Quality of Life through Quality of Information
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Using Enterprise Ontology for Improving Emergency Management in Hospitals

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Abstract. In a competitive world, healthcare organizations are forced to make improvements in order to compete and prosper. Healthcare services suffer from lack of change and inefficiency, which affects the delivery of sustainable services. We propose a method based on 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, has a strong and well-formed theory, and allows a good alignment between the enterprise design and operation. A demonstration of the method was accomplished in an emergency department, making it possible to find transactions that can be improved or automated. To evaluate the results we used interviews, Moody and Shanks Quality Framework, and the Four Principles from Österle et al., which shows that the method yields an adequate and clear process view and is reliable when it comes to improving healthcare operational processes.

Keywords. Operational Processes, Enterprise Engineering, Enterprise Ontology, DEMO, Healthcare Improvement, Emergency Departments

Introduction

Healthcare organizations face the challenges of providing services more efficiently, striving to achieve strategic and operational success, and to improve their business processes. The inefficiency of processes and the lack of transformation are the main reasons for failure, entailing serious consequences for the business [1] [2]. Hampering these challenges, healthcare services suffer from operational management weaknesses, which is considered to affect its delivery, overall economy and quality of life [3] [4].

Available data indicates that cost and quality are not correlated and showing inefficiency in resource consumption, which is not reflected in improved quality of care [2] [3]. Hence, we state our research problem as: **Healthcare processes inefficiencies have become unsustainable, affecting the delivery of quality services.**

Although this problem could be addressed with redesign and reengineering, some authors still argue that there is not a reliable method to solve it [5]. It is estimated that over 70% of these initiatives tend to fail [6] [7]. There are 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 for change management that advocates the development of a self-awareness within the organization [8] [9].

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Following this, our research proposes an approach based on Enterprise Ontology and the particular modeling methodology: Design and Engineering Methodology for Organizations (DEMO). We chose this approach as foundation for our proposal as it provides 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 and reengineering strategy [5] [10]. Moreover, there are successful validations in healthcare [11] [12], in business process reengineering [10], and relies on fifteen years of experience [13]. Our objective is to **propose a method based on DEMO to uncover non value-added transactions, and redesign them to improve the processes' efficiency,** applied to a hospital emergency department (ED) facing pressures to change [14] [15]. This research aims at contributing to study the operational management of clinical processes. This research was conducted by using the Design Science Research Methodology (DSRM) [16] [17].

1. Methods

Our proposal starts with the **Modeling Phase**, based on DEMO to study a healthcare organization and its processes. It provides a structured working approach for the reengineering by layering the organization 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 independent of the implementation [6]. To construct its diagrams, DEMO consists of a defined sequence of steps (Figure 1), beginning with a textual or process representation of an organization, and it ends with an aspect model. In this research we will focus on the Construction and Process Models from DEMO [5].

The proposal continues with the **Innovation Phase**, which is based on four additional steps from a Lean method [18]. During this phase possible improvements are identified from previous models, prioritized in terms of impact and feasibility, and then the organization is redesigned to include the most relevant improvements. These steps assist on handle transformation processes, and help to choose the most profitable improvements first (using an appropriate method to quantify the impact and feasibility).

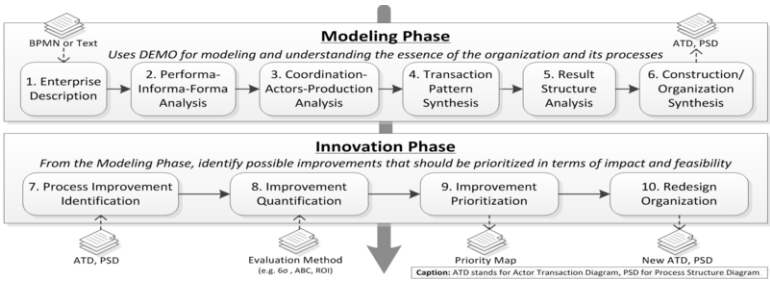

Figure 1. Graphical representation of the proposed method

Having the redesigned models, a proposal with specific implementation strategies is prepared, in order to take the suitable actions to apply the improvements. Alternatively, one can deepen some analysis including more information in the Enterprise Description or producing the other aspect models (State and Action Models). To sum up, this method replaces the analysis from Lean methodology by a Modeling

Phase based on DEMO, including its contribution to achieve models considered formally correct, easier to analyze, and enabling a unified reengineering strategy [5].

2. Results

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 the elimination or automation of wasteful transactions can improve processes without compromising the organization. To conduct the demonstration, we interviewed 5 patients and 10 practitioners (the ED director, other physicians and nurses, and health services researchers), namely to obtain the ED enterprise description.

In Figure 2 we are just presenting the ATD. 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 requested by an external actor, the *patient*. They are respectively requested to the *registrar*, *triage handler* and *patient problem handler*.

The handling of the patients' problems may lead to the following actions: performing some urgent internal examinations to the patients (T4); performing medical interventions to the patients (T6); performing supplementary examinations (T8); 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 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 deliver of means (T5 and T7).

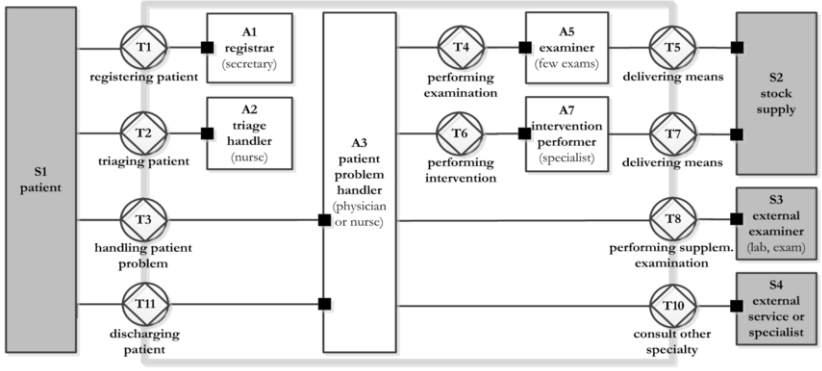

Figure 2. Actor Transaction Diagram of the Emergency Department

In the **Innovation Phase**, one must identify process improvements from the obtained diagrams. First, the ATD shows that transaction T1 can be removed, since the patient can register during the triage (T2), or automated through a computer terminal with a standardized electronic form. In fact, the secretary performs tasks with non value-added, and consequently this actor could be allocated to other activities.

With the other aspect models from DEMO, one can conclude that it is not efficient having to pass through several iterations and actors to be forwarded to another external service (specialist or examiner). For example, instead of being forwarded immediately after triage, patients need to be admitted, triaged and seen by a physician to be forwarded to another specialty outside the ED. This leads to unnecessary consumption of resources, a higher waste of time, and patient leaving without being treated in the ED. There is some related work suggesting strategies of *Fast-Tracking* and *Provided Directed Queuing* to anticipate the resolution of some patients' problems improving the waiting time, customer satisfaction, length of stay, and resource expenditure [19] [20].

In Table 1 we quantify the improvements in which we want to work at. To infer the level of impact, we consider that transaction elimination has a higher impact than precedence change. Avoiding a transaction conducts to the same classification as eliminating it. Eliminating an actor has even higher impact, because it avoids transactions 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.

Table 1. Improvements identification 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, add a new one, avoid actor	Triage should be fast
B	Automation in patients register	5	4	Avoid transaction and actor	New hardware and software
C	*Provided Directed Queuing*	5	5	May eliminate transactions and reduce flow	Reallocate only one physician
D	*Fast-Track System*	4	4	May eliminate transactions and reduce flow	Reallocate physician and a new space

The priority map addressees 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. To evaluate the artifact and its results (in Section 3) we used: a) Interviews with practitioners; b) The Four Principles proposed by Österle et al. (Abstraction, Originality, Justification, and Benefit) in the design of an artifact [21]; c) The Moody and Shanks Quality Framework to evaluate produced models [22]. We are using these validations and demonstrations as feedback to improve the method, as suggested in the DSRM to avoid the traditional descriptive and interpretative research.

3. Discussion

The feedback from interviews (using the referred practitioners) was rather positive: a) The importance of the research problem was validated; b) They understood and agreed with the obtained models, which directly revealed some possible improvements; c) Improvements were discussed and agreed to be similar to those obtained from the Innovation Phase; and d) They concluded that our method could be applied effectively and efficiently to solve the research problem, regardless of whom applies it. Overall, there was a good acceptance for this innovative approach, and the Four Principles from Österle et al. were accomplished.

From the Moody and Shanks Quality Framework, almost all quality factors were accomplished (only *understandability* was partially, and *implementability* was not). As

in the beginning the stakeholders find the models difficult to interpret needing an adaptation period and since models are implementation independent they only describe the essence of an organization.

Considering the evaluation, we conclude that the expectations were largely achieved since it was possible to: a) Formulate the method; b) Demonstrate its use; c) Find non value-added transactions when applying it; d) Suggest redesign innovations; and e) Get validation and positive feedback from the method and its results.

To finalize, 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 industry. Furthermore, it can also be a contribution towards helping the healthcare professionals to validate processes and improve their way of working, even if it is used together with other existent methods.

As future work it is important to better quantify the expected income with the innovations and improve the method by analyzing the realizations between transactions and information links, adding the Action and Interstiction Models, which can be useful in the redesign of information systems (inline with previous researches [10]).

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