A Case study of Interoperability in Health Information Systems for Developing Countries

Specialization Project, TDT4501, NTNU

Fall 2013

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December 16, 2013

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Nomenclature

API Application Programming Interface

DHIS District Health Information System

DHIS2 District Health Information System 2

etc Et cetera

GIS Graphical Information System

GUI Graphical User Interface

HISP Health Information System Programme

HMIS Health Management Information System

ICT Inforfmation and Communication Technology

ICT Information and Communication Technology

ICT4D Information and Communication Technology for Development

OS's Operating Systems

PBF Performance Based Financing

RPF Rwandian Patriotic Front

SMPP Simple Message Pear-to-Pear

SMS Simple Message Service

Abstract

This report gives an introduction to interoperability, transtion strategy and touches on the topic of ICT's in developing countries. A case taking place at Rwandas Health Ministy is then presented. Lastly some guides for how one could go from an interoperability issue to a descriptive plan in order to increase interoperability in an action based research process.

Chapter 1

Introduction

This paper tries to describe how interoperability goes from being an issue to form an executeable plan in an environment with limited resources. The paper partly based on action research. Although the full iteration of the action research was not conducted, the diagnosis and planning were and will form the basis of a subsequent research. The diagnosis was conducted as a exploratory case study at the Ministry of Health in Rwanda. As a practitioner researcher I was able to collect qualitative data that would later form the basis for making the second step in the action research process. This plan will define the steps that will be taken in order to decrease the presence of silos and increase interoperability in the health information systems of Rwanda. By first introducing the relevant theory comparing this with the case study I will propose actions steps that would increase interoperability.

Chapter 2

Interoperability

2.1 Syntactic

Interoperability is the ability of making systems and organizations work together or inter-operate. When talking about information systems the syntactic interoperability is the first step. One system cannot recieve any data in a format it does not accept, although this probably is self explanatory, it should be mentioned. The level of ineffectiveness is enourmous because of this simple problem. I would first relate this to switching-costs and lock-in for users. As of now there is 3 main operating systems, Linux, Windows and OSX. Businesses would have to think twice before deciding on either. First one would have to train personell to use the operating system, so one would be subject to brand-specific-training lock-in [15]. This in turn would make the use of the system a barrier for interoperability, since users are now trained in one operating system and would now prefer this over the others. Now, some software is only supported for some operating systems, or OS's. If one relies on one OS, then uses software that is only supported by this OS, chances are that it would be problematic to exchange information to a different OS. The first thing to consider is that the data representation is likely to be very different from software to software. Just to illustrate the problem, let's say one organisation is running Windows as in in figure 2.1 and another running OSX. The users of each organisation has had training

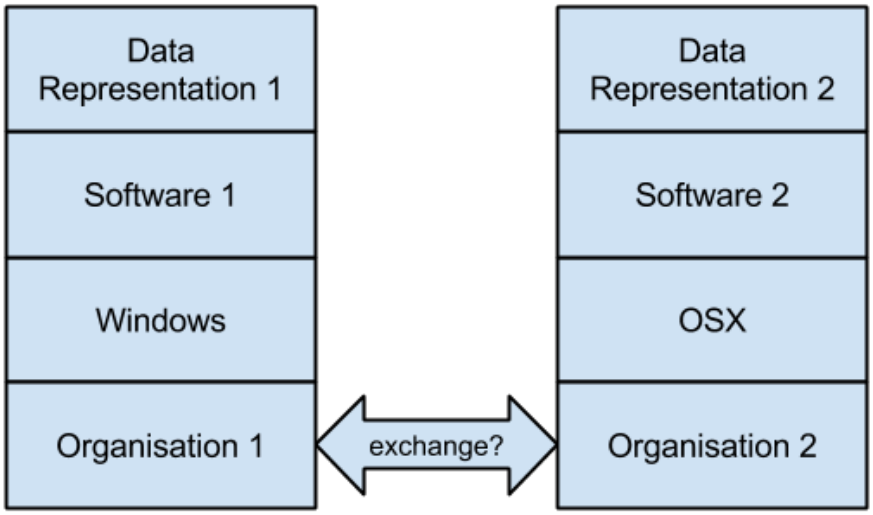


Figure 2.1: The beginning of Silos

on the operating system of their organisation, making the switching costs substantial. Money is already been invested in software that only runs on the given OS and the data representation is only supported by the software running on the OS. Clearly they would have some work to do before being able to exchange data. This type of scenario represents the formation of silos. Silos are systems which are closed to the outside. These systems have trouble with exchanging data with external systems.

2.2 Semantic

Another part of interoperabillity is semantic interoperability. In this case the problem will be more subtle. The syntax is the same, but the meaning behind it is different. A simple example like when two people are asked to work together. Both understand what it means, but have different understandings on how to do it. Person one will split the work in half an take his share. Person two is constantly askiing person one about his half and sharing ideas on how to do it. When they finish, person one is complaining on how he would have to do almost all the work for both of them. Person two is

complaining that person one was reluctant to work together. This exemplifies how different semantics would make less likely for these two individuals to work together in the future, thus decreasing the level of interoperability. Of course in the computer world it would not be that easy to find out if all parties involved are understanding it the same way.

2.3 Solutions and methods

To achieve interoperability between systems one has to integrate one with the other systems in the same environment or context. Systems in the same context is the same as systems in the same bubble. It's just a way to refine our model so we don't have take all systems in the world into account. The general approach to achieving interoperability is to define a common standard between systems. Through these standard channels the system would be able to communicate with echother. I will present four general approaches here that are loosely defined[16].

Vertical integration In this approach we do consider the different systems as silos. Each of the silos contributes with some functionality and as a whole delivers the required functionality. This would probably provide the cheapest solution for gaining interoperability short-term.

Star integration Each system has a one interface for all other systems. Thus, introducing a new system would be quite expensive since one would have to make an interfaces for all existing systems. This method does make it easy to reuse functionality between systems.

Horizontal integration In this approach one uses a own system dedicated to facilitate communication between systems. This way only one more interface is needed when introducing a new system.

Common data format This method only requires that one sets a standard data exchange format. It is recommended to provide an adapter so that one could easily transform from the native format to the common bus format.

EXHIBIT 1
Example Calculation: Annual National Benefit From Level 4 Health Care Information Exchange And Interoperability (HIEI) Between Outpatient Providers And Independent Laboratories

Item	Amount
A—Lab fee billed per test	$40.00[a]
B—Provider administrative cost incurred per test (included in fee billed for visit)	$19.25[b]
C—Total cost per test to labs and providers (A+B)	$59.25
D—Lab test costs billed per person per year	$86.52[a]
E—Number of lab tests per person per year (D÷A)	2.17
F—Total cost of lab tests per person per year (C×E)	$128.57
G—Avoidable redundancy in testing, estimate one	20%[c]
H—Avoidable redundancy in testing, estimate two	8.6%[d]
I—Average avoidable redundancy in testing (average of G and H)	14.3%
J—Proportion of avoidable redundant tests that could be avoided at Level 4	95%[b]
K—Tests avoided at Level 4 (I×J)	13.7%
L—Tests avoided per person per year (E×K)	0.294
M—Costs saved from avoided tests per person per year (C×L)	$17.41
N—Remaining tests per person per year (E−L)	1.87
O—Proportion of lab test administrative costs that could be avoided at Level 4	95%[b]
P—Provider lab test administrative cost avoided per person per year (B×N×O)	$34.18
Q—Lab administrative cost incurred per test (included in fee billed for test)	$20.40[b]
R—Lab administrative cost avoided per person per year (N×O×Q)	$36.22
S—Total avoided cost per person per year, from avoided tests and avoided administrative costs on remaining tests (M+P+R)	$87.81
T—U.S. population	281,421,906[e]
U—Cost adjustment factor	1.286[f]
V—Annual national benefit of Level 4 HIEI between outpatient providers and laboratories (S×T×U)	$31,800,000,000

Figure 2.2: Exhibit 1

Of course this just exemplefies how to go about interoperability, as mentioned above, the general approach is to agree of a standard way of communicating cross systems.

2.4 Experiences

To give an estimate of the benefits of interoperability I would like to represent some data collected and analyzed by a group of scientists in the USA[11]. These numbers are based on upgrading the health information system in USA. The financial gain in figure 2.2 represents the annual gain by upgrading to a system described below.

> Machine-interpretable data—transmission of structured messages containing standardized and coded data; idealized state in which

EXHIBIT 2
National Ten-Year Roll-Out And Annual Costs Of Health Care Information Exchange And Interoperability (HIEI)

	Roll-out cost ($ billions)		Annual cost ($ billions)	
	Level 3	**Level 4**	**Level 3**	**Level 4**
Clinician office system cost	163	163	9.08	9.08
Hospital system cost	27.1	27.1	1.58	1.58
Provider interface cost	124	76.2	9.04	5.40
Stakeholder interface cost	6.41	9.92	0.467	0.467
Total	320	276	20.2	16.5

SOURCE: Authors' analysis.
NOTE: Payers participate in Level 4, making stakeholder interface costs higher than Level 3 during the rollout. Their annual costs are unknown. For explanation of Level 3 and Level 4, see text. All results are stated to three significant digits.

Figure 2.3: Exhibit 2

all systems exchange information using the same formats and vocabularies (examples: automated exchange of coded results from an external lab into a provider's EMR, automated exchange of a patient's "problem list").

This is what they call level 4. Figure 2.3 describes the estimated costs for such a system. As one would notice the roll-out costs are substantial, but looking forward stakeholders would probably begin harvesting from their investment withing a decade. Also, not all benefits can be measured in terms of money. The possibilities for new technology to make its appearance is huge. The reduction of error, ease of improving data exchange with other sectors in society and the possibility of reusing functionality should also be considered when measuring the benefits of interoperability.

Chapter 3

Transition Strategy

In order to make interoperability possible one as to transition from the old way of doing to the new. And with a transition I talk about taking the system as it is and change it to something new. It's the process from old to new. The process of transforming systems or system migration if you will.

3.1 An overview

Making a transition involves a switch from the old system to the new. There is the source system, also referred to as the legacy system and the target system. At one end of the specter we have the Big Bang strategy, were we taken on an revolutionary approach. A complete new system is developed, supporting all the required functionality. Then one decideds a time when all of those involved switches to the new system. This way usually has a high risk of failure. On the other end of the spectrum we have the evolutionary approach. Gradually one introduces new functionality, or the same with a new system, then after the legacy system is not used anymore, one turns off the switch.

3.2 Planning and conducting a transition strategy

There are some predifined methods for conducting a system migration which also could be usen in a transistion strategy plan. Remembering that one moves from a source system into a target system. As mentioned, solutions to transition problems could be characterized by how revolutionary it is. The most revolutionary would be redevelopment, followed by migration, maintenance and finally wrapping. One would choose the most appropriate strategy based on the level of risk. Like wrapping, one takes almost no risk, since it requires no real change to the system, but instead provides an updated interface for the source system. Althogh this way is low risk, this could complicate things later on. Making use of wrapping not only slows down the system, but also makes maintenance more complicated. The most appropriate use of wrapping is when one wants to make a new Graphical User Interface (GUI). Like when moving from a text based front-end to a graphical based front-end. With redevelopment on one end and wrappng on the other, in the middle we have system migration. This technique allows for a smoother approach while being able to have control.

3.3 Migration

When redevelopment is to risky and wrapping is unsiutable, migration usually is the best way to go. This allows for both systems to co-exist while making the transition from one to the other. Migration usually involves moving an existing system to a new platform. Before making the transition one has to decide on some basics. Like how one would like to migrate to the new system. Much of the time is spent on testing the target system. Therefore it is good practice to not introduce new functionality while migrating to a new platform. It also makes the testing easier since one could compare with the old system for output results. New functionality should be introduced afters the old ones are supported.

3.3.1 The cutover

The cutover is the last step in the migration process. Here are three main approaches[23].

The cut and run This is the most revolutionary way of migrating. It is much like redevelopment and seldom used alone. Once the target system is ready on turns of the source system and enable a new feature rich system.

Phased interoperability In this strategy incremantal steps towards the target system is used. Replacing functionality over time and slowly moving towards target system until all functionality is replaced. The last part of the cutover would be cut and run to some degree.

Parallell operations In this strategy both systems are running at the same time. Both source and target system is operational. The target system is continually tested and only when it's fully trusted, the source system is disabled.

The cut and run is very simple, but usaually involves high risk. Parallell operations usually become quite complex, but are fairly safe. Phased interoperability is somewhere in the middle.

3.3.2 Methods

The chicken little strategy

1. Analyze the source system
2. Decompose the source system structure
3. Design the target interface
4. Design the target application
5. Design the target database
6. Install the target environment

7. Create and install necessary gateways
8. Migrate the source systems databases
9. Migrate the source systems applications
10. Migrate the source systems interfaces
11. Cut over to the target system

The chicken little strategy is propesed by Michael Brodie and Michael Stonebreaker. The method has severel steps towards migrating to the target system, making it a phased interoperability strategy. It can be quite complex to handle source and target databases when using this approach.

The butterfly

This approach is a little different. One can here develop the different system in two seperate processes and making a kind of cut and run. Before initation of the cutover, one freezes the source database and stores all datamanupilations in a temporary database. When the transfer is complete, another temporary database is used while transferring the temporary one. Making the set of manipulatons smaller and smaller until transfer takes as little time that a cutover would not cause any problems. The target system is then ready for use with all data ready to be used.

Chapter 4

ICT in Developing Countries

Lately there's been a growing focus on the global digital divide. The main focus is the gap between developed and developing countries. The global digital divide is an inequality in access, use and knowledge of information and communication technologies (ICT) from an international perspectice.

Analysis across countries has shown that education and income are the most likely to determine were on the ICT scale an idividual is[21].

4.1 ICT for development

The theory is that ICT's will further the development of society. ICT4D (Information and Communication Technology for Development) refers to using ICT's in socieconomic development, international development and human rights. Since the gap is mainly between developed countries and developing countries, the focus for application is in developing countries. An interesting estimate is that 40% of the worlds population has on average 20$ to use on ICT's pr. year [22]. Thus, ICT for development has to be low cost. Open source projects are therefor a suitable candidate for these kinds of efforts. In 2003 the World Summit on the Information Society held in Geneva, Switzerland, came up with an action plan on how ICT can support sustainable development. They identified the following sectors to focus on.

- E-government

- E-business
- E-learning
- E-health
- E-employment
- E-environment
- E-agriculture
- E-security

[22]

4.2 Overcoming the digital divide

An estimate shows that the borderline between ICT's as a necessity or luxury is around 10$ pr. person pr. month. Further, 40% of the worlds population lives on less than 2% a day. 20% on less that 1$ a day. So for the poorest 20% this means that one would have to use one third of their available resources on ICT's. The average in in the world would be about 3%. The importance of low costs ICT is therefore obvious. Besides the economics there are two main barriers in order to overcome the digital divide. Access and knowledge. The infrastructure has be in place in order for people make use of ICT's. After the user has access, user has to know how to use the information systems in order to take advantage. This has made people shift their focus not only on access and building infrastructure, but also to focus on teaching people how to use the technologies.

4.3 Future problems

Even in developed countries one has noticed a digital divide taking shape. Applications has become so efficient that a users could basicly use ICT's without any previous knowledge. Creating a new digital divide between users and

individuals able to develop applications. Although this could works as a benefit, it is worth noting, so one can meet the future with some awareness. The benefit might be that ICT"s will be of such quality that users can intergrate ICT's in their own field of knowledge without much effort. Seeing ICT's as a tool for accomplishing other tasks is important so that one does not loose sight of why the tool is made in the first place.

Chapter 5

Context

In the center of Africa we find Rwanda. A very small country, only $26338km^2$. This would be about 7% of Norway. Their population is estimated to be around 12 million wich makes it about 420 people pr. square kilometer. Rwanda is made up of 5 provinces, east, west, north, south and Kigali. Each province is again divided into districts and there is a total of 30 districts. Under districts there is a total of 416 sectors[1], see figure 5.2.

Because of its location it works perfect as a gateway to all countries in Africa. Due to the stable environment, it is very attractive for foreigners to do business here. Making it the 'Singapore of Africa'.

Rwanda has a goal of being transformed to a knowledge based economy with Information and Communication Technology or ICT. This means basicly that they want to offer ICT services for other kind of resources. They want to be the regional center for training top quality ICT professionals. In turn, create wealth, jobs and entreprenaurs. From their perspective they have some competetive advantages in order to achieve this:

- Cheap labor compared to other countries in the Region
- Young and dynamic workforce (98% of the population is under 50 years and 43% is under 16 years)
- Most favorable business environment in the Region (8th best place to do business in the world 2012)

Figure 5.1: Rwanda in the World [14]

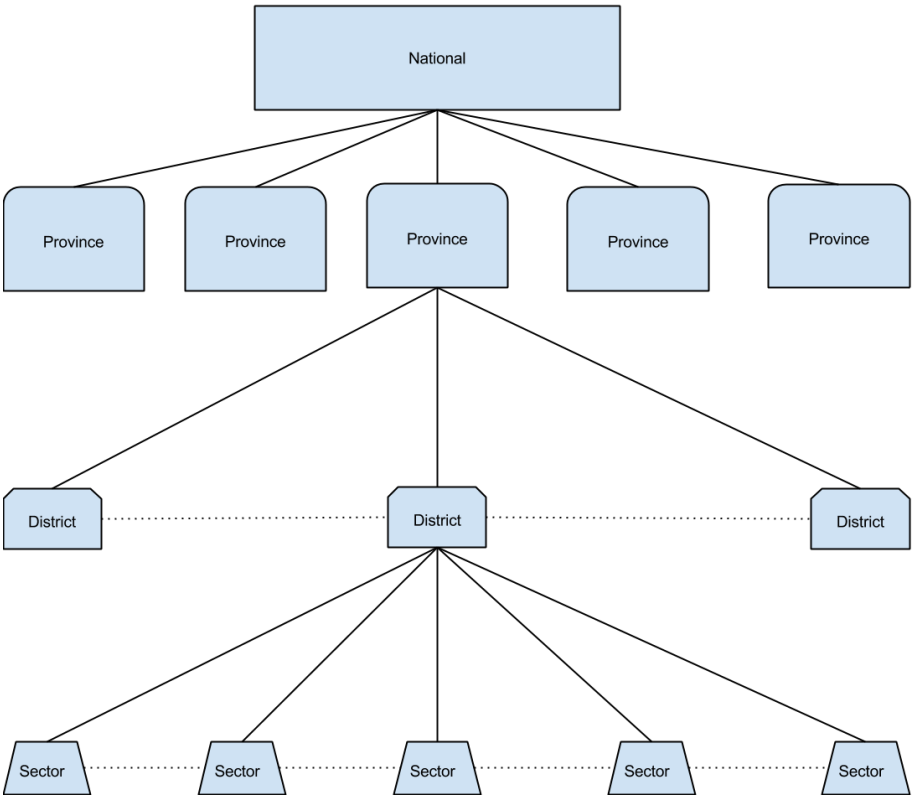


Figure 5.2: Rwanda Administrative Division

- Low levels of corruption - Zero tolerance (Transparency international Bribery index 2012 ranked Rwanda as least bribery prone in the EAC)
- World class ICT infrastructure
- Strong & visionary leadership
- Bi-lingual business environment (French and English)

[2]

5.1 Brief History Lesson

At the 14th centuary, the Tutsies enters Rwanda. Before them there were two other peoples, Hutu, which means farmers and Twa who was the very first recorded prople in Rwanda. There is some disagreement of what the differances are between the peoples, but origanily, Tutsies were cattle owners and the Hutus were farmers. About five hundred years later the first European visits Rwanda and in the same centuary Rwanda becomes a german protectorate. This makes Rwanda under the protection of Germany with some oblegations for their services. Skipping fourth to 1933, now occupied by Belgian forces, all citizens are issued with an identity card defining their identity. In 1962 Rwanda becomes independent and gets their 1st elected President. After this there is turbulent times for Rwanda. The Hutus and Tutsies are having violent reactions towards eachother with a peak in 1994. A geneside primeraly by Hutu extremists, killed over 500,000 people, primeraly Tutsies, in the course of about 100 days. The genocide was triggered by the assasination of the Hutu president Habyarimana. The Tutsie Rwandian Patriotic Front, also known as the RPF, takes action and took control of Rwanda the same year. The current President, Paul Kagame, was a former member of the Rwandian Patriotic Front. [17][18][19]

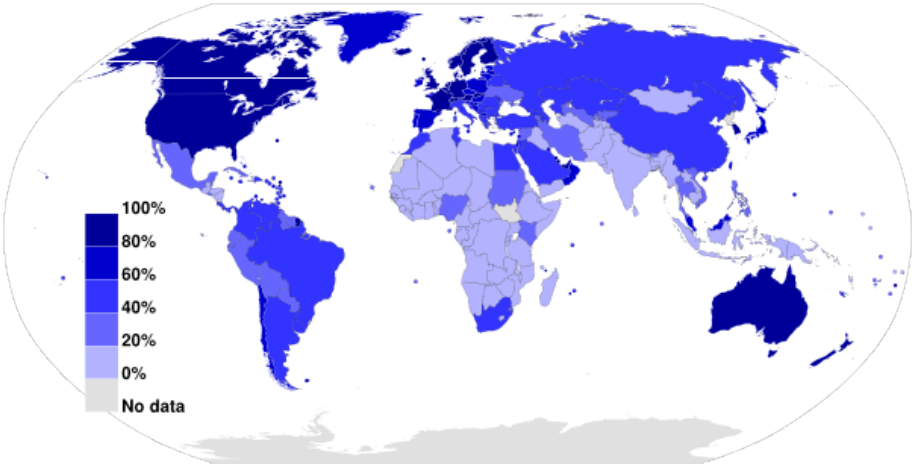


Figure 5.3: Global Internet Penetration in 2012 [3]

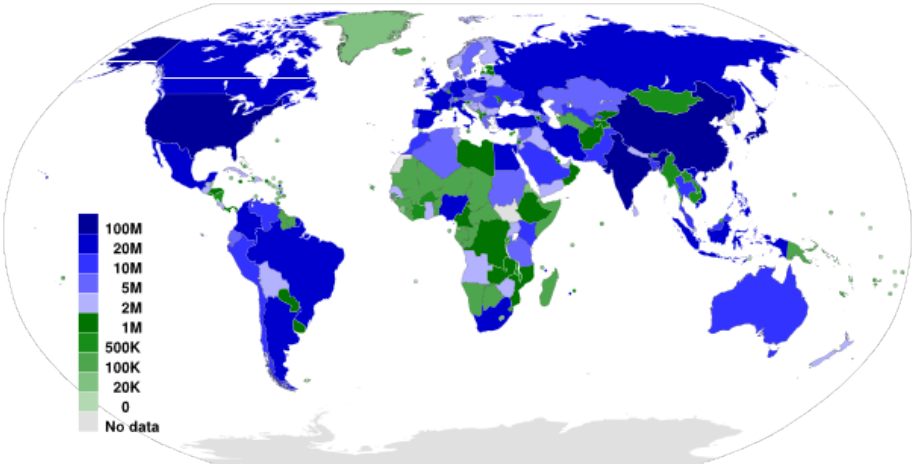


Figure 5.4: Global Internet Users in 2012 [3]

5.2 Information Technology focus in Rwanda

Rwanda has an internet penetration of 7% in 2012. In Africa there is an internet penetration of 15.6% and for the world it is 34.3% (See 5.3)[4]. Rwanda had an increase of internet penetration from 1% to 7% from 2000 to the end of 2011[2]. More interesting is the mobile broadband development in Rwanda. The subscriber base accounts for 48.1% of the population and the network coverage accounts for 99.79% of the country. Thus, the technology is there, but the hardware is not yet updated. In general, people are using simple phones. Some of these phones supports java and a very simple browser, but it cannot be compared to working with a desktop computer. The government of Rwanda has made the decision to become an ICT hub in Africa. Therefore alot of resources and attention is focused on developing knowledge in the field of ICT. As of january 2013 the Rwandian government is planning to set up an ICT park through the Rwanda Development Board. This park will host technological training, industries research and development. The ICT park will support the growth of the following clusters:

- Energy
- Internet, multimedia and mobile telecommunication
- Knowledge
- E-Government
- Financial
- ICT Service and export

[2] Also there were some rumors about free WiFi throughout all of Kigali. They were in 2012 ranked among the top 6 developing countries in the category of "dynamic performance in ICT development"[5].

5.3 Health Information System Programme

5.3.1 About

The Health Information Systems Programme (HISP) is a global network established, managed and coordinated by the Department of Informatics at the University of Oslo. They design, implement and sustain Health Information Systems by a participatory approach[8]. This means including the local users when develping the system in hopes of a more sustainable and successful project. The system developed aims for supporting health care delivery and information flows in selected health facilities, districts and provinces.

Vision To strengthen the development and use of integrated health information systems within a public health inspired framework in India and the South Asian region[9].

Mission To enable networks of collaborative action with like-minded actors who aspire to the ideology of open source software, open standards and decentralized decision-making to create complementary strengths in providing integrated and public health friendly health information systems[9].

5.3.2 History

In the 1970 and 80's the HISP approach to action research and system design was influenced by a number of union based action research projects in Scandinavia. The focus were on empowering workers who were affected or threatened by new technology. Methods may have changed over time, but the philosophy remains the same. Explore ways in wich disadvantaged people could appropriate ICT's for their own empowerment. Original key member of the HISP team had background as social political activists in the anti-apartheid struggle and other social movements. DHIS, a software organized and developed within the HISP network, was actually born out of the political processes following the fall of apartheid[7]. During apartheid and until 1994 there were 14 departments of health in South Africa. Bacause of this

fragmantation it was alot of different procedures, collection tools and data defenitions. In order to take this into account, DHIS became very flexible and one can easily see how this has effected the design. This might be the reason why DHIS framework could be used in other countries.

5.3.3 District Health Information System

The latest version of DHIS during the case study was version 2.13. DHIS2 is now used by over 30 countries across the globe and even more organizations. DHIS2 is a tool for governments and health organizations to manage their operations more effectively, monitor processes and improve communication. DHIS2 is mainly a tool for managing aggregate data. It will let you visualize large amounts of data in a GIS implementation, a pivot table and in charts. These data representations can then be shared with other user registred in the same DHIS2 instance. Probably the most powerful feature would be GIS. This feature shows selected data on map based on province, district etc. The regions on the map can then be colored based on the data. If one has data for the hole country one can in seconds get a accurate impression of the current health status. DHIS2 runs on server wich is connected to a database. As long as this server is connected, anyone with a decent browser and an internet connection could access and make use of DHIS2.

GIS

The GIS that is integrated in DHIS2 is relatively easy to use. One selects what kind of regions that are of interest and apply the correct data that should be visualized, see figure 5.5. Heres a list of some of the functionality that the GIS offers:

- Thematic mapping of areas and points.
- Visualize catchment areas of facilities.
- View facilites based on classifications.
- Overlay multiple layers and use googlemaps as a background layer.

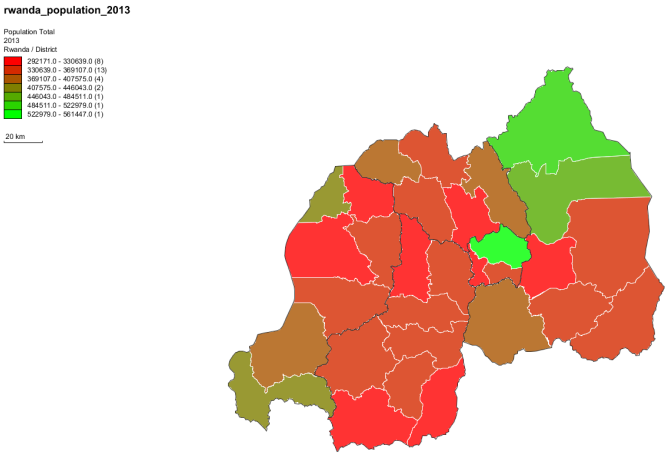


Figure 5.5: A population count using GIS in DHIS2

[10]

Charts

The charts are a little bit trickier. In short the series is the y-axis and Category is the x-axis. Displaying data as a chart is allright once you get what the words mean. Figure 5.6 shows an example counting population by district. Types of charts supported include:

- Column
- Line
- Pie
- Stacked Column
- Area

[10]

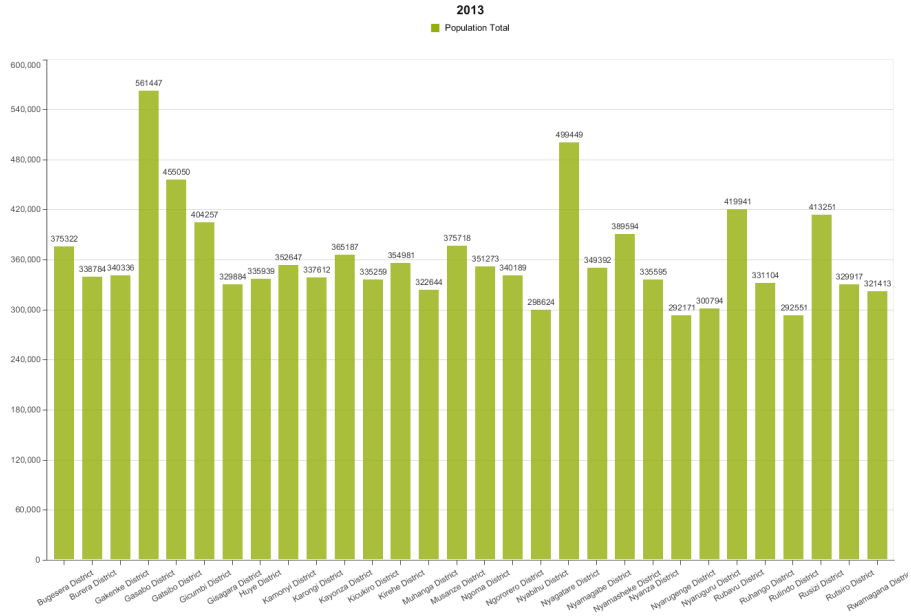
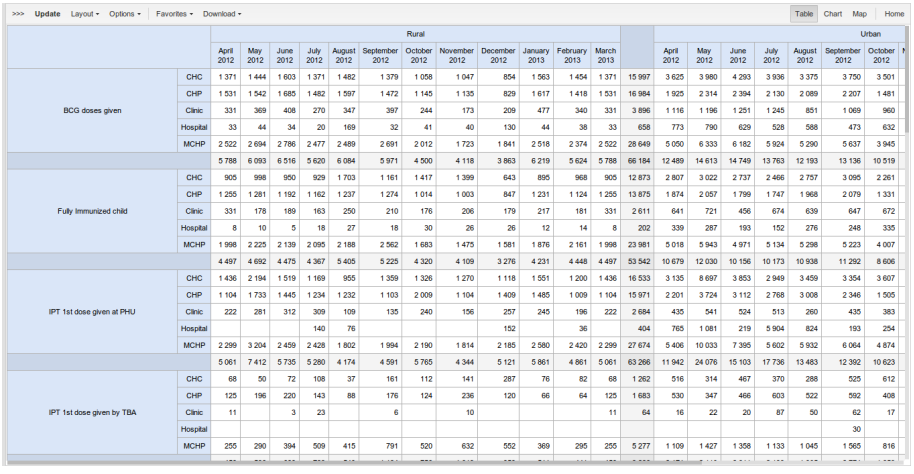


Figure 5.6: A population count using a chart in DHIS2



>>> Update Layout Options Favorites Download — Table Chart Map Home

		Rural													Urban						
		April 2012	May 2012	June 2012	July 2012	August 2012	September 2012	October 2012	November 2012	December 2012	January 2013	February 2013	March 2013		April 2012	May 2012	June 2012	July 2012	August 2012	September 2012	October 2012
BCG doses given	CHC	1 371	1 444	1 603	1 371	1 482	1 379	1 058	1 047	854	1 563	1 454	1 371	15 997	3 625	3 980	4 293	3 936	3 375	3 750	3 501
	CHP	1 531	1 542	1 685	1 482	1 597	1 472	1 145	1 135	829	1 617	1 418	1 531	16 984	1 925	2 314	2 394	2 130	2 089	2 207	1 481
	Clinic	331	369	408	270	347	397	244	173	209	477	340	331	3 896	1 116	1 196	1 251	1 245	851	1 069	960
	Hospital	33	44	34	20	169	32	41	40	130	44	38	33	658	773	790	629	528	588	473	632
	MCHP	2 522	2 694	2 786	2 477	2 489	2 691	2 012	1 723	1 841	2 518	2 374	2 522	28 649	5 050	6 333	6 182	5 924	5 290	5 637	3 945
		5 788	6 093	6 516	5 620	6 084	5 971	4 500	4 118	3 863	6 219	5 624	5 788	66 184	12 489	14 613	14 749	13 763	12 193	13 136	10 519
Fully Immunized child	CHC	905	998	950	929	1 703	1 161	1 417	1 399	643	895	968	905	12 873	2 807	3 022	2 737	2 466	2 757	3 095	2 261
	CHP	1 255	1 281	1 192	1 162	1 237	1 274	1 014	1 003	847	1 231	1 124	1 255	13 875	1 874	2 057	1 799	1 747	1 968	2 079	1 331
	Clinic	331	178	189	163	250	210	176	206	179	217	181	331	2 611	641	721	456	674	639	647	672
	Hospital	8	10	5	18	27	18	30	26	26	12	14	8	202	339	287	193	152	276	248	335
	MCHP	1 998	2 225	2 139	2 095	2 188	2 562	1 683	1 475	1 581	1 876	2 161	1 998	23 981	5 018	5 943	4 971	5 134	5 298	5 223	4 007
		4 497	4 692	4 475	4 367	5 405	5 225	4 320	4 109	3 276	4 231	4 448	4 497	53 542	10 679	12 030	10 156	10 173	10 938	11 292	8 606
IPT 1st dose given at PHU	CHC	1 436	2 194	1 519	1 169	955	1 359	1 326	1 270	1 118	1 551	1 200	1 436	16 533	3 135	8 697	3 853	2 949	3 459	3 354	3 607
	CHP	1 104	1 733	1 445	1 234	1 232	1 103	2 009	1 104	1 409	1 485	1 009	1 104	15 971	2 201	3 724	3 112	2 768	3 008	2 346	1 505
	Clinic	222	281	312	309	109	135	240	156	257	245	196	222	2 684	435	541	524	513	260	435	383
	Hospital				140	76				152		36		404	765	1 081	219	5 904	824	193	254
	MCHP	2 299	3 204	2 459	2 428	1 802	1 994	2 190	1 814	2 185	2 580	2 420	2 299	27 674	5 406	10 033	7 395	5 602	5 932	6 064	4 874
		5 061	7 412	5 735	5 280	4 174	4 591	5 765	4 344	5 121	5 861	4 861	5 061	63 266	11 942	24 076	15 103	17 736	13 483	12 392	10 623
IPT 1st dose given by TBA	CHC	68	50	72	108	37	161	112	141	287	76	82	68	1 262	516	314	467	370	288	525	612
	CHP	125	196	220	143	88	176	124	236	120	66	64	125	1 683	530	347	466	603	522	592	408
	Clinic	11		3	23		6		10				11	64	16	22	20	87	50	62	17
	Hospital																			30	
	MCHP	255	290	394	509	415	791	520	632	552	369	295	255	5 277	1 109	1 427	1 358	1 133	1 045	1 565	816

Figure 5.7: An example of a pivot table in DHIS2[10]

Pivot Table

A pivot table is a data summarization tool. It generally sorts data and show them in categorized table. The DHIS2 pivot table let's you analyse data along all data dimensions and arrange these on columns, rows and filters, see 5.7.

Dashboard and social features

One can send messages and share all data visualizations with users registrered on the DHIS2 instance. Interpretations of the visualizations can be commented and viewed by all other users. This way DHIS2 let's users experienced in the field help others interpretate the data while they are looking at it. Also one can store charts, maps and pivot table at a dashboard so they can easily be referenced later.

Individual Records

DHIS2 was mainly intended for aggregated data that could not related to anyone person. The need for a system which can track individuals is a requirement that most users of a health care system would want. Therefore the DHIS2 tracker was developed. It let's you sign up people for programs and track them through the process. Also send out reminders so that patients come to their scheduled checkups. One problem with the individual records is that it does not work as a patient record system. Such a system is that it requires a level of confidenciality that DHIS2 currently is not supporting. Also a patient record system needs all health facillities to be users of the same system if it is going to be of any use.

Data entry and validation

DHIS2 let's users entry data even if their not online. This feature is crucial for countries with unreliable connection to the internet. For developing countries with regular power cuts, one can understand why this is. Data entry is done with prepared forms and then uploaded to the server which is running

the DHIS2 instance. The forms are highly customizable due to the varying requirements from users. Also there is the possibility to validate the input. For an example shouldn't there be more people under five years than people in the same region, just to give an example. The data entry can be done in alot of different ways. One example is through SMS. In industy countries this may sound odd at first, but in developing countries health facilities might not have access to computers. This is the simplest form of data entry, even though it might require some coding of data representations. Since DHIS2 is accessible from any device with a browser the range of devices that can be used for data entry goes from a mobile phone that supports SMS to a sophisticated computer.

5.4 Healthcare

The health care in Rwanda is still influenced by the genocide in 94, but compared to the state it was in back then, it's is in pretty good shape. The health system is financed primarely the state, insurrance, individuals and direct fees for services. The biggest health program is the Mutuelles De Sante. This is an insurrance based scheme. Individuals pay a fee of 6$ a year pr. family member and 10% fo the service pr. visit. The program started in 2004 and by 2010 91% of the population had this insurrance policy. Users of this system can go to a public and non-profit health centers, but are not allowed to use 'for profit' health centers. Although there's been alot of improvemnet in the recent years, the government still says that they have a long way to go to meet the countries needs[20].

5.4.1 Health Information Systems in Rwanda

The government instance that has the responsibility to maintain and manage health information data is the Ministy of Health. Here there is a team that maintains the Health Management Information System. The HMIS is built around the open source District Health Information System 2. The health ministry has made some modifications so that there is in fact 4 instances of

DHIS2 running for different purposes. Besides DHIS2, there is alot of other systems running that in some way has to be coordinated and synchronized. Sharing data between these systems is crucial for maintaining an overview of the current health status in Rwanda.

Chapter 6

Method

The overall research method used in this study is action reasearch. In this case a full iteration through the process was not conducted, time as usual, was not on our side. Nevertheless, some progress was made. This study is scheduled to be continued in a few months as of writing. The work here will serve as the first two steps in the action research process, diagnoses and planning.

6.1 Action Research

Action research is based on an iterative process, plan, act and reflect. Another way to describe this process is by:

Diagnosis: Figure out what the problem is.

Planning: Figure out what to do about it.

Intervention: Execute the plan.

Evaluation: Comparing the results of actions taken with the proposed results in theory.

Reflection: Figure out if the goal was met, if any new knowledge was aquired and whether a new cycle is required.

[13] The approach to set a diognosis was by conducting an exploratory case study. As with exploratory studies, the study should define the problem and uncover the theoretical topics which are relevant. In short, it was a short-term, contemporary study. Meaning that is focused on getting an overview of the present situation.

6.2 Selection of case

The case was selected partly because it is a typical instance and partly of the unique opportunity. Typical in the sense that the frames of the case was already set. It was a health case that should be investigated within HISP. Within the HISP developer team I took part of a DHIS2 workshop in order to get familliar with the software. While being included in meetings and email threads I've got in touch with HMIS team. They talked about two suitable cases were there could be useful to have some students working. It was well suited for our purposes so we've decided to proceed.

6.3 Data Collection

As with all case studies and action research one has to generate some data to analyse. In this case a practitioner-researcher approach was used[13]. This is a way of combining working with a researchers hat. Thing is, the case in question is already in my field of education. For working purposes I were an intern at the company hired to facilitate the HMIS in Rwanda. This method of working has some drawbacks. For obvious reasons the setting is somewhat artificial when people know that you are conducting a research while working. This could be due to the fact that everythng they do and say could be recorded.

Chapter 7

Case

7.1 Background

The health information system in Rwanda is now going through a transition phase. This is from one of the members of the health management information system team.

> We'd like to transition to DHIS-2 but it will require quite a bit of work on programming alerts - outgoing SMS messages - and setting up an interface for defining alert levels (ceilings) at which point the messages are sent.

They are now in some way trying to transition from a series of systems to an open source software called DHIS2, see section 5.3.3, page 21. The benefits in switching to the DHIS2 is many. For starters it is an open source software. Currently parts of the health information system is contracted to companies in the private sector using proprietary software. Open source is free. Propietary software is not. Clearly the transition will have some finacial benefits. One example is a contract currently worth 300 000$ pr. year will due to the transiton become terminated. As one goverment employee puts it:

> It is costly for the Ministry to maintain their infrastructure and is not open source.

The transition from propietary software also puts the governement in control of their own software and becoming independent from companies as it relates to bug fixes, adding functionality and so forth. The government is made up of different departments. Different departments leads to the formation of silos. Silos makes it hard to co-operate, making interoperability an issue. Also propietary software usually has restrictions, which contributes to the formation of silos. Open source software has no restrictions, which makes easy to modify and fit to the workflow and software of other departments. Thus making interoperability easier. Making the transition also leads to some added functionality, like charts for data analysis, using GIS placing data on the map, but it is also opens a door for alot of possibilites.

7.2 Situation report

This case mainly concerns Health Management Information System and their implementation of DHIS2. HMIS is a part of the Health Ministy in Rwanda. For this paper, DHIS2 servers are run by HMIS, so a DHIS2 server is the same as an HMIS server. HMIS got the main responsibility to manintain and to facilitate the flow of health data in Rwanda. Even though they are the people with the main respnsibililty, as described earlier, there are other actors as well. For an example there is Voxiva. A propietary software company that currently is supporting the data flow to the government using a voice response system, see figure 7.1. In figure 7.1 you can see how the data flows from users all the way to the DHIS2 database. If you take the route from users to the DHIS2 database, the data from users to health facilites are paper based. The data flow that goes through the paper based system would greatly benefit from transitioning to an electronic based system. Since DHIS2 does not support data specific to villages, another system is used to support this, currently delivered by Voxiva. In short, making the users report data twice at the village level. One time electronicly to the Voxiva system, and one time via the paper based system to the health facility. The paper based data collected at the health facilities are entered by data managers and then pushed to the DHIS2 databases. Data at the health facilities are aggregated

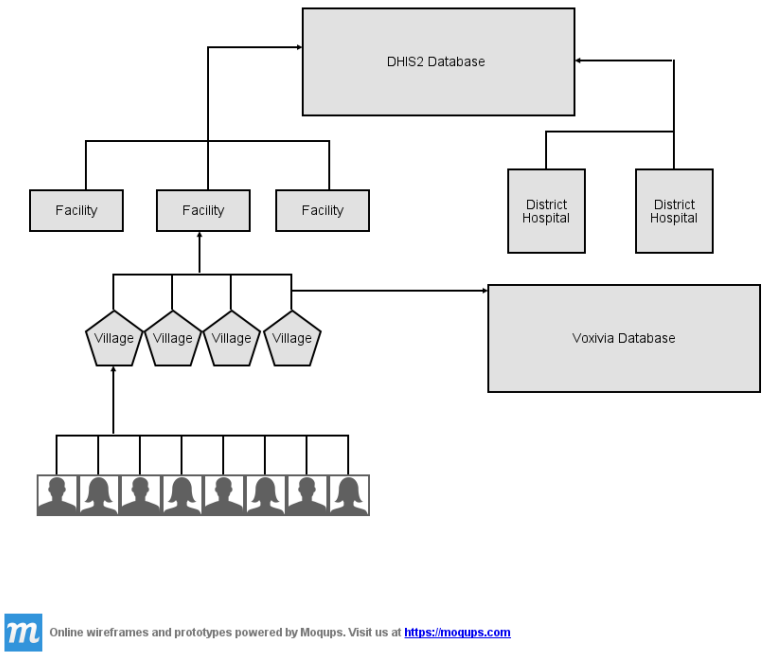


Figure 7.1: Dataflow

by the data managers, so one cannot tell the difference between villages. The government would like to transision to DHIS2, but since data is aggregated at the facility level when using DHIS2, one has to use the Voxiva system for village specific data. One typical scenario is when a village is running empty of some drug. Another village connected to the same health facility has to much of the same drug. DHIS2 would report the drug stock to be allright since the data is aggregated. One cannot ignore this problem so HMIS is still dependent on Voxiva's system for problems like these. Clearly one could benefit from some interoperability. Since the data is reported twice, the system could exchange data and make life easier for the users.

7.2.1 External Systems and DHIX

DHIX

DHIX is not an abbrevation, but a name for describing the systems at HMIS as a whole. This system include four instances of DHIS2, each running on a

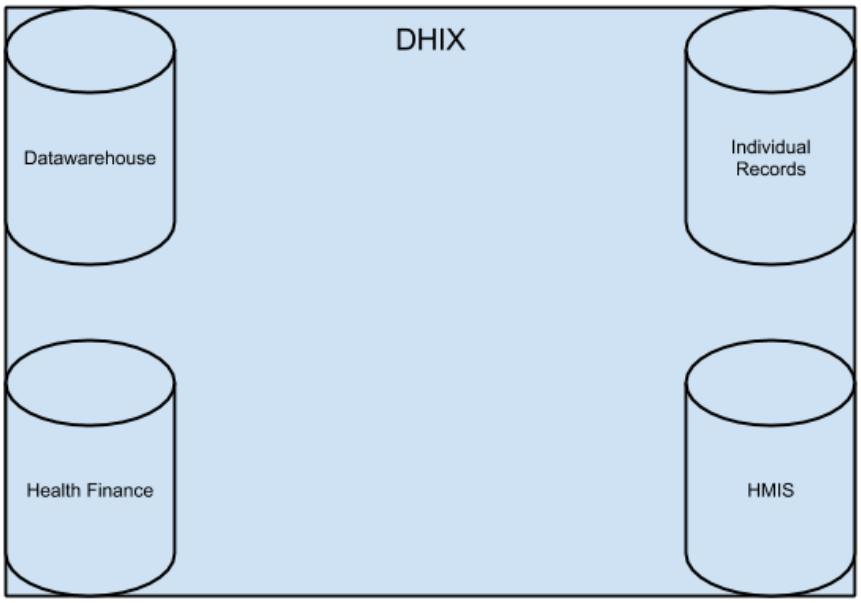


Figure 7.2: An overview of the DHIS2 servers at the HMIS

separate server with some scripts linking them together.

HMIS This server contains general statistics about Rwanda's health.

Health Finance Contains information about performed health services throughout districts. This data is used for the Performance Based Financing or PBF.

Individual Records HMIS has a dedicated server containing information about individuals using the tracker module in DHIS2.

Datawarehouse This collects data from other DHIS2 instances. Data is pushed to this server about once a month.

External Systems

Figure 7.3 shows the systems mapped during the case. All of these systems has some relation to the DHIX and interoperabililty between the external systems and DHIX would be of benefit. As mentioned, the Health Information system in Rwanda is going through a transition. Therefore, it is likely

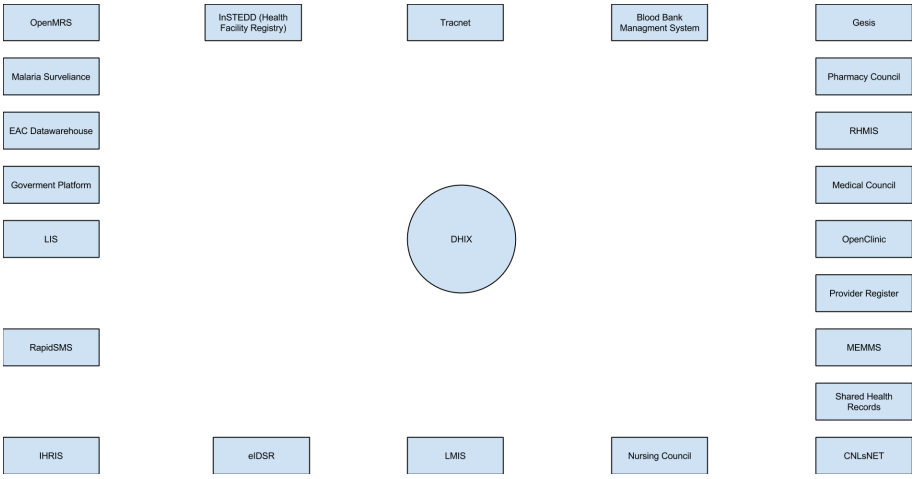


Figure 7.3: Overview of systems included in the Health Information System of Rwanda

that there is some of these systems that could easaly do the switch from the old system to DHIS2 and easaly be integrated in DHIX. This would require a huge study that I did not have the time to do during this case study, but is definitively recommended. I got the chance to study one of these systems in some detail and it is presented in short here.

7.2.2 Malaria Surveliance

The purpose of this system is to map were there is an outbreak of malaria in order to initiate countermeasures. The malaria surveliance project consists of two main branches.

Sentinel Surveliance

The malaria sentinel project is implemented and is currently reporting weather data and malaria cases, with some extra information. The purpose of this instance is to map all malaria cases based on their geographical location and see if there is a connection with malaria data and weather data. The sentinels are differents stations spread throughout Rwanda, see figure 7.4. Adding up the sentinels catchment area they should cover all of Rwanda. Currently these stations data flow is not integrated in DHIS2. The data being reported

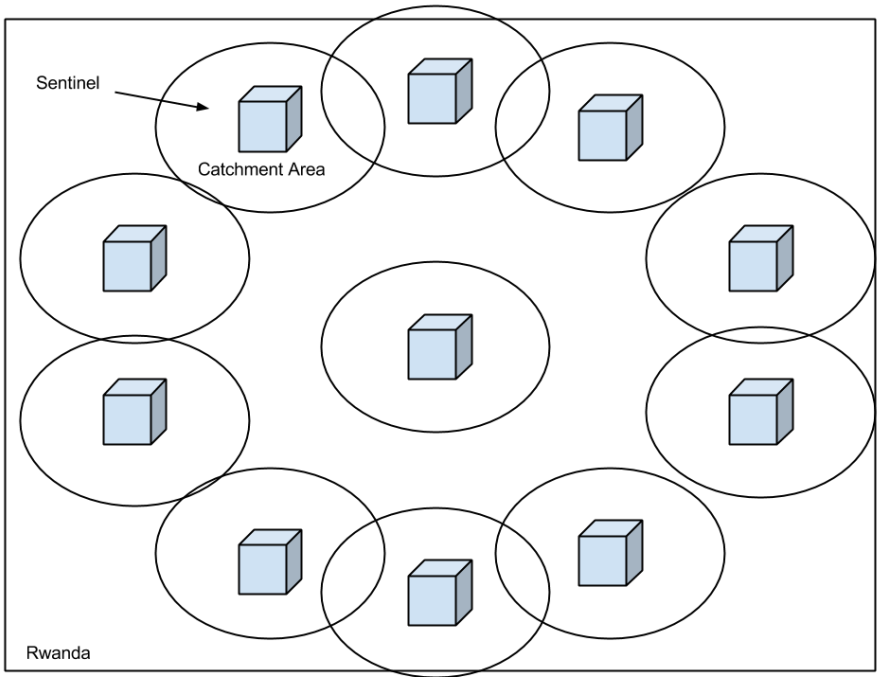


Figure 7.4: Sentinel Surveillance

should happen daily. This is currently supported by DHIS2 and would be solved by making some predefined forms for the staff making the reports. A very simple task, but it needs to be coordinated by the responsible so that everybody is onboard with the solution. DHIS2 is currently supporting all the requirements, but in order to make the transistion the personell doing the reporting has to be trained and take part in the transition.

Active Surveliance

Active Surveliance is another branch of the malaria surveillance. The thing is, one wishes for data from the place were the malaria was first noticed. This kind of data would include if the infected person has bednets, if others in the same house has malaria and other contextual data in hope of seing a pattern to what is most likely to make a person infected. Currently the health personell is using a paper based reporting form, but would like to transition to an electronic based report. See appendix A for an example of a paperbased reporting form. The technology that the health workers currently

are equipped with is usally regular simple phones that could interact with DHIS2 with SMS. DHIS2 is supposed to support this feature, but it is not been properly tested. A requirement is that one would have to set up a SMPP gateway with a local teleoperator. In this case the most likely teleoperator in Rwanda would be MTN. The technical expertise for this kind of functionality is not the main obstacle. It's the bearucracy of decision making. The decicion process is long and it takes a while just to map who to talk to about what before one could even start setting up the necessary components.

As one would notice, the technology is already in place.

7.2.3 Health Facility Registry

Another external system which used is the inStedd platform. This is currently being used to make register and delete health facilities and making the changes available to other systems. The changes are first being made at the HMIS server at the health ministry. Then the changes are made at the inStedd platform, which is being run by another open source system. From there other systems and user can get the latest updates on the health facilities. Thing is, this is not being synchronized automaticly. The HMIS server does not get updated if a new health facility is registred at the inStedd platform and vice versa.

7.3 Future goal

In short, the topic of the problem is interoperability. We have two scopes here. One within the organisation and one with the HMIS and external systems.

7.3.1 Intraoperability (DHIX)

As mentioned, DHIX is the a collection of severel independent sub systems. Thing is, the HMIS team would like to make this systems interoperate. Currently one would like to add some functionality to DHIS2. This would mean

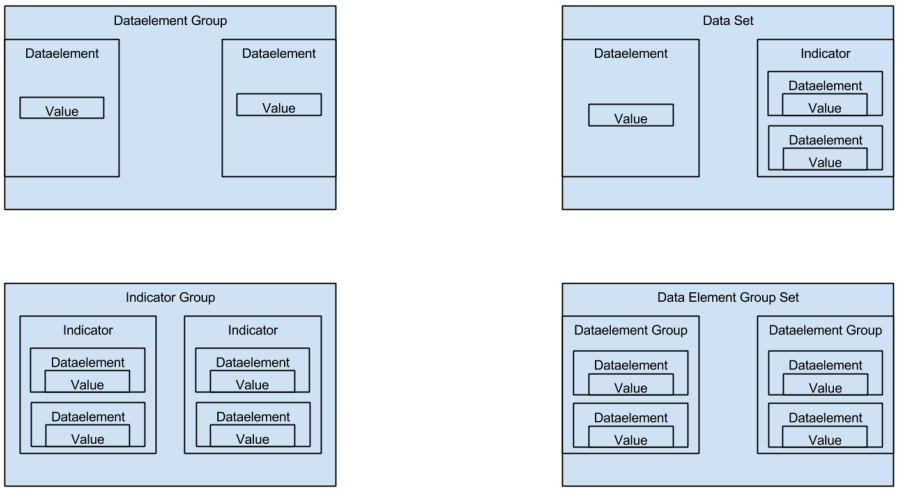


Figure 7.5: Data representation in DHIS2

that one would be able to exchange data between instances in a new way. Simply explained. The user should be able to select the data he/she want transferred based on groups or a specific type of data. In order to explain, some information about the dataelements in DHIS2 is needed.

Dataelements

Dataelements are the lowest level of data representation in DHIS2. Dataelments are just a count of a thing. One would have to create a data elment in order to begin counting. Like if one would like to count the number of people with tuberculosis. One makes a data element called tuberculosis and add it to a report form. The report form is then reported in with a fixed time intervall. Maybe daily. So then one could see how many from each health center had tuberculosis. The dataelements can be combined to data groups or indicators. see figure 7.5. Indicators are one value based on several data elements. Data groups are a collection of data elements. Indicators can also be grouped into indicator groups. Data sets can be a combination of data elements and indicators. Finally there's data element group sets which basicly is a group og data element groups. Indicators allows one to make some mathemathical operations with the data elements before presenting the number.

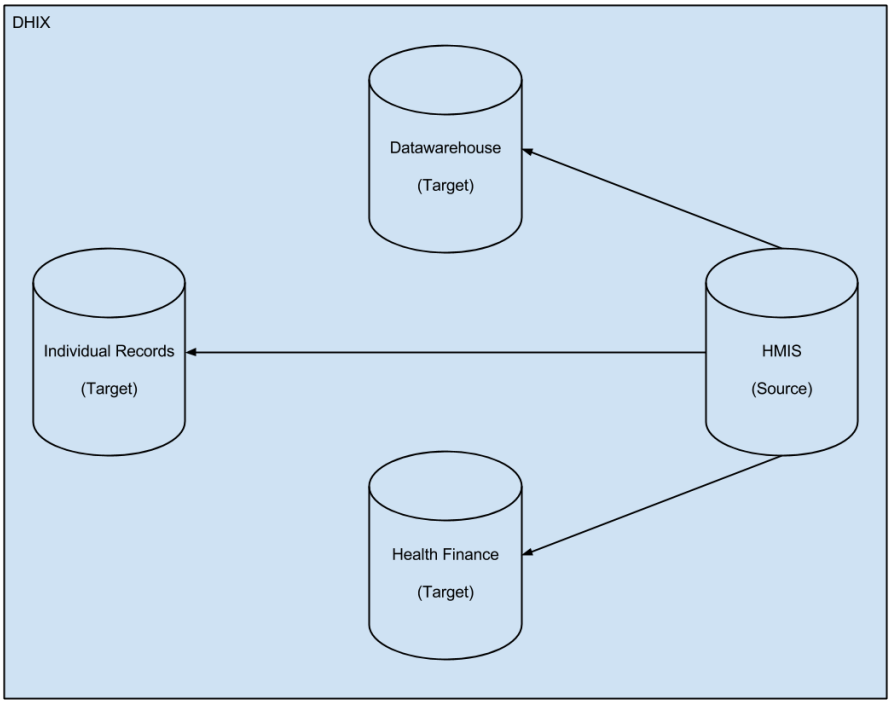


Figure 7.6: Exchange data between DHIS2 instances

Like showing how many incidents of tuberculosis pr. thousands of villagers.

Thing is. Setting up all of these data representations and groupings can take some time. Like in this case study we have several instances of DHIS2 running at the same time. The HMIS team would like to be able to transfer dataelements, indicators, groups and sets without creating them at the target server. Now one has to first create the dataelements at the target server, then one has to transfer the values. And since one has to make the dataelements, the groups, indicators and sets also must be entered manually before transferring the values. In figure 7.6 one can see the general idea. Given one source server, one would like to be able to transfer elements, sets and groups by the click of a button. This is generally interoperability within HMIS, I just call it intraoperability in this report.

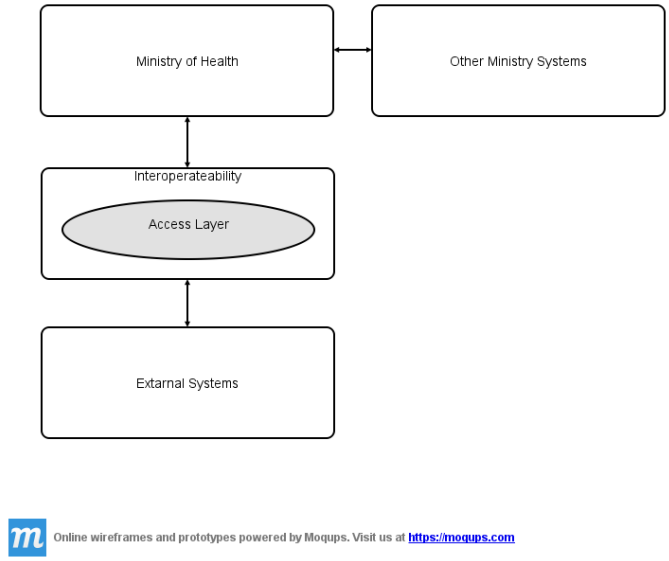


Figure 7.7: Future Design

7.3.2 Interoperability

The second future goal concerns interoperability with external systems. In general, the same functionality as in figure 7.6, but with external systems. Here it gets quite complicated. For startes one has to figure out what protocols the external systems are supporting and what fileformats that can be used. As we took notice in figure 7.3, theres alot of systems and probably even more. Nevertheless, interoperability is not binary. One could achive more or less, so setting up for easier data exchange is a good start.

In figure 7.7 the overall architecture is proposed as a HMIS vision. This is the future for the health information system from a HMIS perspective. The idea is that HMIS should provide an access layer for the external systems. This layer should provide the necessary application programming interface, or API , so that HMIS, or the Ministry of Health, will be able to exchange data with external systems. After discussing the design, we've implicity talked about using the same access layer for other ministries, but nothing was decided.

7.4 Challenges

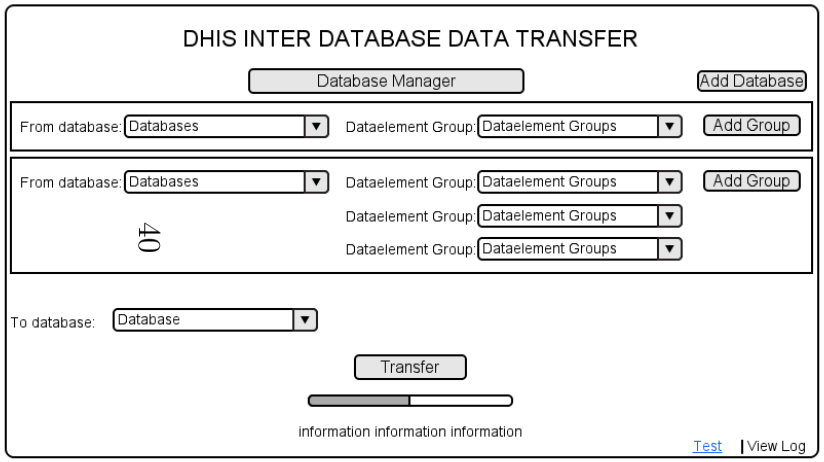
One of the main challenges will be in mapping the different systems and their specifications. Technology is changing faster than ever, new solutions are available before one has the chance to implement the current ones. This is a major challenge when creating standards and making interoperabillity possible. The standard being decided might be outdated by the time its ready to be used. There is really no possible way to completely avoid this, one should keep in mind that these systems should be as timeless as possible. Like an data exchange format like JSON probably will be supported for many years to come. Also one would probably have some difficulties with getting all parties involved agreeing on one solution that suits all.

7.5 My role

My role in this case has mainly been as one of the people trying to identify how one could improve the situation based on my educational background. Based on the case we've found that interoperability is one of the fields that I could contribute the best. The first 2 weeks went on planning and diagnosis in the action research process. 50% of the time available. With another student I started on the third step. Intervention.

7.5.1 Intervention

Together with the HMIS team we figured that working with the interoperability within DHIX would be the best idea. This was due to access and convinience. The goal was set as in figure 7.6. We thought that we would make an internet application that would be tailored to the HMIS teams purposes. As in the mockup in figure 7.8 the user would be able to select the data groups he/she wants to transfer. The does no show the full functionality of the planned appliction, but was meant to be an example of how we thought we would develop the application. Our solution was very much based on a direct connection with the databases. This was not a very popular



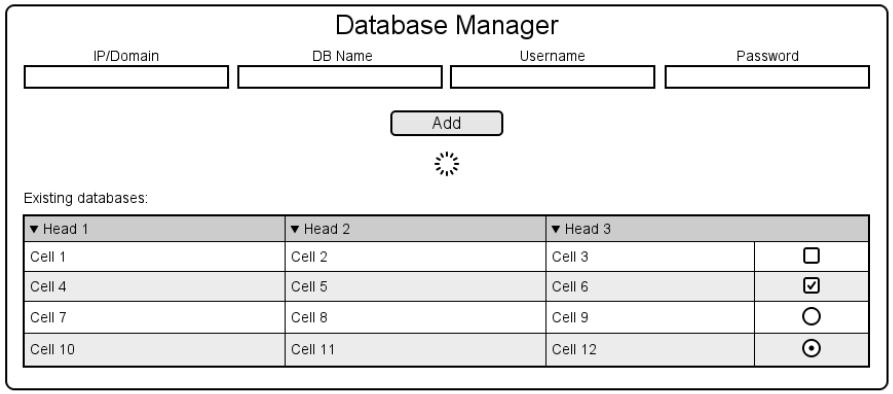


Figure 7.8: Mockup of interoperability application

approach among other team members. Unfortunately, we've spent 1 week on this. Thus, another solution was proposed that would also include the access layer. The last week went on preparing for the second project.

7.5.2 Future Project

The project is now set. My colleague and fellow student is currently working on this project collaborating with a developer over skype and email. If everything goes as planned I will finish the work that they have started in the next months. The general idea is to set up the access layer with the open source Apache Camel framework. This will allow us to support a wide range of protocols and fileformats.

Chapter 8

Discussion & Conclusion

Looking at the case result we see that the problem with the external systems is the formation of silos. The external systems cannot share data with the HMIS. There might be reasons for why this is the case. Like the owner of the external would like to have ownership of the data in order to be able to take care of their contract. There might not be only positive effects of interoperability. Interoperability leads more efficient use of systems. And more efficency leads to redundency. Since old systems that are less efficient are no longer needed, the people facilitating these system are also no longer required to do so. Making people required to look for other endeavors. This might be a good argument for choosing an interoperability method that does not have external stakeholders in the development of a concrete solution. The proposed access layer clearly advocates for a common data format solution, making Apache Camel a very contribution to this solution. The application would in some way synchronize databases with data. In that there is possibility of making changes to data with alot of dependencies. In this case the source system is not clearly defined, meaning that not all systems that will be affected are mapped. This clearly makes the redevelopment approach not suitable. The migration strategy would come in handy, but we are not really looking to move the system over to a new platform. I would be sufficient that we just provide some new functionality with the source system. Therefore a wrapper approach is the best choice, making no changes to the

system already in place. Maintaining the system will then be a more complex job, but developing the access layer in a framework that is suitable for DHIS2 should be possible. The developer team is already planning to launch a DHIS2 appstore that would work perfectly as a framework for this kind of application.

So by first being aware of the presence of system silos in a given context, we see that interoperability can be an issue. From here one should map the relevent systems that should be able to take advantage of an increase in interoperability. This would actually be another way of saying, identifying the stakeholders. One should choose a strategy based on the level of cooperation between stakeholders. In this case the organisations work pretty much as silos, so a common data format is the easiest to implement. From the interoperability strategy we get guidelines for what to develop. Then introducing the new system with the old requires a way of transitioning from the old way, and therefore choosing a transition strategy. In this case a wrapper that is built on top of the already existing system is best suited. In this case one would like to transition from propietary software to open source. For reasons discussed in section 4. As of now, Rwanda is charecterized as an developing country and would greatly benefit from an open source initiative.

8.1 Acknowledgements

Thank you all who have helped me during this research.

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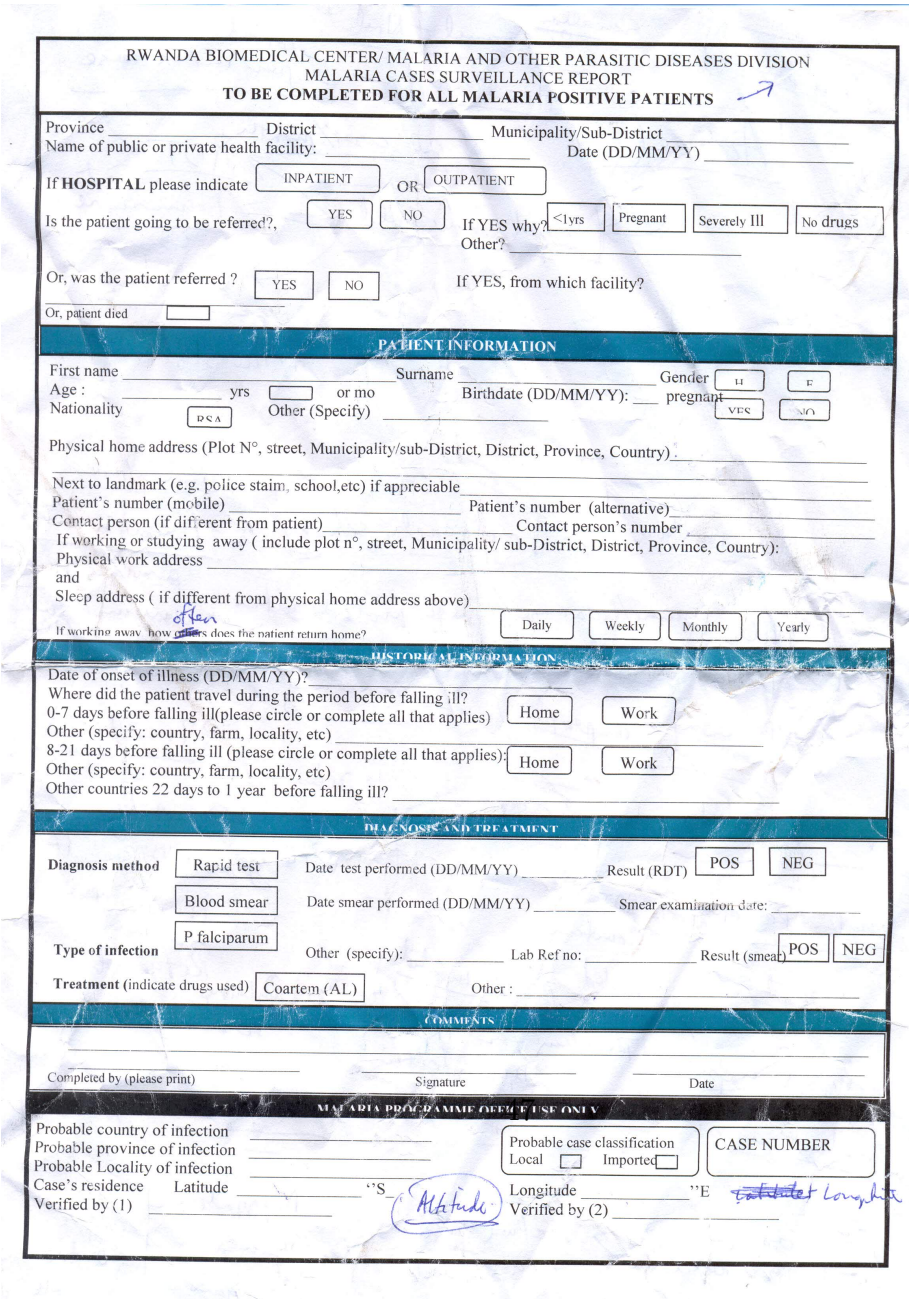
Appendix A

Malaria Reporting Form



RWANDA BIOMEDICAL CENTER/ MALARIA AND OTHER PARASITIC DISEASES DIVISION
MALARIA CASES SURVEILLANCE REPORT
TO BE COMPLETED FOR ALL MALARIA POSITIVE PATIENTS

Province _____ District _____ Municipality/Sub-District _____
Name of public or private health facility: _____ Date (DD/MM/YY) _____

If **HOSPITAL** please indicate INPATIENT OR OUTPATIENT

Is the patient going to be referred?, YES NO If YES why? <1yrs Pregnant Severely Ill No drugs
Other? _____

Or, was the patient referred ? YES NO If YES, from which facility?
_____
Or, patient died

PATIENT INFORMATION

First name _____ Surname _____ Gender M F
Age : _____ yrs _____ or mo Birthdate (DD/MM/YY): ___ pregnant YES NO
Nationality RSA Other (Specify) _____

Physical home address (Plot N°, street, Municipality/sub-District, District, Province, Country) _____
_____
Next to landmark (e.g. police staim, school,etc) if appreciable _____
Patient's number (mobile) _____ Patient's number (alternative) _____
Contact person (if different from patient) _____ Contact person's number _____
If working or studying away (include plot n°, street, Municipality/ sub-District, District, Province, Country):
Physical work address _____
and
Sleep address (if different from physical home address above) _____
If working away, how often does the patient return home? Daily Weekly Monthly Yearly

HISTORICAL INFORMATION

Date of onset of illness (DD/MM/YY)? _____
Where did the patient travel during the period before falling ill?
0-7 days before falling ill(please circle or complete all that applies) Home Work
Other (specify: country, farm, locality, etc) _____
8-21 days before falling ill (please circle or complete all that applies): Home Work
Other (specify: country, farm, locality, etc)
Other countries 22 days to 1 year before falling ill? _____

DIAGNOSIS AND TREATMENT

Diagnosis method Rapid test Date test performed (DD/MM/YY) _____ Result (RDT) POS NEG
Blood smear Date smear performed (DD/MM/YY) _____ Smear examination date: _____
Type of infection P falciparum Other (specify): _____ Lab Ref no: _____ Result (smear) POS NEG
Treatment (indicate drugs used) Coartem (AL) Other : _____

COMMENTS

_____ _____ _____
Completed by (please print) Signature Date

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Probable country of infection _____
Probable province of infection _____
Probable Locality of infection _____
Case's residence Latitude _____ ''S Longitude _____ ''E
Verified by (1) _____ Verified by (2) _____
Probable case classification Local ☐ Imported ☐
CASE NUMBER