further indicated that this should be improved for the core team to get a clear representation of the field.

How the HISP groups collect requirements from end users differs from group to group. This collection can potentially involve a lot of steps and several links of communication. The HISP groups should not use intermediaries between themselves and the end users. Generally, it seems like a majority of the HISP groups recognize the importance of close communication with the end users, whether these are end users on a national level or a district level.

> *"Everyone that touches requirements make small changes to them."*
> - Core team member 2

Without intermediaries, the requirements come directly from the end users to the developers. Therefore, the potential risk of filtration is eliminated. The quote indicates that the core team has experienced that having indirect links lead to filtration or changes. They recognize that direct links to the end users are beneficial for the development process. This, therefore, coincides with the study performed by Keil et al. [25].

Nonetheless, there are several notable differences between the study performed by Keil et al. [25] and with the case of DHIS2. Considering that they are talking about customers as the users of the product and that the intermediaries might not understand the customer needs, the customers can be linked to the end users of DHIS2. The core team does, per contra, facilitate for end users to directly communicate with them through various arenas like Jira and DHIS2 Community website. The difficulty with DHIS2 is that the end user groups might vary significantly from one another and that they might lack proper internet access. This complicates their abilities to utilize these available direct links.

Additionally, the study performed by Keil et al. [25] was executed in 1995. Much has happened within the technological field since 1995. Hence, the actual communication with the intermediaries through groupware is likely significantly better equipped and adapted today compared to what it was over two decades ago. The groupware that is used for communication between the HISP groups and the developers in DHIS2 now is very advanced compared to the communication that took place with intermediaries in 1995.

Another important distinction is that even though the direct links between the low-level end users and the developers of DHIS2 can be considered low in availability or accessibility, there is still more than just one link. Taking into account these differences, lacking direct links with the end users does not necessarily imply a less successful project. But with the large number of intermediaries in DHIS2, they must all be heard to the same degree to make it as fair as possible. It was mentioned during the interviews that the vocal members are often the ones that are heard. This can potentially create biases. The core team should make sure to draw out users representing utmost user groups and use contexts for feedback and requirements, making the process as fair as possible before a feature is released. This can be beneficial for the design and development process. The core team explained that they often receive feedback on features after a release. Hence, maximizing the number of user groups that provide requirements and feedback in advance can diminish the necessity of redoing the work that has been released already.

Despite certain differences between the two cases researched, it is clear that Keil et al. [25] have a lot of interesting points which are still relevant some 25 years later. But it also substantiates the need for newer research that is more attached to current affairs, especially considering the technology propulsion during the last decades.

As explained in Section 2.3, it is hard to create solutions that satisfy all the needs of the different user groups. Johannessen et al. [24] performed a study that reported that as the number of system users grew, the initial users that were involved in the development process had to start fighting to be heard as the responsiveness dropped. As the system

grew, the roles of intermediaries were introduced. These intermediaries were useful, but although the vendors or core team did not distrust them, they still felt the urge to have some sort of contact with the users to get direct feedback from them as well. The number of intermediaries increased in line with the increasing number of customers. The intermediaries made the user base easier to handle for the core team. Another palpable acknowledgment from the study was the users often failed in formulating what their needs and requirements were.

DHIS1, which was the first version of the software, was developed in South Africa in the 1990s. Over the years, the number of countries that have implemented the software has grown significantly, increasing the need for a generic system. At the beginning of the development process, the core developers were in close contact with the end users.

> *"The first version of DHIS (DHIS1), we developed over two months. This indicates that it was a lot simpler. But, for as long as we maintained DHIS1, it was a very tight integration, in reality, between the users and the developer team. I had a lot of interaction with users at all levels. As a result, most of the requirements and what was prioritized, was heavily influenced by end users."*
> - Core team member 5

As DHIS2 grew, the core team did not have the resources to interact with all end user groups regularly any longer. This is why the intermediary HISP groups are relevant. But as the number of HISP groups increases as well, the number of groups that the core team needs close interaction with increases correspondingly. For the most part, it is the product managers that are the communication links between the core team and the HISP groups, making them a potential bottleneck in the development process.

> *"I know that they [the Oslo team] are busy, so sometimes it is hard to get their attention and to get access to them. But if you know how to, you can make sure that you are heard and shout as much as possible and spam their inboxes - then you will get heard*

71

eventually."
- HISP group member 5

The HISP groups have experienced that the end users do not know exactly what it is that they want or what feature they are lacking. In these situations, the HISP groups can be helpful in mapping this out together with the end user, for instance by discussing which features they are lacking and the relevant use cases. They can also evaluate how it can be implemented and if is doable, but also what the benefits of implementing the feature are.

If the requirements that the HISP groups receive are too specific, they could aid in customizing the software or developing applications that satisfy the needs of their local users without involving the core team. With a flexible system like DHIS2 it is useful that the local developers get the opportunity to innovate and customize the system to best satisfy the local requirements. Having the HISP groups developing applications for these specific problems saves the core team both time and resources.

> *"When the requirements are very specific, the local teams can implement it through an additional application to address that requirement."*
> - HISP group member 1

Generally, the HISP groups have a better overview of what DHIS2 has to offer than the end users have. If the HISP groups find out that a feature requested by the end user already exists in DHIS2, they can implement it for them. If the feature is lacking from DHIS2, a requirement is created and taken forward to the core team with a description of the relevance and relevant use cases. This way, the features are thoroughly described and easy for the core team to understand. This is beneficial rather then an end user posting unclear requirements on Jira themselves. It reduces the chance of the requirements getting lost in the crowd.

> *"This is one of the reasons why we have HISP groups - to be able to receive requirements,*

document them and send them to the right people."

- HISP group member 1

There are interesting arguments with the development of DHIS2 that coincides with the discoveries documented by Johannessen et al. [24]. Intermediaries are very useful for the core team developers today. They make the user base easier to handle for the core team. Considering the huge scope of the end users for the product the core team would have to expand significantly in order to be able to communicate with all user groups. Not only do the user groups need to communicate requirements and issues to the core team, but they are also dependent on help for customization of the generic system. This could not be done successfully today without the help of intermediaries.

But the system has unquestionably scaled up significantly since DHIS1 was introduced. This has also lead to the growth in intermediary groups in the regions that have adopted DHIS2. However, as the number of intermediaries the core team communicates with grow, the number of core team members should grow accordingly. If not, there is a skewed distribution of core team members and HISP groups. Consequently, the fight to be heard experienced by the end users in the case of Johannessen et al. [24] can also emerge with the intermediaries in the case of DHIS2.

Furthermore, the DHIS2 core team also expressed a desire to communicate directly with the end users, regardless of the performance of the HISP groups. The core team reported that this communication can be useful as their understanding of the use contexts are more clear. It also allows for the end users to provide feedback if there is something that is too urgent or important to go through the HISP groups. To sum up, these findings do validate the findings by Johannessen et al. [24], but it would be interesting for future studies to investigate how and why the potential filtering takes place in order to try to reduce these risks affiliated with intermediaries.

8 Conclusion

The aim of this study has been to contribute with valuable strategies when scaling up a system from a local product to becoming a large system with geographically distributed teams. It attempts to disclose how and which arenas are useful in the work to maintain sufficient collaboration between teams. It also considered how local teams affect the development process, both how they contribute and what potential drawbacks there are with introducing intermediaries.

The interesting discoveries of this research do not only apply to software projects. Ensuring collaborative environments between teams involved is important for all projects in all businesses with distributed teams working towards the same goal.

To sum up, this study indicates that when developing software with teams that are distributed around the world, distinct arenas for communication and coordination are required to capture user stories and requirements from relevant end user groups. It also suggests that as a system scales up and gains a large user base, it is difficult to maintain a sufficient end user interaction by the global development team in the development processes. This is where the introduction of local teams as intermediaries is essential.

The study does reveal that to gain a mutual understanding of the project by all teams involved, routine communication between the local teams and the global teams is vital. The continued communication between the local teams and the end users, and further, the communication between the local teams and the global teams, is what makes the project useful to the end users. This continued communication is a key factor to avoid misunderstandings, as well as inappropriate design and implementation decisions. The importance of routine communication would also be relevant for other industries planning to scale up their solutions. As the user base grows, it is important to make an effort to understand all relevant user groups to create a solution or product that covers as many use cases as possible.

Considering that it is unrealistic to meet physically face-to-face regularly to maintain

this continued communication, technology is crucial. Meeting face-to-face for the involved teams that are physically separated would be both time and resource-demanding. Groupware systems support the teams and assist the distributed teams in their collaboration. Without groupware, the communication would be insufficient, which would have devastating effects on the product or solution.

There does, however, seem to be lacking one arena or groupware system that meets all the different coordination needs that the teams have. Instead, there are several arenas and several groupware systems contributing to performing distinct tasks. These are used simultaneously with different functionalities. How using several separate arenas for coordination and the impact it has on efficiency would be an interesting study for the future. It would further be interesting to investigate if there exists one groupware that fulfills all the communication and coordination needs of a large distributed project.

When a system scales up, it also introduces the prerequisite of the solution being a generic system with the possibility of tailoring according to the local needs. Developing a generic system requires thorough knowledge about the different user groups to be able to cover all the imperative requirements. This is where the need for the local teams becomes obvious. This is applicable to all systems expanding from a local context to a global market. Understanding the use contexts is vital for the success of a product.

This depends on the local teams to have close communication with the end users and further have the skills to properly and accurately communicate these needs back to the global team. For a software solution, the local teams play an assertive role in the customization work to satisfy the local needs.

With that being said, having local teams as intermediaries between end users and the global team does introduce the risk of filtering the information from the end users before communicating it back to the global teams. This study also indicates that as a system grows larger and the number of intermediaries grows simultaneously, it is strenuous for the global teams to make sure that the local teams spend sufficient time interacting with

end users, ensuring that the use contexts are properly understood.

Additionally, it is challenging to make sure that the local teams seek out not only power users, but also users that might not otherwise be heard. This creates the aspire for the global teams to have direct links to the end users. But this does neither come without risk. For future studies, it would be interesting to research where the risk of filtering occurs and what measures the local and global teams can take to reduce the risk.

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