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Strategies to Deal with Legacy Information Systems: A Case Study from the Mozambican Health Sector

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ABSTRACT

When implementing reforms in the public sector in general and in the health sector in particular, special attention needs to be taken of the role of existing legacy information systems (LIS). Traditional strategies for system change were developed within a frame of one (or few) isolated which can be developed from scratch, and moved from old to new architecture. The existing infrastructure – installed base of LIS – is typically not seriously considered when implementing changes. A theoretical perspective is developed drawing upon concepts from LIS and Information Infrastructure (II) related literature. This theoretical perspective is drawn upon to analyze experiences from an ongoing attempt to introduce new health information systems(HIS) in the context of Mozambique. The paper concludes by proposing some strategies to deal with existing LIS

1. INTRODUCTION

In implementing ICTs, an issue of concern is the existing legacy information systems (LIS), which are normally old and locked, lacking source code and documentation, and tend to be stored in various proprietary formats, making sharing data between different systems difficult. Strategies to address these LIS need to seriously considered, whilst designing and implementing new systems.

In Mozambique, various constraints have been identified through assessments of the present National Health Information System (NHIS) (MISAU, 2003; bMISAU, 2003), amongst them was the presence multiple LIS and the related absence of a unified information and communication infrastructure. As a result, the existing systems are unable to provide heath managers with information on essential indicators which would cross-link different resources with activities, such as relating to different health programs. The aim of this paper is to describe the nature of these LISs, the problems they gave rise to, and discuss some approaches to deal with them.

The available literature on LIS recommends strategies based on the assumption of isolated systems which fail to address the full scope of the problem involving multiple LIS. These LIS cannot be replaced not from scratch but need to be built upon existing systems (Hanseth, 2002). This paper draws upon the theoretical perspectives of information infrastructure (II) and LIS to analyze the potential challenges arising from LIS whilst introducing change. Specifically, the aim of the paper is to document how LIS represent an obstacle to introduce change, and to describe strategies to cope with the technical and socio-political issues of LIS. The empirical basis for this analysis comes from an ongoing action research study to introduce computer based health information systems (HIS) within the Primary Health Care (PHC) sector in Mozambique.

The paper is organized as follows. Two perspectives that help to understand the complexities of changing or replacing existing LIS are described in the following theoretical perspective section. Section three describes the methodology used in this paper. The case study follows in section 4, and it focuses on the challenges contributed to by the existing LIS. Section 5 includes the discussion which focuses on strategies to deal with LIS. The paper ends with a conclusion section.

2. THEORETICAL PERSPECTIVE

The perspectives of LIS and II are first described, followed by their integration to provide the theoretical basis for this paper.

2.1. The legacy systems perspective

When an organization attempts to change its information system (IS), it encounters problems related to the existence of a massive, complex and inflexible base of software, often referred to as LIS (Bisbal, 1999), which is historically embedded and thus cannot be abandoned overnight.

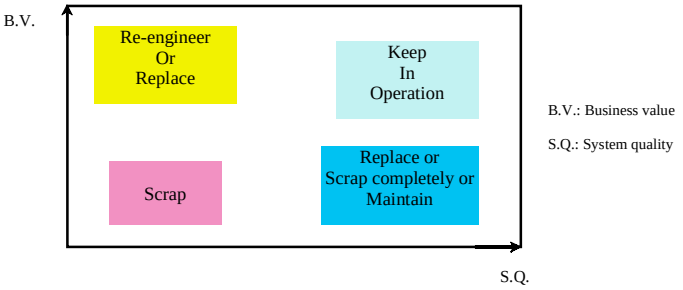
Somerville describes LIS as socio-technical computer-based systems that include software, hardware, data, and business processes (Sommerville, 2001). LIS are typically too slow, unreliable, and inflexible for handling new, more diverse and demanding tasks (Scott, 2001; Kelly et al., 1999; O'Callaghan, 1999). The functions of LIS are difficult to understand making their replacement an extremely challenging task. Replacing a LIS is a risky business strategy for at least three reasons (Sommervile, 2001). One, there is rarely a complete specification of the LIS, as the original documentation may have been lost. Therefore, there is no straightforward way of specifying a new system, which is functionally identical to the system that is in use. Two, business processes and the ways in which LIS operate have been designed to take advantage of the software services and to avoid its weaknesses. If the system is replaced, these processes will also have to change, with potentially unpredictable costs and consequences. Three, important business rules may be embedded in the software and may not be documented elsewhere. Replacing the LIS may lead to a loss of business rules, thus contributing to managers' fear of change.

The need to deal with LIS in an effective way is critical as a business relies on the services provided by the LIS and any failure of it would seriously influence the day-to-day running of the organization. The LIS, over time, differs from the original, due to external and internal factors, such as changing laws, management changes, structural reorganization, and redefinition of information needs. These changes generate new or modified software requirements, so the LIS is inevitably expected to also change. The degree of change is however context specific, and difficult to implement in practice.

Bisbal (1999) suggests three approaches to change or replace LIS: Wrapping, Migration and Redevelopment. Wrapping is to take an existing LIS into a new and more accessible software component. This is done by surrounding existing data, application systems and interfaces with new interfaces, thus giving old components a new and improved look. Migration is about retaining the original LIS data and functionality and moving the LIS to a more flexible environment (new platform) causing minimum disruption to the existing system. Redevelopment is about developing the LIS from scratch, using a new hardware platform, architecture, tools and databases. Usually, in the process of replacing a LIS the above three approaches are combined in varying degrees.

Sommerville (2001) suggests that the strategy to evolve a LIS should be based on the results of the system quality and business value assessment. Low quality and low business value LIS should be scrapped. Low-quality and high-business value LIS make an important business

Figure 1: Decision matrix: Business value versus System value



contribution but are expensive to maintain, and so should be re-engineered or replaced if a suitable system is available. High-quality and low-business value LIS should be replaced scrapped completely or maintained while high-quality and high business value must be kept in operation using normal system maintenance.

2.2. The information infrastructure perspective

Contemporary thinking in IS research seeks to analyse design and change not as IS but as Information Infrastructures (II) (Hanseth et al., 1996). Traditional IS design strategy, assumes that systems can be developed from scratch, as isolated and stand-alone applications with defined goals, start and ending times: as events rather than as ongoing processes (Orlikowski 1996). Such a perspective is limited in the present context where technological solutions seek to integrate multiple systems across organizational and geo-graphical borders, for example Enterprise Resource Planning systems (Hanseth, 2002). An II perspective which seeks to look at systems as inter-connected socio-technical networks is more appropriate to understand the challenges of introducing change when there are multiple LIS already in place, requiring integration.

Key characteristics of II as outlined by Hanseth (2002) are:

- They evolve over a long time where the existing infrastructure - the installed base - strongly influences how the II can be changed or designed;
- II is part of large heterogeneous socio-technical network, encom passing humans, technological artefacts and institutions;
- II supports information sharing among a large community of different users and needs;
- II are not defined from scratch, but rather evolve incrementally over time

Hanseth (2002) outlines some key concepts that help to understand II: increas-ing returns and positive feedback, network externalities, path dependency, and lock-in and cultivation. However, for this paper, only concepts to lock-in and cultivation concepts are drawn upon. The concept of lock in emphasizes that as the community using the same technology or standard grows, switching to a new platform becomes increasingly complex since past selections influence future development (Hanseth, 2002), A classical example of a lock in is provided by the evolution of the QWERTY keyboard layout which is based upon the design of the manual typewriters of more than a century before. The size of the installed base today makes the coordination effort required to switch to a new layout huge (David, 1985).

The concept of cultivation emphasizes that new IIs cannot be designed using top down kinds of methodologies like waterfall, but need to be nurtured gradually, bottom up and incrementally. A classical example of such an approach is seen in the evolution of the Internet (Abbate, 1999). The basic approach consists of changing a small part of the infrastructure and make sure the newly added parts work in consonance with the existing network. Cultivating an II implies building a new one such that the new features also obtain their value from the size of their installed base.

The II and LIS perspectives outlined briefly here taken together provide the theoretical basis for this paper. The II perspective emphasizes the need to respect history of existing systems and their interconnections in the design and implementation of change. The LIS perspective elaborates on the characteristics of these existing systems and thus provides insights into how they should be considered in designing new IIs. These theoretical ideas are drawn upon to analyze an ongoing effort o introduce change in the HIS in Mozambique, a context characterized y multiple LIS.

3. RESEARCH METHODOLOGY

The research is situated in the context of the Health Information Systems Programme (HISP) being currently implemented in Mozambique since 1999. HISP is an ongoing, large-scale action research initiative that operates as a global network within the health care sector across a number of developing countries (Braa et al., 2003). HISP includes the design and development of a not for profit open source software, called DHIS[1], designed for use at the district levels of the PHC care sector as a health data analysis tool (Braa and Hedberg 2002). HISP involves an evolutionary and bottom-up approach to system development, whilst building rapport and human resources capacity at all levels of the organization using participatory prototyping methodologies (Braa and Hedberg 2002). Such an approach is in line with current efforts by the health authorities to decentralize primary health care delivery through flexible systems and build up of capacity at the local level to use these systems effectively.

HISP is currently ongoing in three provinces of Mozambique including Gaza and Inhambane in the south and Niassa in the north. A key challenge in this effort has been to address the multiple existing LIS – at both the technical and political fronts – whilst introducing the DHIS. The HISP team consists of medical doctors and computer scientists, including the author of this paper who is a computer scientist involved with the research problem of systems design and development. Data collection has been carried out in various ways such as interviews with health workers and users of HIS at national, provincial and district levels, participant observation, group discussions, training seminars, and the use of the participatory prototyping approach where feedback from users are obtained. A key aspect of this research has been the socio-technical analysis of the existing LIS in the health sector.

The LIS were assessed through acquiring available documents about the existing HIS, data collection tools and procedures, whilst discussing issues with health staff about the business processes supported and the system quality. A variety of materials, including available CD's, floppy disks, and available reports and documentation were gathered to access the technical content of the LISs in use.

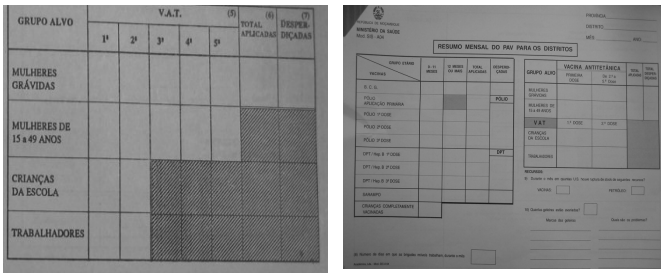
4. CASE STUDY

A long term assessment of the NHIS here called SIS[2] was done to obtain an overview of the system including its role, linkages with other existing systems, information flows, and functionality. The Ministry of Health (MOH) consists of multiple, parallel and fragmented systems (Sitói and Bruno, 1999) representing the needs of different health programs and departments. This multiplicity is reflected in different technological solutions representing a complex and disparate installed base including applications built on MS-DOS and MS-Windows operating systems, using DBASE, Visual Basic, Access, Excel, and Lotus. Below, a summary is provided on the technical details of the different LISs developed and in use at the MoH.

The technical features of the various LIS need to be understood within the historical and socio-political context of their evolution. Like many other developing countries, Mozambique too is engaged in a process of public sector reform through decentralization and introduction of computer based systems. The implementation of health public reforms has been problematic due to reasons of inadequate resources, excessive dependency on international aid. Since nearly 80% of the health budget comes through international aid (Beattie and Kraushaar, 2000), different agencies sponsor their own programme specific systems leading to the nurturing of parallel IS. The simultaneous presence of several international consultancy companies, funding agencies, and the absence of clear MoH policy on their roles creates the risk of duplication of initiatives and resources use. For example in 1998 the

Name of System	Platform	Kind of Application	Purpose of the system
SISProg	MS-DOS	Data base	Management of health data at National and Province levels
SIMP	MS-Windows	Spreadsheet	Integration of the various systems at the MoH
BES		Data base	Weekly Disease surveillance
Pharmacy	MS-Windows	Data base	Management of drugs related data
SIP	MS-Windows	Data base	Human resources management at National and Province levels
SIM _ Org	MS-Windows	Data base	Management of maintenance related data
SIGETS	MS-Windows	Data base	Management of logistics and stocks related data
SISTAFE	MS-Windows	Data base	Management of finances related data
HIV/SIDA	MS-Windows	Data base	Management of HIV related data
DO3, DO4	MS-Windows	Spreadsheet	Management of infrastructure related data at Province level
Tuberculoses	MS-Windows	Spreadsheet	Management of TB related data
CDS/ISIS	MS-Windows	Data base	Documentation management
"GIS data_USAID"	MS-Windows	Data base	GIS data on infrastructure

Figure 2: Old and new paper forms for data collection



MoH approved and signed a contractual agreement with a consultancy company for developing and defining the informatics policy for the MoH (Sitói and Bruno, 1999). The consultancy company started its work in September 2000 without coordination with other ongoing HIS initiatives like the HISP.

As a result of these multiplicity of interests and the different technological solutions that are developed, the HIS in totality lacks uniformity, compatibility, and is incapable of communicating and sharing information between programs. These issues are explored in greater depth through the example of the SISProg. SisProg[3], which represents the National HIS (NHIS), is expected to play the role of integrating the various systems. SisProg was the first computer system of the MoH developed and deployed at the national and provincial health directorates in 1992-1994 (MISAU, 1994; Lungo, 2003). The system was developed on "dBaseIII" relational database management system on Microsoft DOS. This system did not support a mouse, and while it can run in a MSDOS window in Win95, but not on Win98, using 80386 and 80486 hardware (Skobba, 2003).

The problems of the system are contributed to by the design of the manual system in which data is compiled. Figure 2 depicts two paper forms (A04) where the data elements in the columns 2, 3, 4 and 5 on the old form were combined into one column (VAT 2a a 5a Dose) in the new form. Here the health worker is supposed to fill the value for the first (1a) dose in the column 1 and the sum of 2, 3, 4 and 5 doses in the column named VAT 2-5. The next step is to enter these two numbers in SisProg software, which becomes problematic because there is no data element named (VAT 2a a 5a Dose). As a result, there is non-uniformity and ambiguity in the business rules, making comparisons and integration across facilities and time difficult if not impossible.

Problems in the use of the SISProg were also contributed to by the limited computer skills of the health workers. As a result, they did not have the capacity to deal with the already inflexible design of SISProg. The absence of the source code and relevant documentation also created problems in adequately maintaining the existing system. The SISProg example presented here was typical of the other LIS comprising the NHIS.

The consequences of the technical limitations of SISProg are summarized below.

1. Lack of portability across different computers

Despite the purchase of new PCs, the MOH could not port SISProg to this new hardware because they did not have the installation files for SisProg. (See Figure 2 which shows photos of a health office equipped with two computers, one for the old database (the old one), and the new one for secretarial purposes.

2. Long start up time

It takes long time to accomplish tasks that could have been performed in short time with powerful computers. For example, it takes up to 8 minutes for the computer to start.

3. Problems of printing and transfer of files

If users want to include health data in their reports in word processors, they have to print the data, and then re-type them on their reports because the computers are not able to copy-paste large amount of data. In addition, if they want to transfer the data to another computer they have to use diskettes regardless the size of the files.

4. Incompatibility across programs

To generate a customised graph of the health data, users used to print the data and retype them in spreadsheet software like Microsoft Excel since the SisProg generated graphs cannot be copied to word processor programs because is generated in MS DOS program

5. DISCUSSION: STRATEGIES FOR DEALING WITH LIS

In attempting to break the burden imposed by LIS, the HISP strategy was to open the "black box", and make visible the data to planners that for years had been invisible. This opening helped to show the inconsistencies and errors in the existing data, and helped to create a legitimate argument for the replacement of SISProg with DHIS.

Opening the black box was enabled by prototyping the DHIS at the province and district levels so as to populate the DHIS with SisProg health data. This data was then analyzed using the DHIS tools so as to evaluate the capacity of the DHIS as a health data analysis tool. This analysis also served the additional purpose of providing "live data" in various DHIS training workshops and onsite training of health workers. These interactions helped to analyse the quality of the health data, and make visible data to planners that was "invisible" till date. Three options were available to make the data visible: key in data from the filled paper forms; develop an extraction transformation and loading (ETL) software in order to automatically extract data from SisProg and export to DHIS; to purchase a ready-to-use ETL tool. The second option was selected as it was more suitable for customization for local needs in an efficient manner. The ETL allowed populating the DHIS with health data from January 1999 to March 2002, quickly generating required reports, and presenting these to policy makers in the MOH. This process helped to demonstrate the flexibility of the DHIS as compared to the SISProg.

The LIS perspective informs that the chosen strategy for introducing change should depend on system quality and its business value. This

Figure 3: Despite the existence of new powerful computers, the LIS are running on the old computers.

perspective suggests the assessment of the viewpoints of the different stakeholders on these two dimensions. SISProg is business critical, as data supposed to be provided by it is required on a monthly basis by the stakeholders. However, despite being business critical, in practical terms its business value is very low as the data from it is recognized by most as being not trustworthy. The quality of this system is poor, and maintaining or upgrading it is not a viable option given the absence of source code, documentation and the fact that it is locked into very old versions of operating systems. While the MoH's needs, priorities and requirements have significantly changed over time, SisProg has remained locked-into the platforms from 1992-94. The data elements to be collected have changed several times since 1992, but these changes were not reflected in the SisProg software as it was technically not possible to do so. The inflexible design of SISProg has made it very complex to evolve with the fast changing needs and priorities of the MOH. In its current state, SISProg represents a massive, long term investment making it difficult if not impossible to extend or change (Bisbal, 1999).

This analysis suggests SisProg to belong to the low-quality and low-business value category and thus should be scrapped. In recognition of this, the MoH has introduced a new system called SIMP in 2001 in their attempt to integrate the various systems as to captures a wider range of information (MISAU, 2003). SIMP was developed as a temporary technological solution, and is capable of presenting most of critical indicators for the different health services of the MoH. The idea behind SIMP is to bring information from different sources together in one database, addressing the existing problems of lack of integration and flexibility.

Sommerville (2001) argues that ineffective legacy systems such as SISProg should be re-engineered or replaced if a suitable system is available. A recent assessment of the the NHIS by the MoH has described DHIS as a suitable system to replace SisProg as it can fulfil the existing functions of the LIS and is flexible for changes and evolution (bMISAU, 2003). Changing over to DHIS from SISProg represents the strategy of migration since DHIS replicates the business rules, functionality and data elements of SisProg, whilst providing greater flexibility and analysis tools. This strategy helps to avoid disturbance to the MoH through shutting down as may happen in redevelopment. This strategy also helps to use available capacity, requiring lesser training efforts.

Concerning LIS, the general assumption and starting point of the suggested from the literature strategies is that skilled manpower, financial resources, political will and setting and the LIS's source code, system's specification and documentation are available and are aligned. This is not the case for Mozambique due to existence of a multiplicity of challenges hindering the implementation of changes or replacement of LIS: (1) direct influence of the funding institutions and the expert knowledge, advice or consultancy that accompanied the aid, (2) existence of a number of parallel systems and (3) competing initiatives. Additionally, in Mozambique there was no clarity about the planned and expected functionality of the LIS and the administrative system is centralized. Indeed the LIS were designed and developed under top down approaches, thus addressing the central needs and priorities. For example the DHIS was not used by the health authorities, because a formal sanction was not given by the central stakeholders, regardless the recognition of its usefulness.

The work environment of the LIS should be taken into account (Kelly, 1999) when introducing changes as is locked to organizational and individual complexities, which forms the installed base (Braa, 1998) that heavily shape the change. Therefore a cultivation strategy as suggested by the II thinking seems more appropriate to apply in such chaotic setting where the needs are frequently changing and having control of all factors involved is not possible. The cultivation process that the HISP project has pursued in Mozambique included: (1) Developing ETL software which enabled extracting legacy data to an open source software, the DHIS, which is networked and compatible with the old one, and is superior to, representing a more flexible system with additional features and advantages, (2) Setting up an academic program and involving students or researchers interested in topics related to legacy issues like working with both proprietary and open source software, to overcome the challenges related to skills and the technical expertise required and lacking in developing countries and (3) Setting up a collaborative research project and enrolling decision makers from the MoH along with a multidisciplinary team of students, academicians and senior Professors in information systems.

6. CONCLUSION

In this study, the primary concern was about the processes involved in dealing with LIS in the context of developing countries. Specifically, the aim of the paper was to study and analyse the challenges of attempting to change or replace existing LIS within the public health sector in Mozambique. Different standard strategies for replacing LIS were discussed, and appropriate strategies for the health context in Mozambique were analyzed. A key contribution of this study is the emphasis that system design and development should be based on installed base's needs, rather than user's specifications only. The focus is on cultivating the change within a heterogeneous socio-technical network, encompassing humans, technological components and institutions.

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FOOTNOTES

[1] District Health Information Software

[2] Sistema de informação para saúde in Portuguese for health information system.

[3] SisProg - Sistema de Informação Para a Saúde, in Portuguese for health information system.