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Business Process Management techniques for health services: Experiences and Application

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Abstract

In this paper, we present our experience in a Business Process Management (BPM) project for public hospitals. This project is supported by a research network whose overall goal is to develop new health services based on telemedicine. In order to do so, different decision-support and planning methodologies and tools are supported in order to produce new organizational models for efficiently support health services. Among these, we focus on the process-oriented approach rather than the traditional function-oriented approach to health services. According to this approach, health processes must first be identified and modeled in order to simulate the resulting models and seek for alternatives in a BPM context. Since it is more than likely that the new processes to be implemented may imply the redesign of (at least) part of the current information and communication system, a formal description model suitable for software development (i.e. UML diagrams) should also be produced.

1. Introduction

Re-designing and re-engineering new health services are becoming an important issue for hospital managers and responsible for Health Systems. In the developed countries, the aging of the population has led to the increase of a new type of users in the Health Systems. These users (customers) do not require their continuous hospitalization, but some kind of continuous monitoring, treatment, and assessment at their own houses. Hence, hospitals and health systems must provide substantially different services that those currently supported. Therefore, it is of great interest to design and implement these new health services, aiming also at the integration of telemedicine, understood – in a rather broad sense – as IT applied to healthcare.

This is the context in which the project presented in this paper has been carried out. The project is being supported by a research network of 13 nodes, most of them hospitals or tightly linked to the National Health System. The overall goal of the research network is to provide a set of tools (models, methodologies, hardware and software) to facilitate the design, implementation and assessment of new health services using telemedicine. To achieve this goal, a number of home care processes have been chosen as use cases (i.e. home care of terminal patients, home care of post-surgical patients, and the home care of chronic patients). Within the overall goal, a number of specific goals have been established, referring to particular aspects of telemedicine. To achieve these, five Working Packages have been set up, being each one of the packages leaded by one node of the network. From the different working packages, WP1 should address a number of issues related to the new organizational models for health services. This working package is lead by the hospital

"Virgen del Rocío" in Seville (largest hospital in Spain in terms of the number of patients), and the Industrial Management Research Group, from the School of Engineering, University of Seville. The specific goals within this WP are the following:

- To develop a methodology for Health Services (HS) process modeling. According to the review carried out in the next section, there are few experiences in HS process modeling. Therefore, one of the objectives is to adapt or combine general Business Process Modeling (BPM) methodologies for their application in the healthcare sector.

- To provide the network with a number of as-is models representing how the aforementioned use cases are currently being offered in the hospitals. The aim is to promote discussion among the nodes members on how these services should be offered, particularly taking into account the integration of telemedicine.

- To provide to-be models that represent an improvement over the as-is models and may serve as reference models for the rest of the nodes in the research network. Since it is expected that some of the functions in the to-be models are to be implemented by means of IT support, a formal description model suitable for software development (i.e. UML diagrams) should also be produced.

In this paper, we describe the experiences encountered in the development of the project. The rest of the paper is organized as follows: In the next section, we briefly review the related (and rather scarce) literature on applications of BPM to the healthcare sector. After,

we describe the context in which the project is being developed, focusing on the specific obstacles encountered and the requirements posed to the BPM techniques and tools to be employed. In Section 4, we review the ARIS methodology and the IDS Scheer products and show how these match the requirements stated in the previous section. Next, we describe the approach followed in the project, and in Section 6 we briefly elaborate on the experience gained in this project.

2. Related literature

A (business) process may be defined as a set of related tasks that are carried out within a business or organization in order to obtain certain output (Davenport and Short 1990). These tasks such create value for the customer of the business or organization (Gunasekaran and Kobu 2002). Business Process Redesign (BPR) refers to those initiatives aimed to obtaining significant improvements in the organization by means of the increasing the efficiency and effectiveness of key business processes (Wastell et al. 1994). BPR includes two different approaches:

- Top-down approaches seeking radical changes in the organization, such as ‘business process re-engineering’ (Hammer 1990) and ‘process innovation’ (Davenport 1993).
- Initiatives of small scope within a bottom-up approach seeking incremental improvements in the organization (business process improvement) (Harrington 1991).

In general, the suitability of both approaches remains an open question (MacIntosh 2003). Indeed, the authors of the seminal works on business process re-engineering state that, in practice, the changes introduced in the organizations by means of re-engineering have not been as radical as initially expected (see e.g. Champy 1995, or Hammer and Stanton 1995). Besides, it is usual that in a reengineering project where radical improvements in the processes are being studied, some small improvements can be found, so both approaches can be seen as complementary and not excluding ones (Kelada 1996).

Once a process has been targeted for re-design, it is required to model it with certain degree of detail. Therefore, Business Process Modeling (BPM) is consider to be a core part of the BPR and of systems analysis in general (Flynn 1992, Wastell et al. 1994). From an information system viewpoint, BPM is the description of the control flow of a process (Green and Rosemann 2002).

From a process viewpoint, a hospital consists of a high number of processes linked through a client/server relationship (Amberg and Gräber 1996). Therefore, the methodologies, techniques and tools applied for BPM in companies can be also applied to the healthcare sector. In fact, most Hospital Information Systems (HIS) are being re-oriented towards healthcare processes (Reichert et al. 1998).

Although rather scarce, there have been some attempts to apply BPM techniques to the healthcare services. For instance, Waring and Wainwright (2002) describe how several processes in a hospital are modeled. Maij et al. (2002) describe process modeling for a University Medical Center in the Netherlands. Amber and Gräber (1996) carry out the

modeling of the processes of a hospital in order to implement a HIS. Wastell et al. (1994) analyze a number of processes in a hospital and study a number of improvement proposals based on the application of IT. Their analysis is focused on the external patients, and RADs (*Role Activity Diagram*) are employed as modeling technique. Finally, Sprengel et al. (2003) carry out an analysis of image diagnostic processes in two German hospitals.

To the best of our knowledge, there are no published references on BPM in the health sector with the aim of analyze the introduction of telemedicine in the processes under consideration.

3. Context of the Project

In this section, we present the specific context in which the project is being developed. Specifically, we describe the obstacles found and the requirements set up in the beginning of the project. With respect to the obstacles, there are a number of critical issues that have been identified. Some of them are consistently described as common to any BPM project, so we focus on the specific obstacles that we regard as characteristic of the healthcare sector. These are the following:

- *Manual functions*. Most of the key functions are manually performed and there are little chances that they can be automated in the near future. The duties to be carried out by the surgeons constitute an example of the above.

- *Function-oriented organizations*. Due to the high degree of specialization required to carry out the different activities, hospitals are usually strongly function-oriented organizations composed of several units (e.g. X-ray, surgery, etc.) with a great degree of de-centralization among these, particularly regarding resources and funding allocation. This causes a lack of process-oriented view that makes difficult to carry on BPM projects.

- *Skepticism on applying BPM solution to health services*. Despite being techniques widely applied, the intrinsic characteristics of the healthcare sector seem to be the reason for the common belief –expressed by many users– that BPM techniques are of dubious usefulness for improving health services.

Regarding the project requirements, in the context of BPM it is important to distinguish among methodologies, techniques, and tools. Methodologies are modeling paradigms. Each methodology can be supported by one or more modeling techniques. Modeling techniques refer to the set of symbols, diagrams and other notation employed to describe and analyze the system under consideration. Finally, techniques may be supported by software applications that support modeling tasks and act as model repository. For a detailed description of methodologies, techniques, and tools, the reader is referred to Kettinger et al. (1997).

With respect to the modeling technique requirements, the following requirements on the modeling technique have been posed at the beginning of the project:

- The models should be easy to be understood by non-specialists on the domain field. Although it is widely known that the simplicity and ease of understanding of the models is a requisite for any BPM project (see e.g. Curtis et al. 1992, Kalpic and Bernus 2002, or Knott et al. 2003), in our case this requisite is absolutely critical. On the one hand, it is expected that, in the medium/long term, the actors in the process (i.e. doctors and nurses) not only will be able to understand the models, but to model themselves. Therefore, a higher level of understanding of the modeling technique is required. On the other hand, due to the technical complexity of the processes, the improvements should be provided by the actors (either in the form of radical change or continuous improvement). It is not likely to expect that the experts in business process modeling can systematically provide sensible improvements for medical processes, since most of the functions performed in the process constitute 'black-boxes' for non-healthcare professionals.

- Multi-level view of the process. As stated previously, the resulting models should be understandable. To keep the models simple, a high-level description of the processes is required. In parallel, some of the functions composing the process are to be analyzed in detail, for which low-level models are required. It is then clear that a multi-level view of the process has to be addressed in order to meet the above requirements.

- Integration with UML. As previously stated, the introduction of IT for healthcare is expected to be a major issue in re-designing the processes (i.e., for implementing

the to-be models). Therefore, some of the functions will be speeded by developing suitable software and hardware artifacts. To do so, the business models should be seamlessly matched to software engineering models. As a standard, UML seems to be currently the best choice for expressing such models.

With respect to the requirements posed regarding the modeling tool:

- Collaborative work support. Since the project is being developed by a number of persons belonging to nodes physically distant, the tool must allow that the different nodes interact on a single repository of models.

- Simulation capabilities. In this project, the purpose of using simulation is twofold: On the one hand, the models have to be validated by the users. The validation of a model implies not only that the users recognize that the functions (and their sequence) in the model correspond to the real behavior of the system, but also that the resources allocated to the different functions in the model (particularly in terms of time and staff) correspond to the resource allocation occurring in the real system. In other words, we do not only intend that the model reflect the procedures occurring in the real world, but also its dynamic aspects, such as the system workload and resource allocation. It is clear that this second aspects should be validated by showing the behavior of the model by using simulation. The second reason for the use of simulation is to be able to conduct an informed what-if analysis in order to assess the re-design of the processes. For a detailed discussion

on the issues of business process models and simulation models, the reader is referred to Barber et al. (2003).

4. ARIS – ARchitecture of Integrated Information Systems

ARIS (Scheer 2000) stands for Architecture of Integrated Information Systems, and denotes a methodology for modeling business processes. It decomposes a process in a number of aspects (views), such as the functional, data, or resource view. The core technique for modeling in ARIS is the Event-driven Process Chains (EPC) diagram, which serves to link the different views in the so-called control view. As its creator recognizes, EPCs is not a new method in essence, as it contains elements of the Petri nets and GERT (Scheer 2002). It is to note that the methodology ARIS or its core technique, the EPCs, have been often confused with the software tools marketed by the software vendor IDS Scheer, such as ARIS Toolset (IDS Scheer 2003). Just to make one example, in Vernadat (2002) ARIS is labeled as a 'modeling tool'. This confusion is probably augmented by the success of IDS Scheer, who has sold more than 40,000 licenses and it is considered to be a leader in the BPM sector (Gartner Group 2002).

An EPC is a set of events and functions that follow a logical flow specified by the employ of logical operators, such as OR, AND, and XOR. This set of elements is specifically oriented to the description of processes, since some authors define a process as a succession of events and functions (Gulledge and Sommer 2002). In its extended form (eEPC – *extended EPC*) it is possible to link additional elements to the functions in an EPC, such as

data, organizational units, or the product or service provided by the function. For a detailed description of EPCs, the reader is referred to Scheer (2000).

As mentioned before, the EPCs are based on Petri nets. In Van der Aalst (1999) it is shown how it is possible to match a Petri net to an EPC as long as the latter does not contain the OR operator. On the other hand, the ontological consistency of the EPC rules is exhaustively analyzed by Green and Rosemann (2000) by means of the Bunge-Wand-Weber models. The analysis shows, as main obstacle, that it is not possible that a function may be executed by certain organizational unit or another under certain conditions.

After a thorough evaluation of a number of methodologies, techniques, and tools, ARIS has been selected for this project. The main reasons are the following:

- The EPCs match the requirements posed with respect to the ease of understanding by non-specialist in modeling.

- EPCs can offer a multi-level view of the process, since a function in an EPC can be described in more detail by means of another EPC.

- EPCs offer a consistent, formally supported model (see comments above) that can ensure an efficient simulation of the processes.

In order to employ a computer-supported tool for implementing the ARIS methodology, the set of product by IDS Scheer have been chosen. A number of reasons have been invoked for this decision:

- Collaborative support capabilities. On the one hand, IDS Scheer offers the possibility of using a server to act as model repository. This server can be accessed via Internet by other users to create new models or modify existing ones. Finally, there exist utilities to export the models into HTML format and publish them in a Web server.

- Simulation capabilities. IDS Scheer markets a product – ARIS Simulation – that can perform computer-based simulation on the processes modeled. This is a key issue, since a single model can store the static and dynamic characteristics of the process, minimizing the risk of errors due to the release of new versions of the models.

5. Approach and structure of the project

Once the methodology and tool for modeling have been selected, three working groups have been established for each process:

- *Users group*. This group is constituted by the users of the specific process, i.e. doctors and nurses. The goal of this group is to provide a non-formal description of the process. Due to the strong function-oriented view, most of the users only were able to describe certain scenarios belonging to parts in the process. Hence, in order

to ease their tasks and obtain a complete and consistent description of the process, a technique similar to storyboarding has been used. In this storyboarding, the users are asked to reproduce a specific episode (scenario) of their task, therefore describing a particular path for the process.

- *Modellers group*. The goal of this group is to transform the description from the users group into EPCs. This group is formed by modeling experts. In figure 1, one of the models resulting as output of this group is shown.

- *Model validation group*. The goal of this group is to validate or reject the models provided by the modellers group. This group is formed both by users and modelers.

Additionally, another group has been constituted in order to build a glossary resulting from the work of the rest of the groups. Once the model has been validated, it is published to the rest of the network via intranet. The feedback from the rest of the network is later discussed by the users group, and, if validated, included in the next version of the process model.

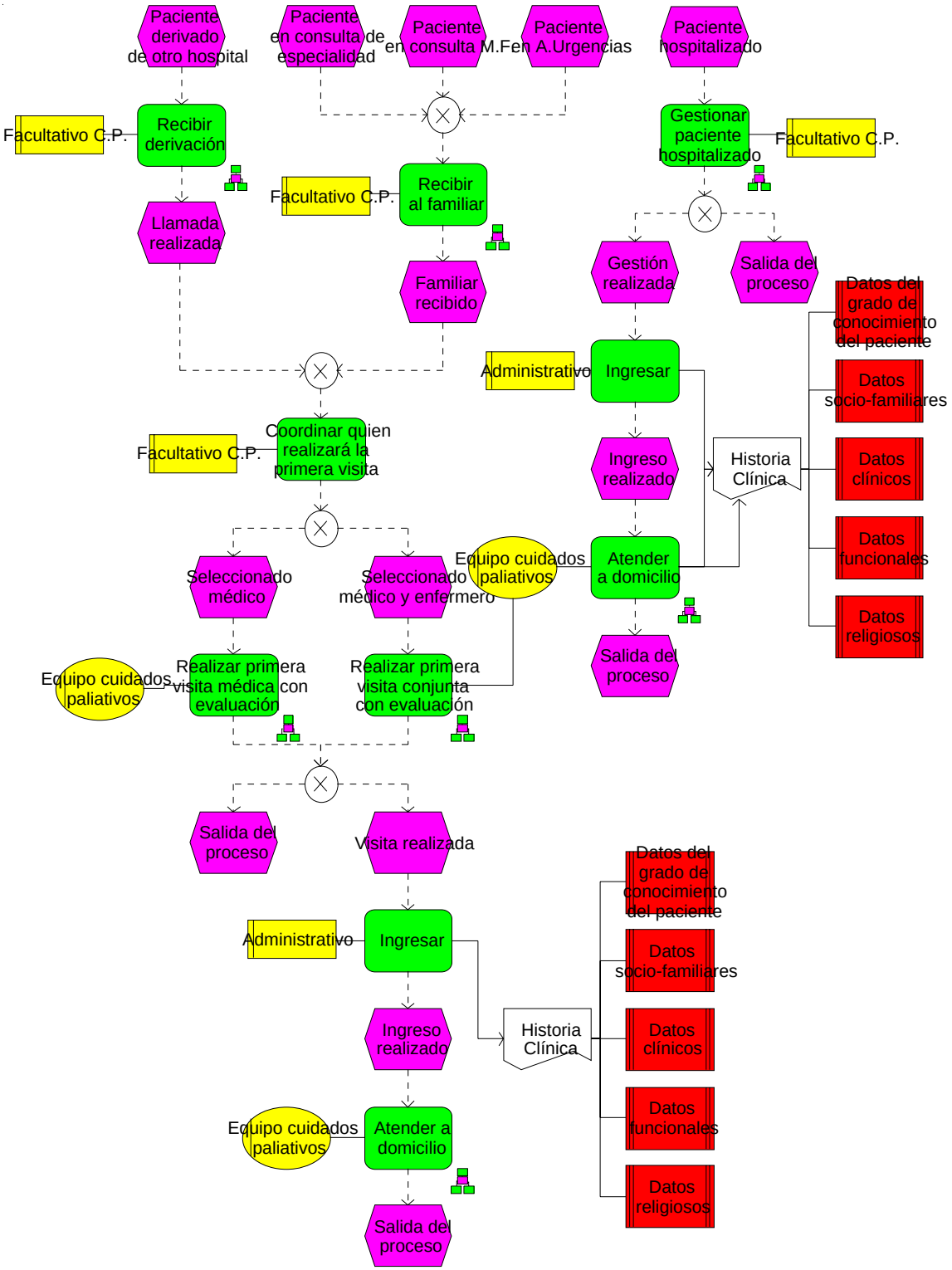

Figure 1. First level model of a home care use case

6. Lessons learned

In this paper, we have presented the experiences encountered in a BPM project for the healthcare sector. Although the project is far from being over, the following comments can be done based in past developments:

- The ARIS methodology and the software tool ARIS Toolset have proved to be suitable for this project. They have matched most of the project's requirements, particularly these regarding the ease of understanding by non-experts in modeling. We have found no difficulties when explaining the meaning of the different elements of the EPC, and the use of filters provided by the software tool has allowed us to reduce the number of elements to the minimum required to describe the processes. As one of the objectives has been obtaining simulation models, the OR operator has been forbidden. An additional reason for disallowing this operator has been that it was detected that the users could employ it to hide the logical behavior of some process that was not entirely clear for them.

- The elaboration of a glossary has been proved to be extremely important for the project. The glossary has served to facilitate the development of future models as well as to ease the understanding of the published models by the rest of the network.

- Simulation is being the key for model validation. In this project, simulation is not only employed for performing what-if analysis, but to validate the dynamic aspects

of the models. Aside, it has been used to extract the knowledge of the process from the users, as in some cases the users agreed with static models but did not agree with the simulation results.

- The integration of process models with UML remains an open question. Although it is possible to obtain UML diagrams from the EPCs, this mapping is far from being automatic. We believe that most of the difficulties steam from the fact that obtaining UML diagrams from business process models implies crossing the boundaries between process-orientation and function-orientation. Process orientation focus on functions meaningful to the customer and does not care about function re-use whereas the latter is the primary concern of software engineering models.

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