Using Enterprise Ontology for Improving the National Health System
Demonstrated in the Case of a Pharmacy and an Emergency Department

David Dias, Carlos Mendes and Miguel Mira da Silva
Instituto Superior Técnico, Technical University of Lisbon, Avenida Rovisco Pais, Lisboa, Portugal

Keywords: Enterprise Ontology (EO), Enterprise Reengineering, Operational Processes, Design Engineering Methodology for Organizations (DEMO), Emergency Department (ED), Pharmacy.

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 thing at a lower cost is rational. To address this, we propose a method based on Design Engineering Methodology for Organizations (DEMO) to find non value-added transactions that must be redesigned to simplify processes. 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. A demonstration was accomplished within an Emergency Medical Service and a Pharmacy, making it possible to find transactions that can be improved or automated. Evaluation was carried out by means of interviews, the Four Principles from *Österle et al.*, and the Moody and Shanks Quality Framework. Results prove that the method yields an adequate and clear process view and is reliable when it comes to improving healthcare operational processes.

1 INTRODUCTION

In a world of growing business dynamics, high rates of technological advances and organizational changes, 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 the main reasons for strategic failures, entailing serious consequences for business (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 problems of operational management, and its processes are considered inefficient (Christensen, Grossman and Hwang, 2009) (Kaplan and Porter, 2011).

A frightening factor is that not only its expenditure accounts for 10% of the Gross Domestic Product (GDP) in developed countries, but there is also an increasing trend, as depicted in Figure 1. Other than that, there is data indicating that cost and quality are not correlated, and showing inefficiency in resource consumption, which is not reflected in improved quality of care. Consequently, the 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 services (Kaplan and Porter, 2011) (Walshe and Smith, 2010). Hence, this research stems from the assumption that many healthcare processes have become inefficient and unsustainable, which affects the management of the healthcare system.

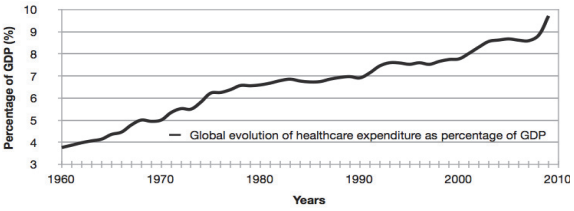

Figure 1: Global evolution of healthcare expenditure – adapted from OECD Website (OECD, 2012).

Although the problem is identified as a need for redesign and reengineering, some authors argue that there is no strong and reliable method to solve this

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problem (Dietz and Hoogervorst, 2008). It is estimated that over 70% of strategic initiatives such as Total Quality Management, Business Process Reengineering, and Six Sigma, among others, tend to fail (Mintzberg, 1994) (Lifvergren and et al., 2010). In this context, we addressed three main reasons for this: 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 operational level due to weak enterprise construction models; and 3) The need to change management that advocates the development of self-awareness within the organization (Dias, Lapão and Silva, 2012) (Dias et al., 2012) (Henriques, Tribolet and Hoogervorst, 2010).

Following this, our research proposes an approach based on the theories of Enterprise Ontology (EO) and the corresponding methodology – Design and Engineering Methodology for Organizations (DEMO). We chose this approach as a foundation for our proposal, because it is considered 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 (Dietz, 2006) (Reijswoud, Mulder and Dietz, 1999). Therefore, we enunciate the research problem as: **Using EO to propose improvements in the healthcare system**.

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

To evaluate the proposed artifact we used: 1) The framework proposed in (Pries-Heje, Baskerville and Venable, 2004), 2) Demonstrations of the utility of the method; 3) Interviews with practitioners; 3) The Four Principles from (Österle et al., 2011) to evaluate the artifact; and 4) The Moody and Shanks Quality Management Framework (Moody and Shanks, 2003) to evaluate the produced models.

The steps from the DSRM are reflected upon in the sections of this paper, which is structured as follows. In Section 1 we just introduced our 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 to redesign the healthcare processes (Section 3). Next we present case studies where the proposal was applied as demonstration (Section 4). In Section 5, we describe the evaluation strategy and discuss the results of applying the proposal. Finally, we draw some conclusions in Section 6.

2 RELATED WORK

This section gives a brief overview of the Quality Management (QM) and EO Sections 2.1 and 2.2.

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). In response to the need of QM and continuous improvement, different methodologies and strategies appeared, such as Organization Design and Engineering methodologies, Lean, Six Sigma, Total Quality Management, among others (Mintzberg, 1994) (Lifvergren and et al., 2010).

Lean 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, J; et al., 2008) (Radnor, 2010). On the other hand, some authors point out some drawbacks, such as the high rate of failed implementations, the mischaracterization or degradation of services, and the loss of organization's essence (Burgess and Radnor, 2010).

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 (Kaplan and Porter, 2011).

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 at the level of human interactions, allowing a better understanding of the operation. Dietz brings a complementary view of the EO, in which ontology 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, Tribolet and Hoogervorst, 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 (Henriques, Tribolet and Hoogervorst, 2010).

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).

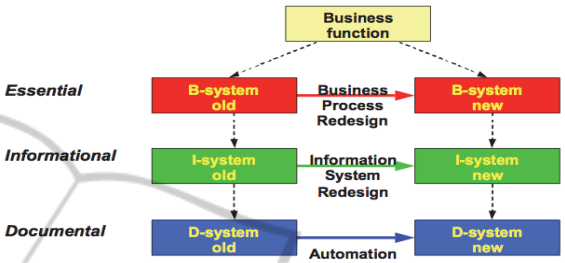

Figure 2: The layered integration of an enterprise and its transformation activities (Reijswoud et al., 1999).

Regarding DEMO methodology, it consists of four interrelated aspect models, represented by particular diagrams, lists and tables, as illustrated in Figure 3. 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).

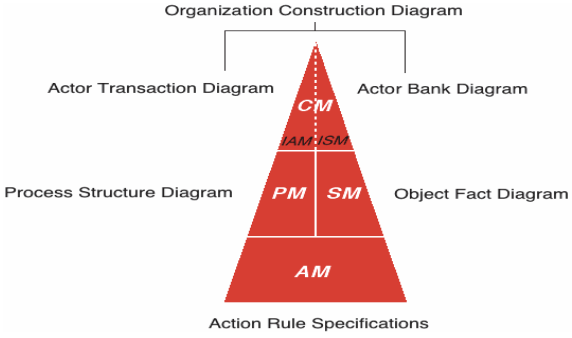

Figure 3: The ontological triangle with aspect models and diagrams of DEMO (Dietz, 2006).

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 and et al., 2000) (Habing and et al., 2001) (Maij and 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. 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, business process reengineering (BPR), and Six Sigma, among others, tend to fail (Mintzberg, 1994) (Dietz and Hoogervorst, 2008) (Lifvergren and 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, Tribolet and Hoogervorst, 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 EO 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 healthcare system. 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, J; et al., 2008).

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 previous publications (Mendes, Ferreira and Silva, 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 and Process Models, which include the Actor Transaction Diagram (ATD) and Process Structure Diagram (PSD).

The proposal 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.

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. 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

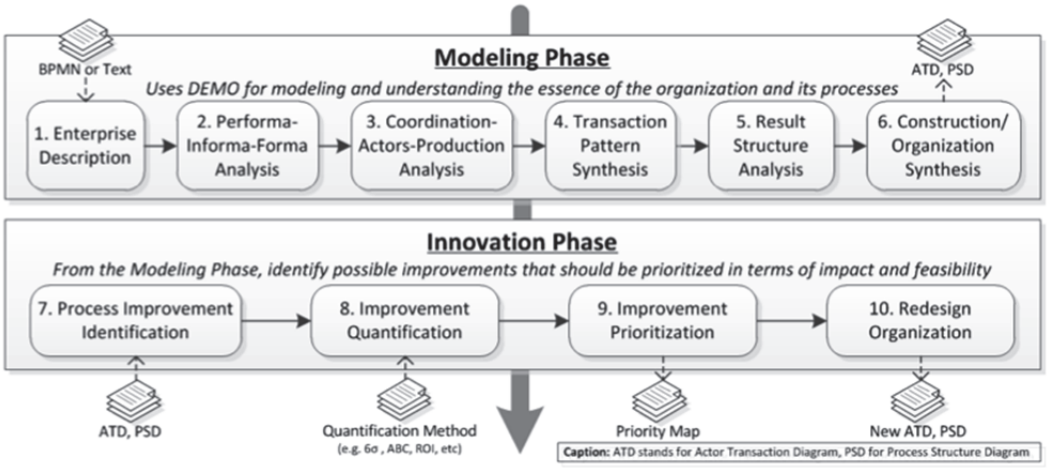

Figure 4: Graphical representation of the proposed method.

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* step of DSRM. In the following sections we apply the proposed method to an ED and to a Pharmacy. We do not fully apply the six steps of the modeling phase due to space limitation. Nevertheless, these steps are demonstrated in previous publications (Mendes, Ferreira and Silva, 2011) (Mendes, Ferreira and Silva, 2012).

In this demonstration we will focus more on the demonstration at the Pharmacy and its possible improvements to increase cooperation with the ED.

4.1 Emergency Department

To demonstrate the method, we applied it to the internal operation of an ED in a hospital near Lisbon with more than 100,000 admissions per year, expecting that by eliminating wasteful transactions, it would be possible to improve processes without compromising the organization. To conduct the demonstration, we interviewed 5 patients and 10 practitioners (the ED director, physicians and nurses, and health services researchers), namely to obtain the enterprise description.

From the enterprise description and after the first two analyses from the proposed method, we defined the transactions by clustering the identified *acts* and *facts* in what is denominated by *Transaction Pattern Synthesis*. The results are presented below in the ATD (Figure 5), according to the Transaction Axiom from EO (Dietz, 2006).

In the ATD, a transaction is represented using a diamond in a disk. Each transaction is connected to two boxes, representing the initiator and 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

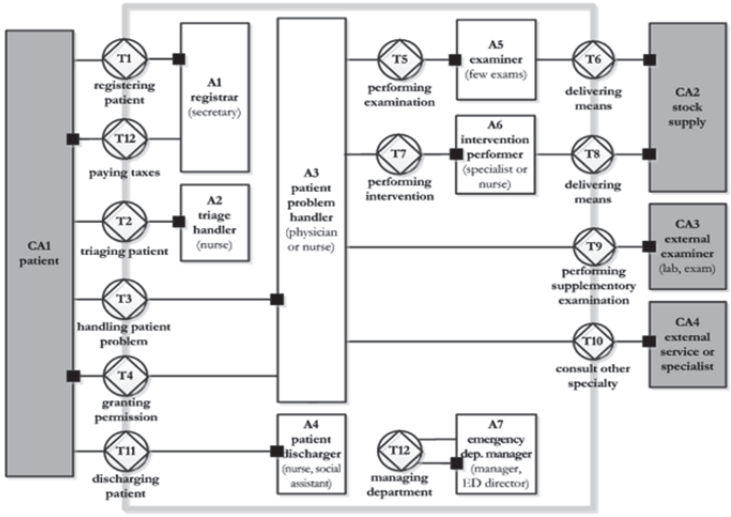

Figure 5: Actor Transaction Diagram (ATD) of the Emergency Department.

Table 1: Improvements identification in the ED with its corresponding impact and feasibility (from 1 to 5).

#	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 actor A1	Computer 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-Track System*	4	4	May eliminate transaction executions and reduce flow	Reallocate physician and a new space

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.

As depicted in this model, 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), and finally the payment transaction (T12).

In the **Innovation Phase**, one must identify process improvements from the obtained diagrams. First, after some analysis from the ATD, one may conclude that transaction T1 can be removed (improvement A from Table 1), since the patient can register during the triage (T2), or at least it is possible to automate T1 through a computer terminal with a standardized electronic form (improvement B). In fact, the secretary performs non-value added tasks, and consequently this actor could be allocated to other activities.

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 (specialist or examiner in T10). For example, instead of being forwarded immediately after triage, patients need to be admitted (T1), triaged (T2), and seen by a physician (T3) to be finally forwarded to another specialty outside the ED. 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).

In Table 1 we quantify the improvements in which we want to work at. To infer the level of impact, 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, because it eliminates the transaction and reduces the costs with human and physical resources. Finally, to assess the feasibility we considered that more changes to the service 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.

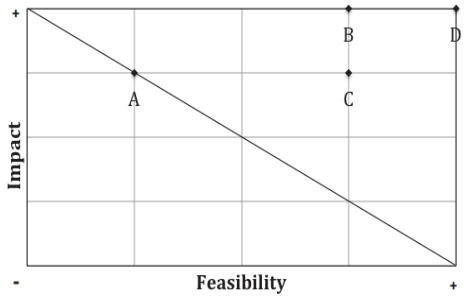

Figure 6: Priority Map of the Emergency Department.

The priority map (Figure 6) addresses the impact and feasibility levels from the last step: D shows large impact and feasibility, followed by B and C.

We could apply a more formal method for the improvement quantification, but this would not change the method itself.

4.2 Pharmacy

Similarly to the previous experiment, we interviewed 6 practitioners (the pharmacy director, pharmacists, technicians, and some researchers), to obtain the enterprise description and validate the obtained results. These interviews included 50% of the practitioners from the studied pharmacy, and 2 external and independent practitioners.

In Figure 7 we present the ATD. As depicted in this mode, patients may choose to create a profile in the pharmacy (T1), fill a prescription for a medicine (T2), get advice about medication or health-related issues (T7), and attend to a consultation with a specialist (T8). These transactions are initiated by an external actor, the *patient*. They are respectively requested to the *registrar* and the *patient handler* (composite actor role) that execute them.

The handling of patients may in turn lead to the following transactions: performing examinations that can go from a simple diagnostic to laboratory analysis (T3), checking medicine interactions (T4), dispensing or preparing medicines (T5) and processing the claim to check for reimbursements (T6). Since these actions have different responsibilities, four different actors roles are discerned: *examiner*, *verifier*, *dispenser*, and *insurance company* (external actor role). After handling patients, they have to pay for the medicines or the provided services (T9).

In addition, there are transactions concerning the pharmacy management (T10), the inventory control (T11), the medicine supply (T12), and their payment (T13). Three action roles are discerned: *pharmacy manager*, *inventory controller*, and *supplier*. Finally, it is possible to schedule some kinds of medical appointments in the pharmacy with paramedics or other healthcare professionals. This corresponds to the transaction T8 executed by the *patient handler*.

In the **Innovation Phase** we identified four main improvements. First, the transaction T11 can be automated (improvement A from Table 2), since the inventory control process requires more human intervention, but does not consider demand forecasting due to the lack of decision support systems. In addition, there is a need to verify the arrival of products manually to check their prices,

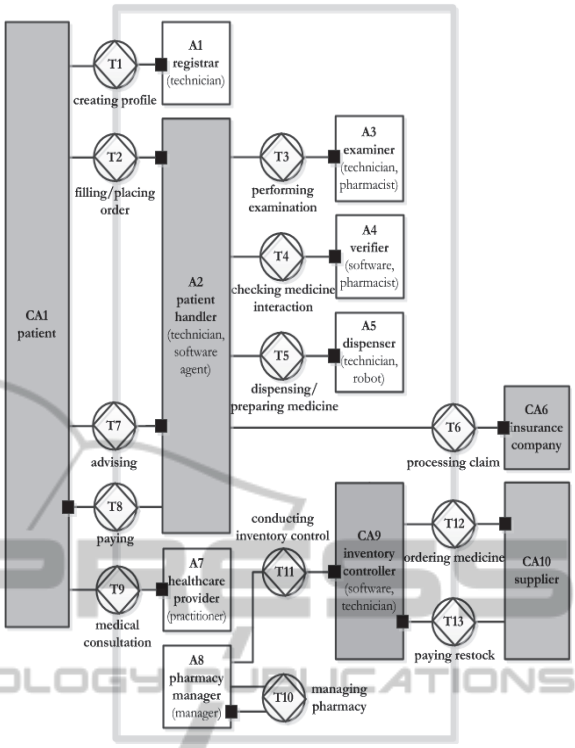

Figure 7: Actor Transaction Diagram (ATD) of the Pharmacy.

quantities and expiration dates.

The second main improvement (improvement B) is the automation of transaction T5 to use a robot instead of a human to dispense or prepare medicines. Despite being a well-known and documented improvement, our analysis revealed that this was a bottleneck with great impact in the number of employees and service time. Without a robot, a pharmacy needs more employees available and there is a higher waiting-time to get medicine. They also help in the storage of the ordered medicines, and help identifying drugs that are almost expiring (without any human intervention), which reduces the waste of products.

The third improvement (improvement C) is the overlapping of responsibilities between hospitals and pharmacies in T2, T3 and T8. In spite of pharmacists' skills, patients need to seek a physician or a hospital to have a prescription, even for recurring or vulgar situations, such as an antibiotic. In addition, there are other legal restrictions hampering the existence of medical consultations or specialties in the pharmacies. This overlapping and the need to resort to hospitals are considered to increase the cost of the national healthcare system (Walshe et al., 2010).

The last improvement (improvement D) is the

Table 2: Improvements identification with its corresponding impact and feasibility (from 1 to 5).

#	Improvement	Impact	Feasibility	Impact description	Feasibility description
A	Automation in the inventory control	3	4	Reduce waste of time, avoid errors in inventory control	Improve Supply Chain Management software
B	Automation in medicine preparation or dispense	4	3	Avoid human intervention, reduce waste of time	New hardware (robot) and software
C	Avoid overlapping of responsibilities	5	4	Avoid duplication/overlap of transactions, reduce spending	Need to change rules, change resistance
D	Eliminate profile creation (unified patient records)	5	4	May eliminate transactions and reduce flow	Change legal restrictions, change resistance

elimination of the transaction T1, since there should be a unified Patient Healthcare Record for all healthcare organizations, to avoid duplication of information, improve access to information, and avoid wasting time creating profiles in different healthcare organizations (Dias et al., 2012).

In Table 2 we quantify the improvements in which we want to work. To infer the level of impact, we consider the same assumptions described in Section 4.1. The priority map (Figure 8) shows that improvements C and D have a larger impact and feasibility, followed by B and A. Again we could apply a formal method for the quantification, but this would not change the method itself.

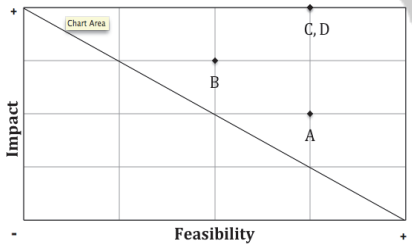

Figure 8: Priority Map of the Pharmacy.

To sum up, **we may conclude** that there is room for improvements in the ED and the Pharmacy. Analyzing those results together we also may find that it is possible to improve their cooperation since we find some overlapped transactions (Table 3).

Table 3: Overlapped transactions between ED and Pharmacy.

ED Transactions	Pharmacy Transactions
T1 – Register Patient	T1 – Creating Profile
T3 – Handling Patient	T2 – Filling prescription
T3 – Handling Patient	T9 – Medical Consultation
T5 – Performing Examin.	T3 – Performing Examin.
T6, T8, T12 – Management and stock supply transactions	T10 to T12 – Management and stock supply transactions

From the previous table we may find that both organizations would benefit from having a unified Patient Healthcare Record to avoid the creation of new registers. In both organizations their professionals have studies and skills to prescribe medications, but only physicians may do it due to legal reasons in Portugal, and both organizations share some exams and medical specialties.

5 EVALUATION

This section corresponds to the *evaluation* step of DSRM.

To evaluate the proposal, we used the framework proposed in (Pries-Heje, Baskerville and Venable, 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 question; 2) Feedback through **interviews with practitioners**; 3) The **Moody and Shanks Quality Management Framework** to assess the quality of the produced models (Moody and Shanks, 2003); and 4) The **Four Principles proposed by** (Österle et al., 2011) to evaluate a DSRM artifact.

This evaluation method follows the **design evaluation guideline within DSRM** (Henver and 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. Nevertheless, the observational and analytical methods could also be used, 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 research.

The framework proposed in (Pries-Heje et al., 2004) was formulated as follows:

- **What was actually evaluated?** The evaluated artifact was the method described in Section 3, which is 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 we used the described strategy, 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 the interviews** (using the same practitioners referred to in the Demonstration) was rather positive because: 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.

6 CONCLUSIONS

Considering this research's objectives and evaluation, we may conclude that the expectations were largely achieved since it was possible to: a) Formulate the method; b) Demonstrate its use in two real case studies; c) Find non value-added transactions when applying it; d) Suggest redesign improvements; and e) Get validation and positive feedback from practitioners about the method and its results.

We may also conclude that it is possible to easily identify redesign innovations to solve overlapping issues in organizations, since DEMO is regarded as a methodology that produces models considered concise and essential, which help to construct and analyze more models in a shorter period of time. In addition, because the designs are also considered coherent, comprehensive and consistent, this gives strength to the obtained models, as described in (Dietz, 2006).

To conclude, it is expected that healthcare organizations may use some of the described advantages of the proposal to solve the problems of inefficiency and unsustainability in the healthcare system. Furthermore, it can also be a contribution towards helping the healthcare professionals to validate processes and improve their way of working, even if the proposed artifact is used together with other existent methods.

To sum up, we may answer to the raised problem and objective statements that: 1) It is possible to use

the EO to propose improvements in the National Health System; and 2) It is possible to create a DEMO based method to find non value-added transactions that could be redesigned.

To complete the cycle of the DSRM, the *communication* step is being achieved through scientific publications and their presentation, aimed at the practitioners and researchers within the science area.

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, such as *Action* and *Intersticion* Models, which can be useful in the redesign of information systems (inline with previous researches (Reijswoud et al., 1999)).

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