A Method for Improving Healthcare Management Using Enterprise Ontology

Summary of dissertation for the degree of Master in Information Systems and Computer Engineering

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ABSTRACT

The global healthcare spending has constantly increased in the last decades, and there is data showing inefficiency in resource consumption that is not reflected in healthcare improvement. The need to introduce new ways to do the same at a lower cost is rational. To address this, we propose a method based on Enterprise Ontology to find non value-added transactions that must be redesigned to improve the healthcare management. This methodology was chosen as a basis for our solution because it provides a better understanding of the dynamics of an organization, and allows a good alignment between the enterprise design and operation. Demonstrations were accomplished within National Health System, making it possible to find transactions that can be refined or improved. Evaluation was carried out by means of interviews, the Four Principles from Österle et al., the Moody and Shanks Quality Framework, the framework from Pries-Heje et al., and the feedback from the scientific community. Results prove that the method yields an adequate and clear process view and is reliable when it comes to improving healthcare operational processes.

Keywords

Enterprise Engineering, Operational Processes, Enterprise Ontology (EO), Design and Engineering Methodology for Organizations (DEMO), Continuous Improvement, and National Health System (NHS).

1. INTRODUCTION

In a world of growing business dynamics, high rates of organizational changes and technological breakthroughs, most organizations need to be effectively and continuously redesigned and reengineered in order to achieve strategic and operational success. The inefficiency of processes and the lack of innovation are some of the main reasons for strategic failures, entailing serious consequences for business and its competitiveness (Kotter, 1996; Henriques, Tribolet and Hoogervorst, 2010).

These strong external forces and the need for innovation also challenge the healthcare system. Its organizations need to improve treatments, eliminate non value-added activities, reduce waiting time and expenses, treat more patients, and implement new technological services. Besides these challenges, the healthcare system suffers from operational management problems, and its processes are considered inefficient (Christensen, Grossman and Hwang, 2009; Kaplan and Porter, 2011).

A frightening factor is that its expenditure accounts for 10% of the Gross Domestic Product (GDP) in developed countries, and there is an increasing trend as depicted in Figure 1. Other than that, there is data indicating that service cost and quality are not correlated by showing inefficiency in resource consumption, which is not reflected in improved quality of care. Consequently, quality of life may be affected because of a knock-on effect on the economy, increase in tax rates and insurance contributions, disinvestment in other public services, and increased difficulties to afford healthcare (Walshe and Smith, 2010; Kaplan and Porter, 2011). Hence, this research stems from the assumption that many healthcare processes have become inefficient and unsustainable, which affects the management of the healthcare system.

Although the problem is identified as a need for organization redesign and reengineering, some authors argue that there is not a strong and reliable method to solve this problem (Dietz and Hoogervorst, 2008). It is estimated that over 70% of strategic initiatives such as Total Quality Management, Business Process Reengineering (BPR), and Six Sigma, among others, tend to fail (Mintzberg, 1994; Lifvergren et al., 2010). In this context, three main reasons are addressed: 1) The lack of integration among the various enterprise elements at the design level; 2) The inability to deal with the enterprise dynamics at the opera-

tional level due to weak enterprise construction models; and 3) The need to encourage management practices that advocates the development of self-awareness within the organization (Aveiro, 2009; Henriques, Tribolet and Hoogervorst, 2010).

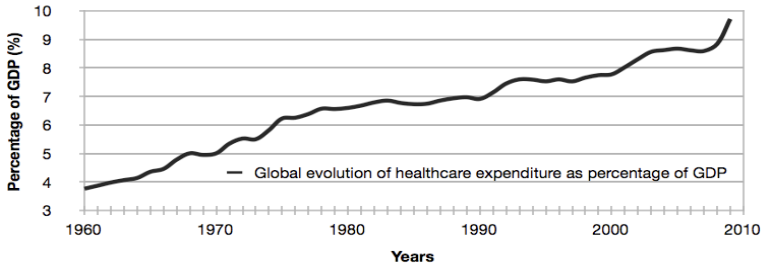

Figure 1. Evolution of the healthcare expenditure as GDP percentage, adapted from (OECD, 2012)

Following this, our research proposes an approach based on the theories of Enterprise Ontology (EO) and the modeling language proposed by DEMO – Design and Engineering Methodology for Organizations. We chose this approach as foundation for our proposal, because it is deemed able to provide a better understanding of an organization's dynamics, has a strong and well-formed theory, allows a good alignment between the enterprise design and operation, and it also enables a unified reengineering strategy (Reijswoud, Mulder and Dietz, 1999; Dietz, 2006). Therefore, we enunciate the following research question that we address in the thesis work: **which is the contribution of EO to improve the National Health System?**

The research was conducted by using the Design Science Research Methodology (DSRM) that aims at creating and evaluating artifacts to solve relevant organizational problems (Henver et al., 2004). The obtained artifact is a method that provides guidance on how to find improvements through a set of steps divided in two phases. In order to demonstrate proposal, we are applying it within medical organizations, such as an Emergency Department (ED), a Primary Healthcare Center (PHC), and a Pharmacy. Besides the possible improvements in each organization, we are also interested in analyzing the interactions between them so that we can conclude how they can improve inter-organizational cooperation.

To evaluate the proposed artifact and its results we used: 1) The framework proposed in (Pries-Heje et al., 2004); 2) Demonstrations of the utility of the method; 3) Interviews with practitioners; 4) The Four Principles of (Österle et al., 2011) to evaluate the artifact; 5) The Moody and Shanks Quality Framework to assess the quality of produced models (Moody and Shanks, 2003); and 6) The feedback from the scientific community through the submission and presentation of papers.

The steps from the DSRM are reflected upon in the sections of this document, which is structured as follows. In Section 1 we just introduced the problem and motivation. Then, a brief overview of the literature is provided (Section 2). Afterwards, we identify the objectives of the solution and describe the proposal (Section 3). Next present the case studies where the proposal was applied as demonstration (Section 4). In Section 5, we describe the evaluation strategy, present its results and the research communication. Finally, we draw some conclusions and unveil the future work (Section 6).

2. RELATED WORK

This section gives a brief overview of the Quality Management (QM) and EO. Other concepts are further described in the dissertation, such as the healthcare management and organization design and engineering (Dias, 2012). The healthcare management is described as a set of principles and practices considered essential to any healthcare management improvement process. Most of those practices are not tied to any methodology, being created and implemented for specific problems and tasks. Consequently, they do not consider an integrated view among the enterprise elements, and there is a lack of vision to deal with the enterprise dynamics due to the inexistent enterprise construction models. However, those practices come from the accumulated experience, can be implemented along with other methodologies, and some of them report good results.

The Organization Design and Engineering is presented as a main subject to describe organizations, understand relationships and dependencies between the enterprise elements, manage its transformation process, deal with their representation, and identify best practices and business patterns. In this context, three main disciplines are presented: Enterprise Architecture, Organizational Engineering, and Business Process Modeling Notations. These disciplines are reported to mitigate some of the previous identified problems, such as the alignment between the business processes with the strategic goals of an organization, the engineering process through the transition to the construction models that can be implemented, and the loss of organization's essence. However, some methodologies for itself do not guarantee the integration among the various enterprise elements at the design level, the ability to deal with self-awareness or the enterprise dynamics, and there is a high failure rate in the BPR (Tribolet, Winter and Caetano, 2005; Gama et al., 2007; Henriques, Tribolet and Hoogervorst, 2010).

2.1 Quality Management

Edwards Deming, one of the main and originator sources in QM, defended that organizations could increase quality and reduce costs by adopting appropriate principles of management. He identified seven constructs as main drivers: visionary leadership, internal and external cooperation, learning, process management, continuous improvement, employee fulfillment, and customer satisfaction (Rungtusanatham et al., 1998). Hence, authors defend that these topics are considered crucial not only to compete and prosper, but also to merely survive against external forces (Kotter, 1996).

One of the methodologies presented in (Dias, 2012) and used with the proposal is Lean, which is considered one of the most used in the management of the healthcare system (Burgess and Radnor, 2010). It is typically grounded in the PDCA Operating Framework, and focus on the waste removal to deliver an improved flow time. The PDCA cycle suggests that all work should be measured and performed to standards, and it is composed by the following steps: 1) Plan: recognize an opportunity and plan a change, its needed steps, and results' prediction; 2) Do: test the change using small-scale studies as trials under controlled conditions; 3) Check or study: changes are tested in small-scale studies to examine its results, and if process improvements were verified, it should be considered the implementation on a broader scale; 4) Act: implement the changes in a broader scale and then repeat the cycle again with a differ plan (Womack and Jones, 2003).

Some of the benefits of the QM and particularly Lean in the healthcare management are the reduction of processing and waiting time, decline in the mortality rate, increase in quality through a reduction of errors, decrease in the service costs and resource expenditure, better warehouse management, and increased employee motivation and customer satisfaction (Fillingham, 2007; García-Porres et al., 2008; Radnor, 2010). On the other hand, some authors point out some drawbacks, such as the high rate of failed implementations, the degradation or mischaracterization of services, and the loss of organization's essence (Burgess and Radnor, 2010).

In addition, the Improvement Quantification is considered another topic related with the QM, which helps to make decisions and prioritize improvements based on the expected return and feasibility. There are different approaches that may help a manager to make informed and just-in-time decisions about improvements. For example, costing models that may help to identify the cost from each activity, allowing for a greater knowledge about its indirect and variable costs. The Time-Driven Activity-Based Costing is an approach based on the identification of resources, allocation to activities, and the calculation of cost rates and time-equations, which we use for demonstration purposes (Kaplan and Anderson, 2007).

2.2 Enterprise Ontology

Enterprise Ontology (EO) is a theory that has its roots in the PSI-Theory (Performance in Social Interaction), and is perceived as a model for describing and understanding the enterprise construction and operation, which is viewed as the "highest level" conceptual model, fully independent of how the enterprise is implemented. It is an enterprise context based concept that is considered the highest conceptual model and helps ensure integrated enterprise. It also guides the transition from ontological models to construction models, which means that it assists in engineering activities (Dietz, 2006; Henriques et al., 2010).

Unlike other methodologies, EO is considered to provide a deep understanding of the dynamics of an organization with a strong and well-formed theory that allows a good alignment between the enterprise design and the enterprise operation. Its particular methodology, DEMO, provides a structured working approach for modeling, (re)designing and (re)engineering of organizations by layering it into three parts, and focusing only on the one that refers directly to the complete knowledge of the enterprise – the *Ontological or Essential Layer*, which is considered to affect the other two layers (*Informational* and *Documental*), as illustrated in Figure 2. Focusing only on the essence conducts to a reduction in the complexity of the obtained diagrams, considered in over 90% (Reijswoud, Mulder and Dietz, 1999; Dietz and Hoogervorst, 2008).

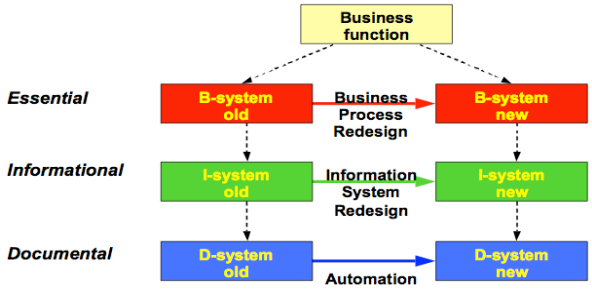

Figure 2. The layered integration of an enterprise and its transformation activities (Reijswoud et al., 1999)

Regarding DEMO methodology, it consists of four interrelated aspect models, represented by particular diagrams, lists and tables, as illustrated in Figure 2. The Construction Model (CM) details the identified transactions types and associated actor roles, as well as the information links between the actor roles and the information banks. The Process Model (PM) specifies the state and transaction spaces, and it is partially based on the information defined on the CM concerning which actor roles perform the *coordination acts*. In addition, PM also contains the causal and conditional relationships between transactions, which determine the possible trajectories between transactions. The State Model (SM) specifies the information banks and the state space of the *production world*: the object classes, the fact types, and the result types, as well as the existential laws that hold. The Action Model (AM) specifies the action rules that serve as guidelines for the actors in dealing with every coordination step, which are grouped according to the distinguished actor roles. The bottom layers from the ontological triangle integrate concepts defined in the upper aspect models, as depicted in Figure 3. For further reading about the EO, DEMO methodology, and the four axioms significant to understand the methodology we refer (Dietz, 2006).

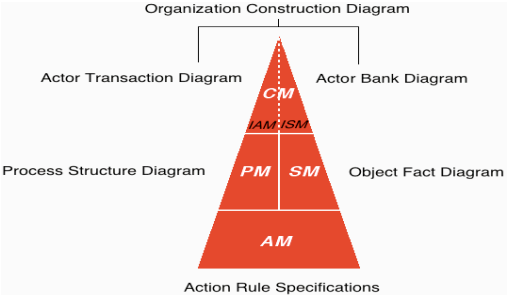

Figure 3. The ontological triangle with aspect models and diagrams of DEMO (Dietz, 2006)

There are some examples in the healthcare system in which EO was applied to study its internal transactions and simplify their analysis. These contributions validated that EO avoids the lack of integration among the various enterprise elements at the design level and produces strong enterprise construction models (Maij et al., 2000; Habing, Dietz and Zwetsloot-Schonk, 2001; Maij et al., 2002). In addition, we can find examples of using EO to improve operational processes (Reijswoud, Mulder and Dietz, 1999) due to its differentiated and structured working approach focused on the essential design of the organization.

3. PROPOSAL

This section corresponds to the *definition of the objectives for the solution*, and the *design and development* steps of DSRM.

3.1 Objectives of the Solution

In order to overcome the problem statement about the inefficiency and unsustainability of the healthcare system, different approaches are identified (Dias, 2012). Nevertheless, some authors still argue that there is not a reliable method to solve these problems. It is estimated that over 70% of strategic initiatives such as Total Quality Management, BPR, and Six Sigma, among others, tend to fail (Mintzberg, 1994; Dietz and Hoogervorst, 2008; Lifvergren et al., 2010). Furthermore, Dietz also adds that the current literature on enterprise engineering consists merely of best practices, without an integrating theory and a clear definition of the field (Dietz, 2006). Inline with that conclusion, *Caetano et al.* demonstrated that when comparing BPMN and DEMO models, there was a set of implicit and missing actions in BPMN, proving that it does not provide means to assess the actual consistency and completeness of a business process, due to the lack of formal semantics and unclear construct description (Caetano, Assis and Tribolet, 2011).

Following this, our research seeks to define an artifact method based on the theories of EO because of the strengths described previously, namely the benefits previously described, the properties of correctness and completeness it assures in its models, and the properties of essentialness and conciseness, which help to construct and analyze (more) models, making it possible to design the healthcare system and seek for inter-organizational cooperation improvements between its units. The improved alignment between the enterprise design and operation leads to an improved self-awareness within healthcare organizations. In addition, EO clearly defines three notions that we considered relevant in governing the enterprise dynamics and to identify improvements in the healthcare system: competence, authority, and responsibility, as explained in the Operation Axiom (Dietz, 2006). Most of these notions are absent or not clear defined in other enterprise modeling techniques (Dietz, 2006; Henriques, 2010).

To take advantage from some already proven benefits from Lean for the QM and Continuous Improvement, particularly in the healthcare system, we intend to combine the analysis from EO with the improvement identification from Lean. This way, the EO may be considered as input for the Plan step of the PDCA Operating Framework, to help with the identification of opportunities. In other words, from DEMO models one may identify improvements (as suggested in the Plan step), and in the end produce and Organization Redesign model that reflects the change plan. To identify improvements one should consider the existing standards on Healthcare Management, BPR, and Improvement Quantification. The following steps from PDCA cycle are out of the thesis' scope, as they need the creation of prototypes and implementation in a broader scale.

In short, our main objective is to **propose a method based on Enterprise Ontology to find non value-added transactions, and redesign them to improve the healthcare management**. Other goals are to demonstrate, evaluate and communicate the artifact, to show its efficiency and efficacy. To do that are applying the proposal to different units of the NHS, such as the ED, Pharmacy, and PHC, since they can be considered representative of the healthcare system in terms of actors, stakeholders, roles, processes, and they share a large part of the problems identified in (Dias, 2012). Besides the possible improvements in each healthcare unit, we are also interested in analyzing the interactions between them so that we can conclude how they can improve cooperation, as part of the demonstration.

3.2 Proposed Artifact Method

This section belongs to the *design and development* step of DSRM, in which we present a *different* artifact (Österle et al., 2011) to identify innovations to improve the healthcare management. It considers the contributions from EO (Dietz, 2006), some additional steps from Lean (García-Porres et al., 2008), and also some concepts from healthcare management and BPR described in (Dias, 2012) as input for the improvement identification as Lean suggests (Womack and Jones, 2003).

The proposal starts with the **Modeling Phase,** which uses EO to study the organization and its processes. To construct its diagrams, it consists of a defined sequence of steps (illustrated in Figure 4) that begins with a textual or process representation of an organization, and ends with an aspect model. The sequence of steps is described in (Dias, 2012). As result, this phase provides a structured working approach by layering the organization into three parts, and focusing only on the one that directly refers to the complete knowledge of the organization and independent of the implementation – the *Ontological Layer*. In this research we focus on the Construction, Process and State Models, which include the Actor Transaction Diagram (ATD), Process Structure Diagram (PSD), and Object Fact Diagram (OFD).

Then it continues with the **Innovation Phase**, which is based on four additional steps from Lean to assist in the Continuous Improvement and the QM process. These steps consist on the Plan step of the Lean PDCA Operating Framework that recognizes an opportunity and plans the change. Therefore, this phase identifies possible improvements from the previous models, prioritizes them in terms of impact and feasibility, and then proposes redesigned models for the organization. As result, this phase gives the appropriate tackle to handle the transformation process, and helps to choose the most profitable improvements first. Figure 4 illustrates the proposal including its inputs and outputs, and subsequently we describe its steps.

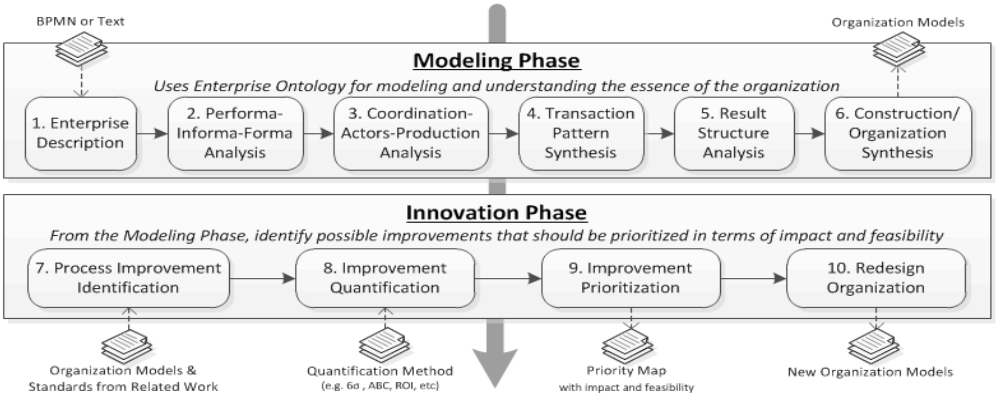

Figure 4. Graphical representation of the proposed method (DSRM artifact)

The Modeling Phase starts by analyzing the Enterprise Description to look for *ontological actions* (or *performa* abilities). This leads to a reduction of the complexity relatively to other methodologies since the *infological* and *datalogical* actions are excluded. Afterwards, the Coordination-Actor-Production Analysis identifies the coordination and production acts. Then, in the Transaction Patter Synthesis the coordination and production acts are clustered into transaction types together with the corresponding results, and dependencies between the transaction types are identified during the Result Structure Analysis.

Finally, in the Construction Synthesis, the initiator and executor roles of each transaction type are identified, and graphical representations are developed. The previous steps apply the four axioms described in (Dietz, 2006).

The first step from the Innovation Phase is the Process Improvement Identification, which identifies improvements from the organization models obtained in the Modeling Phase, considering the contributions and standards from the related work. Considering the ATD, one can identify transactions that do not seem essential and may be removed, changed, or automated. These transactions may be identified with the help of practitioners or literature. Then, using the PSD, one can change the network of communicative commitments to shorten processes, change precedencies, or move conditional relationships, which leads to shorten cycle (and waiting) times. Finally, using the OFD it is possible to make improvements to the information architecture. This step is based on (Reijswoud, Mulder and Dietz, 1999; Dietz and Hoogervorst, 2008).

Afterwards, the improvements are quantified using some metrics that must be established in terms of feasibility and impact. Some common metrics are the time invested in each transaction compared to the total time spent on the whole service, people involved, management frameworks, associated defect, or other analytical methods (e.g. costing models, financial analysis, etc.). The chosen theory or method is not part of this thesis' scope (one can choose the most suitable).

Then, the improvements are prioritized in terms of impact and feasibility, which helps to choose the most profitable improvements for the available resources. This is then represented in a map divided into four quadrants, being the X-axis the feasibility to accomplish it, and the Y-axis the quantified impact. Each improvement is placed in a particular quadrant, being the ones that fit into the superior diagonal the ones that are more important to implement (with higher impact and feasibility).

After choosing the most profitable improvements, the organization is redesigned to include the decisions. Alternatively, one can deepen some analysis by including more information in the Enterprise Description, or producing other aspect models from DEMO. Having the redesigned organization models with the results from the Innovation Phase, it should be prepared a proposal with specific implementation strategies (i.e. the plan with the needed steps). Afterwards, one should continue with the next steps from the PDCA cycle (Do, Check and Act) to implement the planned changes, beyond this thesis' scope.

To sum up, this method replaces the analysis from Lean by a Modeling Phase based on EO, incorporating its contributions to achieve models considered formally correct, easier to analyze, and enabling a unified reengineering strategy (Dietz, 2006).

4. DEMONSTRATION

This section corresponds to the *demonstration* phase of DSRM. To demonstrate the proposal we applied it to healthcare units including a hospital ED, a Pharmacy, and a PHC. We chose these case applications since they share the responsibility for the growing problem identified in Section 1. In this section we present the first demonstration at the ED and a summary with the main conclusions and the NHS redesign based on the overall results. To conduct these demonstrations we interviewed different practitioners, namely to obtain input to apply the proposal (enterprise descriptions), feedback about the obtained outputs (models and improvements), and validation on the proposal and its results. This information was collected through field visits on location at each participating organization as well as through follow-up phone and e-mail.

4.1 Emergency Department

For this demonstration we applied the method to the internal operation of an ED in a central hospital near Lisbon with more than 100,000 admissions per year. To conduct the demonstration, we interviewed 5 patients and 10 practitioners (including the ED director, physicians, nurses, and health services researchers). Next we describe the application of the proposal. Due to space limitations, we only present the most relevant steps of the method. The full application is demonstrated in (Dias, 2012).

Modeling Phase

From the enterprise description we follow the steps of the proposal. The results are presented below in the ATD from Figure 5. In this diagram, a transaction is represented using a diamond in a disk. Each transaction connects two boxes, representing the initiator and the executor actor roles. The initiator is connected to the transaction symbol using a solid line, while the executor is connected to the transaction using a solid line ending in a black square. The grey boxes refer to composite actor roles, i.e. elements whose exact structure is not known. All the environmental elements, i.e. elements outside the organization that we are studying, are represented with grey boxes for that reason. This also means that we can represent the studied organization with a grey box when referring to the kernel of the organization, which can be further specified by using elementary actor roles represented by white boxes.

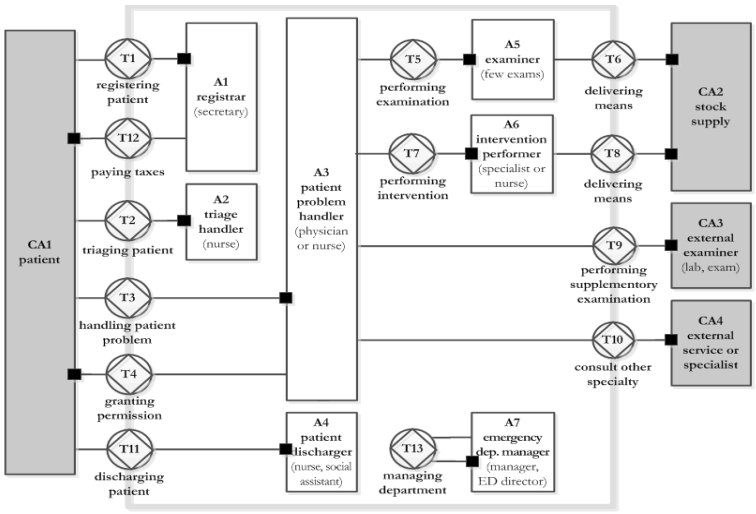

Figure 5. ATD of the ED

As depicted in the ATD, new patients are registered to the hospital (T1); then they go through a triage process (T2); after that, patients' problems are handled (T3); and finally, they are discharged (T11). These four transactions are initiated by an external actor, the *patient.* They are respectively requested to the *registrar*, *triage handler*, *patient problem handler*, and *patient discharger* that execute them. The handling of the patients' problems may lead to the following actions: performing some urgent internal examinations (T5); performing medical interventions (T7); performing supplementary examinations (T9); and consulting another external specialty (T10). Since these tasks have different responsibilities, four different actors are discerned: *examiner, intervention performer, external examiner,* and *external service or specialist.* The first two are internal actors, used for urgent examinations and interventions (i.e. specific interventions may need specialists, such as a surgery or a psychiatry episode). The last two are used for non-urgent situations, such as some extended interventions or supplementary examinations. In addition, there are two transactions concerning the delivery of means (T6 and T8), a transaction concerning the patients' permission (T4), a transaction concerning the management of the ED, and finally the payment transaction (T12).

To finish the Modeling Phase, we may also create Process and State Models, as demonstrated in (Dias, 2012). After completing the Modeling Phase we are able to continue to the Innovation Phase, which will propose and prioritize improvements, and redesign the ED.

Innovation Phase

After some analysis from the ATD, it is possible to conclude that transaction T1 can be removed or automated as the patient can register during the triage in transaction T2, or using a computer terminal with a standardized electronic form. This corresponds to the improvements A and B from Table 1, and they are inline with the carried interviews and the related work in (Dias, 2012). In other words, a common and shared registration is viewed as being vital to individual and population health, avoiding paperwork. This strategy is claimed to mainly improve waiting time and resource expenditure.

With the PSD (obtained from the ATD), one can conclude that it is not efficient having to go through several iterations and actors to be forwarded to another external service, such as a specialist or examiner in transaction T10. For example, regarding a low-acute episode, instead of being forwarded immediately after triage, patients need to be admitted (T1), triaged (T2), and seen by a physician (T3) to be then forwarded to another specialty outside the ED (e.g. specialized consultation, pharmacy or PHC). This leads to unnecessary consumption of resources, higher waste of time, and the patient leaves without being treated in the ED. There is some related work suggesting strategies of *Fast-Tracking* (improvement C) and *Provided Directed Queuing* (improvement D) to anticipate the resolution of some patients' problems. These strategies are claimed to improve waiting time, customer satisfaction, length of stay, and resource expenditure (Medeiros and et al., 2008).

Other improvements could be concluded from the previous models or from the State Model as we have demonstrated in previous publications (Dias et al., 2012; Dias, 2012). In these publications we concluded some improvements concerning the information quality and information exchange. Furthermore, we could also deepen in details about the execution of transactions in the PSD, or analyzing the *infological* or *datalogical* transactions (Dietz, 2006).

In Table 1 we quantify the improvements in which we want to work at. To infer the level of impact, for a demonstration purpose, we consider that the elimination of a transaction has a higher impact than a precedence change. Avoiding a transaction conducts to the same classification as its elimination or automation. Avoiding an actor has even higher impact as it eliminates the transaction and reduces costs with human and physical resources. Finally, to assess the feasibility we considered that more changes leads to lower feasibility (i.e. hardware, software or people involved). The presented values were obtained with the help of the interviewed practitioners for this demonstration purpose. As described in the proposal and related work, we could choose a more formal and robust method to quantify the improvements.

#	Improvement	Impact	Feasibility	Impact description	Feasibility description
A	Patient registers in the triage	4	2	Avoid transaction T1 and transfer responsibility to A2	Triage should be fast
B	Automation in the register of patients	5	4	Avoid transaction T1 and the actor A1	Terminal requires new hardware and software
C	*Provided Directed Queuing*	5	5	May eliminate transaction executions and reduce flow	Reallocate only one physician
D	*Fast-Tracking* System	4	3	May eliminate transaction executions and reduce flow	Reallocate physician and a new space
E	Gatekeeping to separate roles	5	3	Improve resource usage, reduce flow and expenses	Improve PHC and there should be a cultural shift
Caption: The range of impact and feasibility is classified from 1 to 5 for demonstration's purpose.					

Table 1. Profile of the exchanged information (with the Information Use Table adapted)

The **improvement prioritization**, illustrated in the priority map from Figure 7, addresses the impact and feasibility levels from the previous step: D shows large impact and feasibility, followed by B and C.

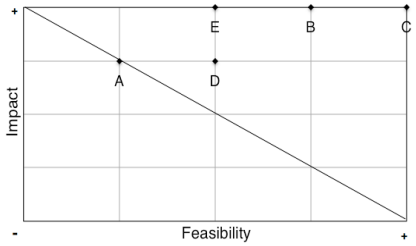

Figure 7. Priority map of the ED

Finally, the last step corresponds to the **redesign of organization**, in which we choose the most profitable improvements to produce improved aspect models. We present the resulting model in Appendix, together with the innovations identified in the demonstrations from the other demonstrations in (Dias, 2012).

4.3 Healthcare Redesign

By analyzing the improvements from the three demonstrations altogether, we also may find that it is possible to improve their cooperation since we found some overlapped transactions, illustrated in Table 2.

ED Transaction	Pharmacy Transaction	PHC Transactions
T1 – Registering Patient	T1 – Creating Profile	T1 – Register Patient
T3 – Handling Patient	T9 – Medical Consultation T2 – Filing Prescription	T5 – Emergency Consultation T10 – Filing Prescription
T5 – Performing Examination	T3 – Performing Examination	T6 – Performing Examination
T7 – Performing Intervention		T8 – Performing Intervention
T10 – Consult Other Specialty		T11 – Consult Other Specialty

Table 2. Overlapped transactions between ED, Pharmacy and PHC

From the previous table, one may identify that a patient has to register and create healthcare records in every healthcare organizations, consuming much time, replicating resources and repeating information. Other than that, we may find an overlap of responsibilities between healthcare units when it comes to handle a patient, as different professionals and organizations handle the same healthcare issues. And other improvements are identified in (Dias, 2012), which lead to the Construction Model presented in Appendix.

5. EVALUATION

This section explains how we proceeded in the *evaluation step* of DSRM. With this assessment we intend to demonstrate that the proposal addresses the research problem.

5.1 Evaluation Strategy

To evaluate the proposal, we used the framework proposed in (Pries-Heje et al., 2004), which aims to help researchers to build strategies for evaluating the outcome of a DSRM. This framework identifies **what is actually evaluated**, **when the evaluation takes place**, and **how it is evaluated**. To answer the third question, we based on different authors to propose a strategy with steps outlined to evaluate a DSRM artifact method. The evaluation strategy entails the following steps.

1. Constructing scenarios to **demonstrate the artifact**, and how to use it to solve the research problem. This is considered a way to validate an artifact of type method (Henver et al., 2004).
2. Gathering **feedback through interviews with practitioners**, regarding the artifact, ability to follow its steps, and potential to obtain relevant results;
3. The **Moody and Shanks Quality Management Framework** (Moody and Shanks, 2003) to assess the quality of the DEMO models produced in the demonstration phase, and their ability to handle the proposed problem and research question;
4. Evaluating the DSRM artifact using the **four principles proposed in (Österle et al., 2011)**;
5. **Appraisal of the scientific community** through the submission and presentation of papers.

This evaluation method follows the **design evaluation guideline within DSRM** (Henver et al., 2004). In this research we have mainly used the *descriptive* evaluation method to assess the artifact, which uses relevant research to build a convincing argument for the artifact's utility, and constructs detailed scenarios around the artifact to demonstrate the utility. Other than that, we partially used the *observational* evaluation, in which the artifact is studied in depth in a business environment (i.e. a case study in a given environment). Nevertheless, the observational and analytical methods could be further detailed, but this would involve introducing observable metrics, conducting socio-technical experiments, and selecting modeling tasks that would allow such measurement (Henver et al., 2004; Caetano, 2008). Such evaluation is beyond the scope of this thesis.

5.2 Evaluation Results

To evaluate the research we start by using the framework proposed in (Pries-Heje et al., 2004) formulated as follows:

- **What was actually evaluated?** The evaluated artifact was the method described in Section 3, which is considered a DSRM artifact method. This evaluation represents an *artifact design process*, since it is defined as a set of activities, methods and practices that can be used to guide a procedure workflow to improve the healthcare management;
- **When was it evaluated?** It was evaluated after the artifact construction, and after the demonstration. Therefore, the evaluation strategy is *ex post*, since it was performed after the design artifact development;
- **How is it evaluated?** To evaluate the artifact and its results (or suitability for solving the problem) we used the steps previously described, which are applied below. This represents a *naturalistic* evaluation since it is conducted using a real artifact in a real organization facing real problems as a case of study.

The **demonstration** reveled that: A) The proposal is generic enough to be applied in different healthcare organizations; B) It is a formal method, with a list of specific steps to follow; C) From a given enterprise description anyone can achieve similar enterprise models, as Dietz suggests (Dietz, 2006); D) From the obtained models it is possible to find non value-added transactions and from them suggest and prioritize improvements; and F) It is possible to obtain a redesigned organization. In other words, it was possible to demonstrate the artifact's utility, and how to use it to solve the research problem.

The **feedback from interviews** was rather positive: 1) They validated the importance of the research problem and the motivations behind the proposal; 2) They understood and agreed with the obtained models (after explaining them), which were considered to properly depict the studied organizations; 3) Improvements were discussed and the interviewees agreed that the ones we identified were sometimes similar to those suggested by them; 4) Practitioners concluded that the proposal could be applied effectively and efficiently to solve the research problem, regardless of whom applies it. Overall, practitioners showed a good acceptance and enthusiasm for this innovative approach.

From the **Moody and Shanks Quality Framework**, almost all quality factors were accomplished. Only *understandability* was partially, and *implementability* was not. The first factor as practitioners find models difficult to interpret needing an adaptation period. The second one as models are implementation independent (describing only the essence of organizations).

The **Four Principles from (Österle et al., 2011)** were also accomplished. 1) Abstraction: the artifact can be applied to any healthcare service from a given enterprise description; 2) Originality: the proposed artifact is not present in the body of knowledge of the domain since it was designed by relating different subjects, such as healthcare management, BPR, EO and Lean; 3) Justification: the artifact is supported by the related work, described by textual and graphical representations, and it was justified and validated in different ways; 4) Benefit: the artifact provides a structured working approach for reengineering, it leads to differentiated and well-grounded improvements, and provides a better understanding of the dynamics of an organization, among other benefits when compared to existing methodologies.

Finally, the **appraisal of the scientific community** was also accomplished with three full papers already accepted in international conferences. The first paper was validated for a conference in the medical informatics field with practitioners related to the healthcare industry (Dias, Lapão and Mira da Silva, 2012). The second one was validated for a top ranked conference according to (ERA Ranking, 2010) in the information systems field (Dias et al., 2012). The third one was validated for the special session on EO (Dias, Mendes and Mira da Silva, 2012).

6. CONCLUSION

This research addresses healthcare management problems, in which its processes have become inefficient and unsustainable. To overcome these problems, this research proposes a method based on EO to find non value-added transactions, and redesign them to improve the healthcare management.

We chose the EO as foundation for our proposal as it is deemed able to provide a better understanding of the dynamics of an organization, allows a good alignment between the enterprise design and operation, and enables a structured reengineering strategy. Furthermore, since its models are regarded coherent, comprehensive, consistent, concise and essential, it gives strength to the obtained models. On the other that, with the addition of Lean, we intended to take advantage from the proven benefits of Lean particularly in the healthcare industry, for the Quality Management and the Continuous Improvement, therefore considering the combination of EO with the PDCA cycle to identify, plan and quantify improvements.

The evaluation showed that the proposal is generic enough to be applied in different healthcare units, and that it is possible to identify improvements and redesign organizations. Overall, the obtained evaluation was positive, and practitioners showed a good acceptance and enthusiasm for this approach, concluding that the obtained models helped to frame discussions while ensuring the consistence and coherence of the improvements found.

Some of the main contributions of this research are: A) The proposal to improve the healthcare management, which differs from the current state-of-the-art approaches; B) Its attempt to solve the problem statement by relating different topics, such as Healthcare Management, BPR, EO, and some additional steps from Lean; C) Its practical demonstrations using three different organizations as case studies; D) The improved inter-organizational cooperation and self-awareness obtained from the redesigned models; E) The evaluation using different methodologies and interviews with experienced practitioners; and F) The communication to relevant audiences with three scientific papers accepted in international conferences, which shows an active interest in this research.

Despite the strong points presented before, the evaluation also identified some limitations. The first one, beyond the scope of this thesis, is the implementation in practice of the obtained improvements in the national health system. Moreover, it was not possible to completely (and quantitatively) demonstrate the improvement quantification, as this information was unavailable in the analyzed organizations. Finally, two limitations were identified in EO: the understandability and implementability of its models, as practitioners find the models difficult to interpret needing an adaptation period, and since models are implementation independent (describing only the essence of organizations).

Nevertheless, it is expected that healthcare organizations may use some of the described advantages of the proposal to address problems of inefficiency and unsustainability in the healthcare system. Furthermore, this research can also be a contribution towards helping healthcare professionals to validate processes and improve their way of working, even if it is used together with other existent methods. Finally, we believe that the proposal may be successfully applied in other fields different than the healthcare, since EO is applicable to any organization from a given enterprise description, and the second phase with Lean is only dependent from the produced models.

As future work, further research is being performed to better quantify the impact and feasibility of the proposed improvements during the demonstration, namely by including costing models to the obtained DEMO diagrams. Furthermore, the proposal should be expanded to consider the remaining application of Lean PDCA cycle and other EO models. Finally, we still can apply the proposal to other healthcare services, namely the six different process missions identified in (Vasconcelos et al., 2005), thus combining the research approach initiated in *Hospitais Universitários de Coimbra*.

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APPENDIX – REDESIGNED NHS