Integrating and scaling Health Information Systems in Africa – the case of Sierra Leone

ABSTRACT

In this paper we address the problem of how to integrate health information systems in low-income African countries within which technical infrastructure and human resources vary significantly. We describe a set of tools to meet the needs of different service areas including managing aggregate indicators, patient level record systems, and mobile tools for community outreach. We present an architectural approach that facilitates the provision of services at each level of the health system (national, regional, facility and community) and provide different configurations of the tools as appropriate for the individual area. The architecture is bound together using an emerging open standard for aggregate health data to define the flows of data and metadata. Using an action research methodology, we present findings on the implementation of this approach in Sierra Leone. In our concluding remarks we observe that the successful implementation of our architectural approach has had significant secondary effects outside of the immediate setting of the case study..

Keywords

Africa, architecture, capacity building, electronic health information systems, standards, Sierra Leone

INTRODUCTION

The role of information and good information systems for the provision of health services has been given increased global attention over the last decade. The Partnerships in Statistics for Development in the 21st century (PARIS21) was established in 1999 to promote *evidence-based* policy making and implementation to reach the Millennium Development Goals. The World Health Organization (WHO) has classified information as one of the six pillars of a health system (WHO 2005, 2007a), and has repeatedly stressed the importance of improving health information systems (see for example WHO 2007b). In 2010, eight global health agencies, including WHO, the Global Fund to Fight AIDS, Tuberculosis, and Malaria, the World Bank, and UNAIDS, called for action to improve health information systems and use (Chan et al. 2010). The launch of the Health Metrics Network (HMN), a partnership hosted by WHO, in 2005 provided global leadership as well as a consensus-based overall strategy for the development of national HIS; interoperable sub-systems within a national framework where aggregated data from the subsystems are integrated and made available in a national data repository. The HMN Framework (Health Metrics Network, 2008) provides an overview, context and tangible goals for national HIS development, and current work aims at providing guidelines for *how* countries could actually achieve these goals, particularly given the current status of their HIS, human resources and general technical infrastructure. For example, the fact that technical infrastructure is very unevenly distributed between rural and urban areas poses a particular challenge when designing Information and Communications Technology (ICT) solutions for uniform implementation in a country. Moreover, when the HMN Technical

Framework advises countries to implement a central data repository receiving data electronically from sub-systems and the peripheral levels, it presupposes uniform access to a wide area network like the Internet. Furthermore, when many of the data sources are paper-based, as is the dominant tendency in Africa, new ICT solutions need to be established and interoperability created based on the available infrastructure, which ranges from a complete lack of power and connectivity through portable data systems, such as USB memory sticks all the way to mobile networks and the Internet.

In order to address this complex situation, this article argues for national HIS strategies in Africa to be based on *scalable* and *comprehensive* solutions. Scalable refers to the need for rolling out the solutions in a paced manner: 1) vertically "down" the health hierarchy, from national to region, district, facility, and finally to the patient and community levels, as well as 2) horizontally in "scope" of services and functional areas and finally 3) geographically. *Comprehensive* refers to the need for providing solutions that meet the needs of each service area and level of the health system; from medical records for patient management to aggregated data and indicator repositories supporting district management and national monitoring and evaluation (M&E). In combination, scalable and comprehensive mean that a long-term vision must be in place from the outset, so that stepwise development can take place that does not compromise further expansion.

The need for scalable strategies applies also to the comprehensiveness of the solutions. The pace of rolling out solutions along the vertical and horizontal axes will depend on the evolving maturity of the system in terms of human resources, institutional learning and infrastructure, as well as funding. For example, the HIV/AIDS area will typically take the lead on medical records, paving the way for other patient groups segments to be implemented later; national and district data repositories will start with essential indicators on some, but not all relevant areas; geographical and administrative regions may develop at different paces depending on infrastructure and maturity. The key issue, however, is that the various scaling processes develop within an interoperable and integrated framework, or *architecture*. This paper outlines one collaboration among several different organizations working together to build a scalable and comprehensive health information system using free/open source software (FOSS) components and open standards within an architecture model.

FOSS AND OPEN STANDARDS

An important feature of the system components presented in this embodiment of the architecture is that they are each based on mature Free/Open Source Software (FOSS) components and are web based. Far from being accidental, the use of FOSS contributes to the scalability (there are no licence transaction costs in replication of nodes) of the architecture as well as facilitating long term meaningful appropriation by the client government departments in a political and economic environment where African countries are increasingly being required to comply with multilateral commitments regarding copyright protection and enforcement (May, 2006).

Interoperability between such independently developed and maintained FOSS systems is nevertheless difficult. Interoperability has been described in ISO/IEC 2382-01 as "*The capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units*" (JTC1, 1993). Achieving this interoperability is a critical requirement for building the flexible architecture described later in this paper. We have proposed an open standards driven approach informed by arguments of economy and efficiency (Ghosh, 2005) as well as broader political and developmental considerations related to state procurement of ICT systems in developing countries (deNardis, 2009). We use the term "open standard" in the sense

described by Krechmer (2006) to indicate standards which are not encumbered with intellectual property constraints and which enjoy legitimacy through open, fair and participatory development and maintenance arrangements by a not-for profit agency.

Whereas such openness can be an important factor in establishing legitimacy (Froomkin, 2003; Werle and Iverson, 2006), this is far from sufficient to ensure that it will deliver technical or economic benefits (West, 2003). For a specification to be pronounced useful and worthy of standardisation it should be demonstrated to be so. West and others (for example, Nickerson and Muehlen, 2006) point to the requirement of the Internet Engineering Task Force (IETF) for two or more working implementations as a pre-requisite for standardisation. This requirement is summarized in a catch phrase associated with the culture of the IETF: the need for *rough consensus and running code*.

A challenge faced in the implementation of the architecture described in this paper was that there was not, at the time, a mature and widely used standard for exchange of aggregate health information system data. But there was an emerging effort driven by the World Health Organisation (WHO) to create such a standard. This emerging standard, SDMX-HD (Statistical Data and Metadata Exchange for the Health Domain), is an implementation of the ISO SDMX standard (TC154, 2005). Whereas SDMX is a relatively mature standard which has found use in a number of domains for international reporting of statistical data, SDMX-HD, as being proposed by WHO, was unproven. By engaging in both the standards development processes of the WHO as well as in its early practical implementations, the participating partners in the collaboration described in this paper, have made a significant contribution to shaping and legitimizing the SDMX-HD standard.

METHODOLOGY AND APPLICATIONS

In order to expand the HMN Framework into practical implementable guidelines, example implementations as well as consistent conceptual models are needed (Stansfield, Orobaton, et al., 2008) In this article we use the HMN project in Sierra Leone as an example for describing a conceptual model together with practical solutions that may also be used in other countries. Sierra Leone has been a "first wave" country for implementing the HMN model since 2007, including initial HIS assessment and the development of a strategic plan for national HIS as according to the HMN Framework. National data sets and reporting tools have been harmonized and the District Health Information System (DHIS) v2 data repository software application has been implemented at district and national levels since early 2008. In early 2010, the Open Medical Record System (OpenMRS) was implemented to track ART patients, and is configured to use the Statistical Data and Metadata Exchange for the Health Domain standard (SDMX-HD, described below) for sharing aggregated data with the data repository. At the time of writing, this solution of *connecting* other interoperable software is also being applied to the iHRIS software for human resource management. Sierra Leone represents the first country implementation of SDMX-HD for data exchange.

Several of the authors have been actively involved in the development of the described system in Sierra Leone, both abroad and in-country. In-country work has evolved around designing and implementing the local HIS, collecting and translating user requirements into software functionality, capacity building, fostering consensus for data definition harmonization, and enabling managers at all levels to use information for decision making. The work can be labeled action research, where the authors actively engage in change processes, evaluate and re-evaluate along the implementation phases in a participatory

manner with the key stakeholders in the country. These processes have given the authors insights into the challenges and opportunities of the Sierra Leone context, which have proven invaluable for gravitating towards the proposed solutions. All authors have experience in implementing health information systems in resource-constrained settings in other countries, which also forms the base for work in Sierra Leone.

A similar approach has characterised our engagement with the SDMX-HD standard development process at the global level. One of the authors is an active member of the technical committee formed around the standard. Through this involvement we have been able to ground much of the development of the global standard on the country experience of implementing SDMX-HD within real systems, such as in Sierra Leone. In this article, the case of the HIS development in Sierra Leone including the interoperability between OpenMRS, DHIS v2, and iHRIS is used to develop a general maturity model for scalable and comprehensive solutions and strategies for national HIS development in Africa. The following sections will present the various initiatives and development processes that are active in the development of the Sierra Leone information architecture.

DHIS

The District Health Information Software (DHIS) is a generic tool for collecting, managing and presenting aggregated data and indicators. Rather than being a pre-configured database application, DHIS has an open metadata model and a flexible user interface which allows the user to design the contents of a specific information system without the need for programming. The first version of DHIS is based on MS Office and has been under continuous development in South Africa since 1997. After initial piloting and deployment, first in four districts, then in two provinces, DHIS v1 was established as the national HIS in South Africa since 2000 (Braa, Hedberg, 2002). Since then, DHIS v1 has been deployed in a number of countries in Africa and Asia through the so-called Health Information Systems Project (HISP) network, which is made up of universities, HISP-NGOs, as well as Masters and PhD programs (Braa, Monteiro, Sahay, 2004). Development of the fully open source and web-based DHIS v2 began in 2004 under leadership of the University of Oslo, but aimed at distributing development activities to a number of the countries in the HISP-network in order to bring software development closer to the contexts of use. A stack of Java-based technologies was selected for v2, and in parallel a distributed development platform similar to those employed by many Free and Open Source (FOSS) projects was set up. After the first pilot in Kerala in the beginning of 2006, use of v2 spread rapidly in India and is now implemented in more than 20 states. Since 2008, in addition to India, Vietnam, Tajikistan, Tanzania and Sierra Leone have been the key implementation and development sites for DHIS v2 (Titlestad, Staring, et al. 2009). Currently WHO is collaborating with DHIS v2 to provide the GIS functionality in their new version of openHealthMapper.

OpenMRS

OpenMRS (www.openmrs.org) is a community-developed free and open source medical record application (Mamlin, Biondich, et al. 2006). The core data model captures information concerning the clinical encounter between a patient and healthcare provider and observations recorded during the encounter. OpenMRS is a general-purpose patient-based system and observations are mapped to a concept dictionary that can be easily configured to store any real world observable linked to the encounter. A modular design includes a robust core codebase and flexible modules conferring functionality that can be

added to OpenMRS as part of the customization process.

OpenMRS has emerged as a key building block in a number of HIS due, in part, to the fact that it is flexible and standards-based making it highly interoperable with other open health applications. The OpenMRS concept dictionary links to other coding systems through the concept collaborative, a powerful mechanism for creating flexible mappings between data elements. In addition, the development of OpenMRS has a strong community component (Seebregts, Mamlin, 2009) a key feature for its sustainability and capacity development features.

iHRIS

Sub-Saharan Africa suffers from 24% of the global burden of disease, with only 3% of the global health workforce to provide necessary services. Furthermore, in many African countries, information for planning and monitoring the health workforce is unreliable or unavailable. In cases where reliable data are accessible, they are infrequently used for planning and decision-making. To address these issues, USAID's Capacity Project developed a Human Resource Information System (HRIS) Strengthening methodology and a suite of free and Open Source software products (iHRIS) to help countries plan, measure, monitor, and manage their health workforce.

The follow-on projects to Capacity, which include bilateral projects in Central America, Namibia, Kenya, Southern Africa, Tanzania, and Uganda as well as a new five-year global project, Capacity*Plus*, are advancing this work, expanding the knowledge base and tools available to track the health workforce and monitor routine HRIS performance. A key expansion effort is focused on improving the interoperability of iHRIS with other health information systems such as DHIS 2, OpenMRS and CommCare. This will support a consistent set of provider data that can be used effectively by the other systems.

The three applications described above (DHIS, OpenMRS and iHRIS) were used as the initial building blocks to realize the proposed architecture in a case study in Sierra Leone. The case study is described in the following section.

CASE STUDY: INTEGRATION, SCALING, AND INTEROPERABILITY IN SIERRA LEONE

Background

Sierra Leone, a relatively small country in West Africa, is one of the poorest countries in the world and was ravaged by civil war that had lasted for ten years before it was officially declared over in January 2002. The public health system, which suffered from a huge loss of both personnel and infrastructure during the war, is slowly rebuilding the capacity to improve the service provision across the country. This effort is led by the government and supported by many international agencies, and aims at achieving the health millennium development goals. The rapid growth of various health initiatives has created a situation of fragmented information systems where each donor initiative and vertical health program tend to establish their own data collection systems based on their own data standards for reporting. Data is reported on paper from the health facilities, and prior to mid-2008, captured in different computer based tools. At this time about 17 different paper forms for reporting were in use, with an overlap between them between 0-50%.

HIS Implementation

Sierra Leone was selected as one of Health Metrics Network's (HMN) pilot countries for health information systems strengthening in 2007. A strategic plan in line with the HMN technical framework, which emphasizes integration of health data using a data warehouse approach, was developed. In early 2008 a project to use DHIS 2 as an "integrator" of the various data reporting structures at district level was initiated in 4 pilot districts. The approach was to acknowledge the existence of the various overlapping data collection tools by providing a data entry form for each one of them, while at the same time harmonizing all the data elements (variables) being collected in the database. In this way all stakeholders got their data, as well as the other health data, integrated in one database. The pilot was regarded as a success and was scaled up to cover all 13 districts as well as the reporting from the districts to the national level towards the end of 2008. The result was that at the end of 2009 the national level had a comprehensive data set of all data collected and reported by the health facilities though the district. The analysis of the data showed that the data quality was relatively poor, with incompleteness - missing reports – being the major problem. The achievement was, however, that this was the first time the Ministry of Health in Sierra Leone could make a comprehensive analysis of all data being collected in the country. Having seen that one integrated system, a shared data base and joint efforts in data collection and data management, was able to satisfy the needs of the participating health programs and other initiatives, all stakeholders agreed in January 2009 to combine and integrate their plethora of data collection formats. Integrated data collection forms and a new version of the DHIS 2 were consequently rolled out during the first half of 2009. Later the data collection forms and DHIS 2 application have been revised again. The availability of a comprehensive data set from the entire country, with increasing quality, has led the various donors to also start using the data from the shared repository. A training workshop for donors and other stakeholders on how to analyse and use data from the DHIS 2 was conducted February 2010, thus adding to the positive momentum.

The HIV/AIDS program, traditionally a very separate and financially independent organization, was not part of the initial DHIS 2 implementation. During the January 2010 revision of data collection tools and database, however, they agreed to also use DHIS for their data collection. Thus their forms on voluntary testing (VCCT), prevention of mother to child transmission (PMTCT), and paediatrics were included in the new database. The agreement to also collect aggregate HIV/AIDS data through DHIS followed the introduction of OpenMRS in early 2010. OpenMRS and electronic patient records are used for management of AIDS patients on anti-retroviral treatment (ART). Due to the concentration of ART administration, one pilot implementation of OpenMRS at the main hospital in Freetown, the capital, covers 4000 out of 6000 patients nation wide. The export of aggregated ART, HIV testing, and PMTCT data from this electronic medical record system to DHIS 2 was the first implementation of the SDMX-HD standard for health data transmission, the development of which is being led by WHO (see next section).

Human resource management and drug logistics are two other priority systems component to be included in the interoperable suite of health information systems in Sierra Leone. Management of human resources is critical because there is currently no satisfactory overview of health staff in the country; while reported number of staff is about 5500, the number of staff actually receiving salary is about 6500. The implementation of iHRIS, which will include bio data for each health worker, is expected to provide sufficient transparency and overview to be able to remove most "ghost workers" from the salary list. The integration of DHIS and iHRIS is already solved through implementations in India, and iHRIS will be implemented during

2010. Corruption and mismanagement related to drug distribution represents another drain of resources in Sierra Leone. The selection of an appropriate system for logistics support is, however, not yet finalized.

The integration in Sierra Leone can then be seen as taking place through two phases. Though a majority of efforts have been organizational in nature, typically involving two or more departments within the ministry of health to agree upon sharing routines and infrastructure for data collection, from an application point of view the two phases represent distinct approaches. The first phase involved aligning all actors that are users of aggregate data, and use DHIS to scale up the information system to cover these various programs. The second phase focuses on scaling up *beyond* aggregate data, by linking DHIS with OpenMRS and iHRIS. This allows the computerization of specific patient and human resource data, but also the electronic transmission of aggregate patient and human resource data to DHIS. Thus, interoperability is now the leading technical driver for integration and scaling.

The use of mobile applications for data collection and reporting is currently at the planning stage. In the discussions we have included mobile applications as part of a general maturity model, as a somewhat exceptional case given the different nature of infrastructure – mobile connectivity is usually much more evenly distributed across urban and rural areas than cable connection, which presents the opportunity to leapfrog infrastructural restrictions which currently apply to computers and cable networks.

The use of SDMX-HD for aggregate data interchange

An immediate challenge in the implementation of the proposed interoperable architecture was to define the way in which DHIS2 would exchange metadata relating to aggregate data elements (as well the aggregate data itself) with participating systems such as iHRIS and OpenMRS. The benefits of using open XML-based standards for interoperability between disparate systems is well understood and particularly so in the context of developing countries (deNardis, 2009). Through the use of an open standard we could reduce the dependency of the architecture on specific software products as well as leverage emerging best practice in the domain. Whereas it would have been easier to implement custom protocols between DHIS2 and OpenMRS and between DHIS2 and iHRIS, we decided early on that we would instead make use of the emerging standard, SDMX-HD, for this purpose. While the initial implementation is more challenging, by using the emerging standard, we ensure it will be much easier to link with other standard-compliant systems in the future as well as reduce vendor lock-in on the existing systems.

As a first step to interoperability with OpenMRS, we developed SDMX-HD profiles to represent the ART Summary paper form as an SDMX-HD data set which is an input into DHIS2. We successfully exported the metadata describing this form in SDMX-HD from DHIS2. The OpenMRS program running in the pilot facility was able to import this metadata and use it to produce a monthly summary report. DHIS2 is able to read in the resulting report and update its database. This is a process which would otherwise consist of staff at the facility completing a paper form which would be entered manually at the district level.

The process was made challenging by the fact that SDMX-HD is a very new protocol and there were no reference implementations to guide us. The exchange of data between OpenMRS and DHIS2 is in fact the first concrete use of SDMX-

HD for data exchange. This has resulted in valuable real-world experience which is being fed back into the standard development process.

Having successfully implemented the ART Summary form reporting between DHIS2 and OpenMRS, we are now in a position to implement and test using SDMX-HD for the remaining forms in the Sierra Leone data set. The metadata for all of the Sierra Leone forms has now been generated in the SDMX-HD format, including those with Human Resource related dataelements. The iHRIS system is now also able to produce data reports using this SDMX-HD metadata, opening the way for seamless exchange of data between the systems.

Sustainability

The implementation of the project in Sierra Leone has been supported by HMN both through funding for workshops and supervision as well as for two staff at the Ministry and support by external consultants. A key challenge, however, is to establish a local support structure that can ensure sustainability. While important work is being done in this regard, including building regional networks of support among countries applying the same applications, this aspect, undoubtedly crucial for the success of the efforts, is not covered in this paper. It is, however, important to stress the importance of planning for sustainability, just as we are arguing for planning for a maturity model for scaling.

DISCUSSION: STRATEGIES FOR INTEROPERABLE SYSTEMS AND SUSTAINABILITY

Creating a Comprehensive and Scalable HIS

Our goal is to combine the strengths of the above systems and the experience of their development communities to create a scalable and comprehensive system. Our approach assumes that infrastructure, skills, and uptake will be uneven through most countries. Some facilities may use electronic medical records at the point of care with access to sophisticated decision support while others are still working off paper registers. One common rollout strategy is to quickly overcome all foreseen obstacles, e.g., by planning to install solar power, increase connectivity, perform additional trainings etc. In contrast, we will attempt to build a flexible system that can exist under many different configurations. For example, there may be situations where OpenMRS is implemented without any mobile data collection, or alternatively there may be patient-level data being collected on mobiles without OpenMRS. When OpenMRS is present, it will automatically aggregate data and report it to DHIS. Facilities using paper registers may use mobile devices to assist with monthly reporting or they may continue to use paper reports that will be typed into DHIS at a central facility. To achieve this flexibility in design several additional factors need to be kept in mind.

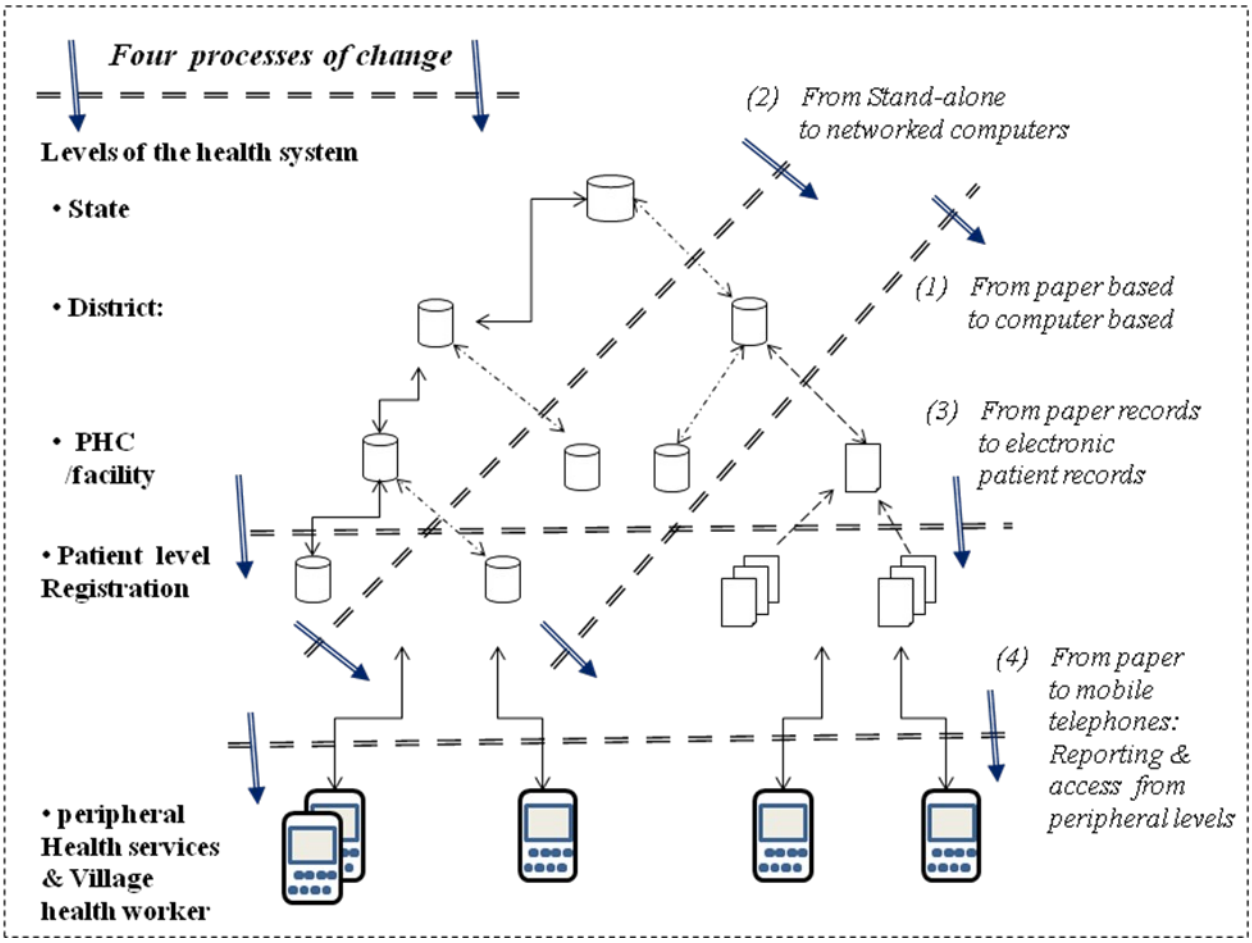

Figure 1 Processes of change and scaling model

Scaling and unevenly developed infrastructure

The infrastructure in Sierra Leone is poor, but while Internet and power supply are not generally available, the mobile network (nearly) is. When it comes to infrastructure, rural areas have always been lagging behind urban areas. The rapid spread of the mobile telephone infrastructure, however, has for the first time provided rural and urban areas with the same communication infrastructure. Meaning that, at least within the limited area of SMS and voice based mobile services, a "uniform" technical infrastructure is available country wide. Provided appropriate mobile solutions, rural areas can thus "leapfrog" many stages of infrastructure development. The maturity model implies that solutions need to be able to grow with time; from one to more places, from one level of the health system to the level below (from district to facility) and generally to become more granular and comprehensive. Figure 1 depicts four general processes that are ongoing at the same time, but, in particular for the three first processes, at different paces within the same country:

1) From paper to computer. The introduction of computers in the district offices for capturing and managing the data.

2) From stand-alone computers to networked computers. The poor Internet in Sierra Leone prevent the use of web-based data capture on central servers, but data is being reported from districts to central level using file attachments to e-mails.

Furthermore, in the district offices, all computers have access tot the DHIS2 database through Wi-Fi. As the DHIS2 server is installed in a Linux server, the added benefit is a virus free environment for data management.

3) from paper-based patient records to electronic medical record systems, and we can add, from paper based to electronic human resource records and other computerizations of former paper based data processing systems, such as for logistics and drugs, and laboratories. The process of introducing medical records systems will in itself typically represent uneven development within patient groups, starting with HIV patients enrolled in ART programs. In Sierra Leone the electronic medical records have typically started with the ART data.

4) Using mobile telephones to report and to access data. In Sierra Leone this is still on the planning stage, but the network is well distributed and users know the technology well. The first trial will be on reporting aggregate data on disease surveillance.

The first three processes may be regarded as a general maturity model where the systems need to be able to grow with time; as capacity is being built new features are being used and old features are being used in better ways, and as the infrastructure grows, computers and web-based services are being introduced. This maturity model is also a practical way in which to implement the HMN framework in a country. The national data repository represents an integrated framework within which medical record systems can scale, as they are “plugged in” (transferring aggregated data) at the pace they are being implemented for particular patient groups or facilities. Where Internet is not available, as in most districts in Africa, the national data repository will have instances implemented in each district, which will report to the national level using whatever means are available.

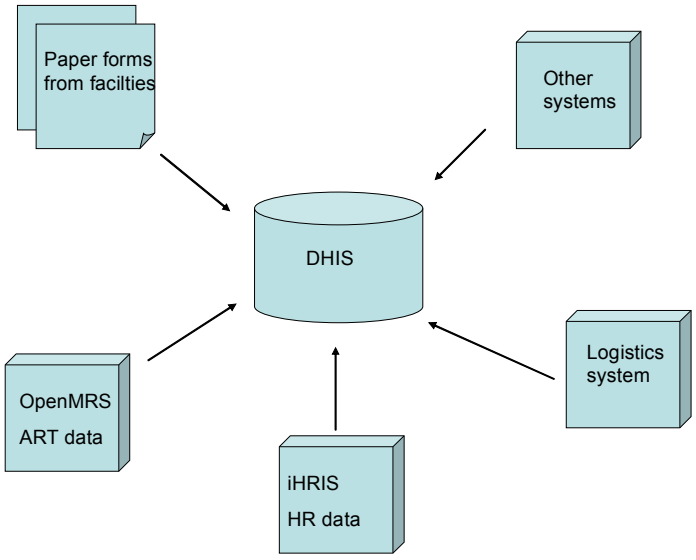

Figure 2 An overall architecture currently under development in Sierra Leone

Interoperability in the case of Sierra Leone

The specific planned implementation is shown in Figure 3, which combines Figure 1 and 2. Health information is captured at multiple levels of the system, either by paper entered into a computer or via mobile phones. Data can be entered directly into phones or computers in either patient-level or aggregated form. OpenMRS represents the core patient-level repository and DHIS v2 handles the aggregated data and the roll-up through the hierarchy. The scaling processes from Figure 1 are included also in Figure 3; Process 1 From (aggregate) paper to (aggregate) computer, Process 2 From stand-alone to networked, Process 3 From (single case) paper to (single case) computer, and lastly, Process 4 Mobile devices. Another important flow, which the diagram does not show, is that DHIS v2 also acts as a metadata repository providing the Sierra Leone Ministry of Health data element and data set metadata to the reporting systems in the standard SDMX-HD format.

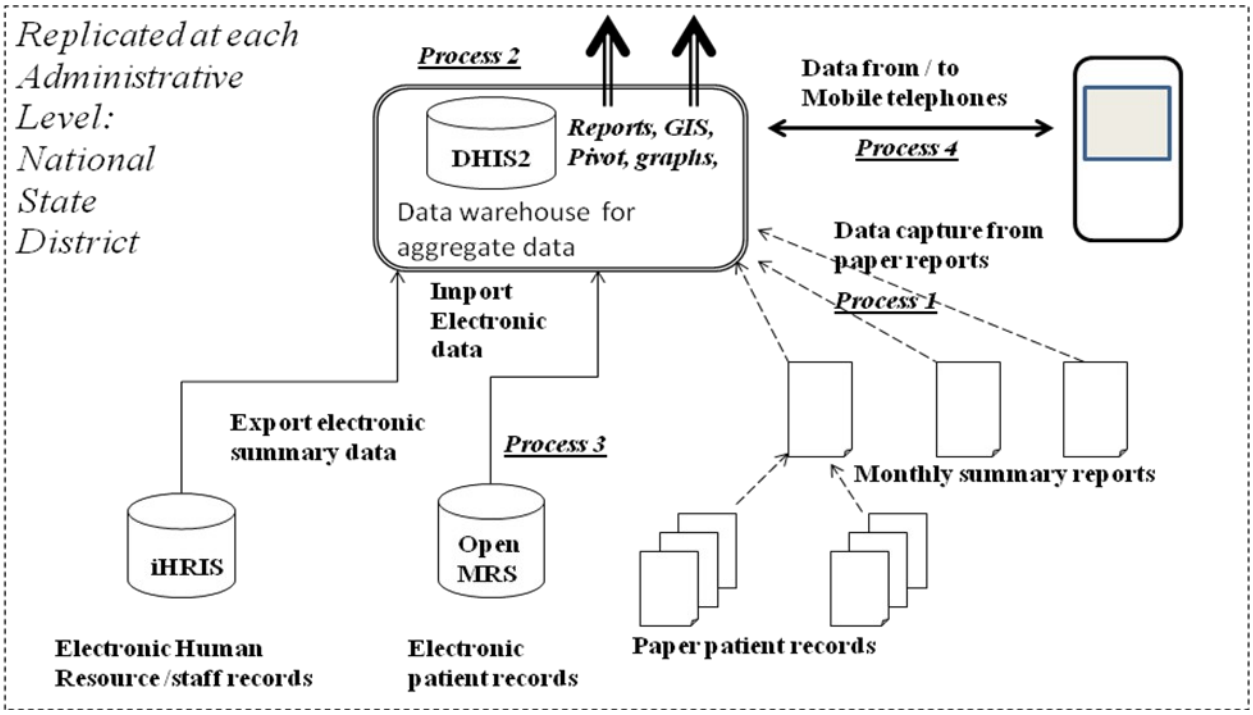

Figure 3: Proposed health information system architecture for Sierra Leone.

Conclusion and Next Steps

We have presented an approach that is standards driven and emphasizes flexibility, architecture, and collaboration. Several existing networks, each with a deep experience in one area of expertise have committed to integrating scalable and comprehensive information systems into Sierra Leone's health system. Our experience of using SDMX-HD in this context has shown that it is a viable protocol for the domain, but with important lessons from the field which we have been able to feed back into the standards development process. In this way we have realized an important advantage of open standards – the ability to participate in the development process to ensure that the standard is grounded in concrete use-cases.

At the point when we initially came in contact with the draft SDMX-HD standard, it lacked maturity and groundedness in applied use cases. By engaging directly in the standards development process, encouraging other stakeholders to do the same and, most importantly, testing its implementation in the field, we have contributed to the technical and political credibility of the standard development project. Our motivation in doing this is derived from both the practical requirement for such a standard in our domain as well as a response to the increasing demand for the use of open standards which is becoming a central aspect of the ICT policy and procurement discourse in many developing countries.

The process of integration in Sierra Leone has also been significant in throwing new software requirements into relief which would not have been the case had systems been implemented in isolation or as vertical program silo projects. In particular lessons learned in the management and governance of public health metadata will be absorbed into the learning processes of the collaborating networks.

With DHIS v2 deployed as an infrastructural base in Sierra Leone with the ability to interoperate with other systems through an open standard, the architecture is set to evolve to take into account uneven spreads of technology, resources and skills, deploying OpenMRS, iHRIS, mobile and other systems where appropriate and helping to build capacity where necessary.

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