

# HEALTHINF 2008

International Conference on  
Health Informatics

## Proceedings

Volume 2

Funchal, Madeira - Portugal · 28 - 31 January, 2008

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# HEALTHINF 2008

Proceedings of the  
First International Conference  
on Health Informatics

Volume 2

Funchal, Madeira - Portugal

January 28 – 31, 2008

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**INSTICC – Institute for Systems and Technologies of Information,  
Control and Communication**  
and  
**UMA – University of Madeira**

Technical Co-sponsorship by  
**IEEE EMB – Engineering in Medicine and Biology Society**  
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Systems and Technologies

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# FOREWORD

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This volume contains the proceedings of the *First International Conference on Health Informatics* (HEALTHINF 2008), organized by the Institute for Systems and Technologies of Information Control and Communication (INSTICC) and the University of Madeira, technically co-sponsored by the IEEE Engineering in Medicine and Biology Society (EMB) and the Workflow Management Coalition (WfMC), in cooperation with AAAI.

The purpose of the *International Conference on Health Informatics* is to bring together researchers and practitioners interested in the application of information and communication technologies (ICT) to healthcare and medicine in general and to the specialized support to persons with special needs in particular.

Databases, networking, graphical interfaces, intelligent decision support systems and specialized programming languages are just a few of the technologies currently used in medical informatics. Mobility and ubiquity in healthcare systems, standardization of technologies and procedures, certification, privacy are some of the issues that medical informatics professionals and the ICT industry in general need to address in order to further promote ICT in healthcare. In the case of medical rehabilitation and assistive technology the use of ICT has had important results in the enhancement of the quality of life, contributing to a full integration of all citizens in the societies they are also part of. HEALTHINF is a forum for debating all these aspects. Furthermore, this conference is also a meeting place for those interested in understanding the human and social implications of technology, not only in healthcare systems but in other aspects of human-machine interaction such as accessibility issues.

HEALTHINF is one of three integrated conferences that are co-located and constitute the International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC). The other two component conferences are BIOSIGNALS (International Conference on Bio-inspired Systems and Signal Processing) and BIODEVICES (International Conference on Biomedical Electronics and Devices).

The joint conference, BIOSTEC, has received 494 paper submissions from more than 40 countries in all continents. 65 papers were published and presented as full papers, i.e. completed work (8 pages/30' oral presentation), 189 papers reflecting work-in-progress or position papers were accepted for short presentation, and another 86 contributions were accepted for poster presentation. These numbers, leading to a "full-paper" acceptance ratio below 14% and a total oral paper presentations acceptance ratio below 52%, show the intention of preserving a high quality forum for the next editions of this conference.

The conference included a panel and six invited talks delivered by internationally distinguished speakers, namely: Sergio Cerutti, Kevin Warwick, F. H. Lopes da Silva, Vipul Kashyap, David Hall and Albert Cook. Their participation has positively contributed to reinforce the overall quality of the Conference and to provide a deeper understanding of the field of Biomedical Engineering Systems and Technologies.



## FOREWORD (CONT.)

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The proceedings of the conference will be indexed by several major indices including DBLP, INSPEC and ISI-Proceedings and it will also be submitted for indexing to EI. A book with the revised versions of a short list of selected papers from the conference will be published by Springer-Verlag in the new CS book series: Communications in Computer and Information Science (CCIS). Additionally, a special issue of the IEEE Transactions on Biomedical Circuits and Systems will be edited based on the very best papers of the conference.

The program for this conference required the dedicated effort of many people. Firstly, we must thank the authors, whose research and development efforts are recorded here. Secondly, we thank the members of the program committee and the additional reviewers for their diligence and expert reviewing. Thirdly, we thank the keynote speakers for their invaluable contribution and for taking the time to synthesise and prepare their talks. Fourthly, we thank the program chairs, Luis Azevedo and Ana Rita Londral, whose collaboration was much appreciated. Finally, special thanks to all the members of the INSTICC team, especially Marina Carvalho at the conference secretariat, and the local organising committee from the University of Madeira, especially Jorge Cardoso and Paulo Sampaio, whose collaboration was fundamental for the success of this conference.

This year, the organization will distribute two paper awards at the conference closing session: the best paper award and the best student paper award. The decision was mainly based on the paper classifications provided by the Program Committee.

We wish you all an exciting conference and an unforgettable stay in the lovely island of Madeira. We hope to meet you again next year for the 2<sup>nd</sup> HEALTHINF, details of which are available at <http://www.healthinf.org>.

Joaquim Filipe

INSTICC/Polytechnic Institute of Setúbal

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# PROCESS MODELING OF THE HEALTH SECTOR USING BPMN: A CASE STUDY

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**Keywords:** Business Process, Health Sector, Modeling, Case Study.

**Abstract:** The importance of the analysis, modeling and management of business process is not restricted to a specific enterprise sector. In the field of sanitary management, due to the nature of the service offered, sanitary institutions' processes are also the basis for decision making focused on achieving their objectives to grant medical assistance of quality. In this work, we will present the application of business processes modeling to the processes of an institution of the health sector, using the BPMN notation. The objective of this work is to show our experience obtained in the elaboration of the conceptual models of some hospital processes that can be used as a basis for others in the collaboration with hospitals for modeling their processes using BPMN. Hospital processes are very complex, and with their graphical visualization, their management and improvements are facilitated by means of the understanding and detection of possible failures.

## 1 INTRODUCTION

Business processes enable the activities of a company to be described in a manner which is understandable to all its users, with the purpose of analysis and design. Design means explicitly modeling, designing, simulating and redesigning the process as the organization learns what is possible. Due to the need to respond to competitive pressure or to business opportunities, business analysts need to restructure processes quickly (Smith *et al.*, 2002).

In business process modeling the main concept is that of the business processes themselves, which describe the activities involved in the business and how they relate to and interact with the necessary resources to achieve a goal for the organization. Some specific goals of business process modeling are: (Beck *et al.*, 2005; Erickson and Penker, 2000): 1. To ease the understanding of the key mechanisms of an existing business, 2. To serve as a basis for the creation of appropriate information systems that support the business, 3. To improve the current

business structure and operation, 4. To show the structure of an innovated business, 5. To identify outsourcing opportunities and, 6. To facilitate the alignment of business specifications with the technical framework that IT development needs.

Similar to all types of organizations, in the health sector it is vitally important to keep its business processes up to date. This objective must not only be achieved through the continuous improvement of the services offered but also as a fundamental part of the quality programs in which it is immersed.

Business processes in hospitals are very complex and variable, due to the daily work which requires frequent reactions to the interim results of diagnostic processes as well as to unexpected medical instructions. When comparing the business processes in a hospital to the processes of other business areas, certain characteristic properties are evident, such as those pointed out by (Amberg and Gräber, 1996): a high number of cooperating organizational units, limited resources, a high ratio of manual activities, most medical processes can be

blueprinted only roughly in advance and details of medical processes are frequently changed.

From the point of view of computer science, the tendency of clinical practice is to move towards a shared care environment in which knowledge of clinical information systems (a combination of technology, data and people) should include definitions of all clinical processes' aspects, as well as the functions and responsibilities of the people involved in them (Colreavy, 2000). In this line, (Osterweil, 2006) argues that more precise and comprehensive process definitions are more effective bases for the kinds of definitive analyses that lead to successful improvement efforts in a more efficient manner.

Our interest is based on the conceptual modeling of the health-care sector processes by using the philosophy of business process models as a starting point. There are several important works dealing with this subject, such as those presented by (Framiñán *et al.*, 2004) and (Parra *et al.*, 2005a; Parra *et al.*, 2005b) in which business process modeling and simulation are applied to the health sector, particularly in processes such as telemedicine and hepatic post-transplant. On the other hand, (Graeber, 1997) had already carried out a similar work but on the basis of workflow management systems for the design of hospital information systems. In (Röhrig, 2002) an approach is presented through which existing business process descriptions are reused to analyze health care security requirements. Additionally, in the literature there are works related to business processes in the health sector, for example the presented by (Anyanwu *et al.*, 2003) as well as (Habing *et al.*, 2001).

In this work, we will present the application of the Business Process Modeling Notation (BPMN) for business process modeling in the health sector with the aim of showing our experience in the collaboration with the process modeling that can be applicable to any institution in the health sector.

Our intention when modeling hospital processes is that of facilitating the visualization and understanding of the activities that are carried out in the fulfilment of their mission. Another main target is to make visible the current processes (as-is models) for their analysis and comparison with the target processes (to-be models). This is one of the main problems that arise when clearly identifying the logical sequence of the real processes and their efficiency. This is due to the fact that, in most cases, hospital employees carry out their activities mechanically without having a theoretical basis.

This paper is organized as follows: In section 2, the BPMN notation for business process modeling will be detailed; in section 3 an overview of the collaboration context will be shown and in section 4 we will describe and illustrate our first experience in health-care process modeling. Next in section 5 we will present some lessons learned from this work. Finally, in section 6 some of the conclusions drawn from this work will be put forward.


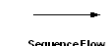



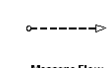
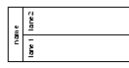

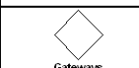


## 2 BUSINESS PROCESS MODELING WITH BPMN

Business process models (BPMs) can be created or presented by using many different techniques or languages. These languages are very different from one to another, since each one studies the processes in a different way, depending upon the purpose for which it was created (Dufresne and Martin, 2003). Among the languages for modeling business processes mentioned in the literature, special attention must be paid to the following ones: IDEF 0 (FIPS, 1993), IDEF 3 (Mayer *et al.*, 1995), UML (Erickson and Penker, 2000), UML 2.0 (OMG, 2003), and BPMN (OMG, 2006).

We are particularly interested in BPMN because its first goal is to provide a notation that can be easily understood by all business users, from the business analysts to the technical developers and business people (White, 2004). Moreover, it provides a graphical notation to express business processes in a Business Process Diagram (BPD), based on a flowcharting technique tailored to create graphical models of business process operations allowing the easy development of simple diagrams.

BPD is composed of two basic categories: the first one is formed by core elements (*Flow Objects*, *Connecting Objects*, *Swimlanes* and *Artifacts*) that make it possible to develop simple process models and a complete list of elements that allows the creation of complex or high-level business process models. Some of the BPMN elements for business process modeling are shown in Table 1.

Table 1: BPMN notation elements.

BPD Core Element Set			
Flow Objects	Connecting Objects	Swimlanes	Artifacts
 Events	 SequenceFlow	 Pool	 Data Objects
 Activities	 Message Flow	 Lanes	 Groups
 Gateways	 Association		 Text Annotation Text Annotation

### 3 OVERVIEW OF THE COLLABORATION CONTEXT

With the objective of analyzing the use of BPMN notation in real cases, a multidisciplinary work group was created. The group was composed of software engineers from the Alarcos Research Group of the University of Castilla-La Mancha (UCLM) and health professionals and administrative staff from the General Hospital of Ciudad Real (GHCR) which is a part of the Health Care Services of the Spanish region of Castilla-La Mancha.

The main interest of the GHCR group is to build a state-of-the-art health care system, but it has faced several challenges in the application of business process modeling to health care processes. In this context, a set of work objectives and methodology to be followed were defined for each group. The applied research method was Action-Research (A-R). A-R is a collaborative research method aimed at joining theory and practice between researchers and practitioners by means of a process of a cyclical nature. A-R is focused on new knowledge building which must be useful in practice and which is obtained through searching for solutions to real situations (Avison *et al.*, 1999). Given its qualitative and cyclic nature, A-R is a very suitable method to apply to organizations in order to promote the continuous improvement of their processes. Being most advisable for our study, this one was the method that was selected.

On this basis, and in agreement with the research method, our first move was to approach the GHCR work team. The work in collaboration was carried out in different phases that are detailed below:

*Phase 1:* The first phase was started with three informative meetings that lasted three hours. In this first meeting with the hospital manager and the people in charge of the different areas of the hospital, the objectives of the process were put forward and a brief introduction to business process modeling and its advantages were presented; moreover team works were defined for choosing the processes to be modelled. Later on, two other meetings with the people assigned by the hospital team work to be responsible for the collaborative work took place.

*Phase 2:* In the second phase the personnel of the hospital received a 20 hours intensive course. This training session went into depth in the subject of modeling and the techniques for business processes modeling specifically BPMN notation, as well as in the importance of Business Process Management.

*Phase 3:* In this phase the hospital work group carried out meetings for the selection of three possible processes with different degree of complexity but equal importance level for the institution. This selection was mainly based on the following criteria:

- Processes must be well-known by all the participants in the work group.
- The process must affect multiple departments
- Information technology was considered as an essential tool during the workflow.
- Necessity of improvement of the process.

*Phase 4:* The next step was the definition of the work method by the members of this group. With the purpose of integrating the knowledge of the different members of the team, a specific work group was selected for each process, designing at least one representative member for each subprocess or affected organizational unit. Moreover, it was necessary to carry out the compilation of information, data and documents (such as textual definition of the process, paper-based documentation and electronic forms) that could be used for the elaboration of the selected process models.

*Phase 5:* In this phase, two meetings of both team works were carried out (GHCR and UCLM) that lasted around 2 hours each. In these meetings, the selected processes were: a) Programmed Surgical Patient (PSP), b) incorporation of a new employee, c) Citation process.

*Phase 6:* This phase consisted basically of the development of the PSP process model. The way of creation of the model was collaborative and iterative. In order to achieve this goal, there were necessary work meetings with the person in charge of the process for the refinement of the model to be carried out. Also interviews to some of the participant roles in the process execution took place.

### 4 MODELING A HOSPITAL PROCESS

In this work, we used the Business Process Modeling Notation (BPMN) for the health care sector processes modeling. We have selected this notation because it is widely accepted and recognized in the enterprise market due to the easiness that it provides for the construction of simple or high level processes. In this case, the model has to be as simple, transparent and understandable as possible for all the stakeholders in the health sector.



The process model presented in Figure 1 shows at a high level abstraction the Programmed Surgical Patient (PSP) process and the activities that are carried out when a patient is admitted into the hospital for the accomplishment of the surgical treatment of an injury or a disease that has been previously prescribed by means of diagnosis.

At the construction phase of this model a first rough draft was elaborated on the basis of the information that has been previously compiled (textual description of the process, documents, forms, etc.). Having elaborated a first version of the conceptual model of the process, a meeting with the stakeholder in charge of the process from the GHCR work group was carried out.

Therefore, simultaneously, the construction of the final model was possible, by means of the process description by the group of users to obtain a continuous feedback of the process. The construction of the model presented in Figure 1 was also possible thanks to the interviews made to the departmental personnel (participant user group and roles) involved in the process execution. By means of these interviews users explained to the modeler the work that they develop and the main activities that are carried out throughout this health care process. Once evaluated the PSP process model, the development of this model in a lower level of decomposition began. The first subprocess to develop is that corresponding to the Surgical Waiting List (SWL).

Similarly, for the construction of this subprocess the necessary textual and documentary information was compiled. Moreover, we have counted on the collaboration of the person in charge of this subprocess for its description and validation. The obtained result is shown in Figure 2.

With the development of this first model, and one of its subprocesses, it was possible to obtain the As-is model of one of the most representative processes within the sanitary service that offers the participant institution.

The work done will be the reference model that will serve as a basis for the construction of the “to-be” models. The application of the BPMN notation was very useful, since due to its characteristics; at any moment the construction of the processes models presented was facilitated for both participant groups (of business and systems).

### 5 LESSONS LEARNED

In the development of the “as-is” models of the process selected, there were some difficulties and limitations, mainly the following ones:

- Due to the nature of the work in the health sector, management in hospitals is oriented towards functions and not towards processes. This is because of the high degree of specialization of the different activities which frequently are made up of units with a high level of decentralization.

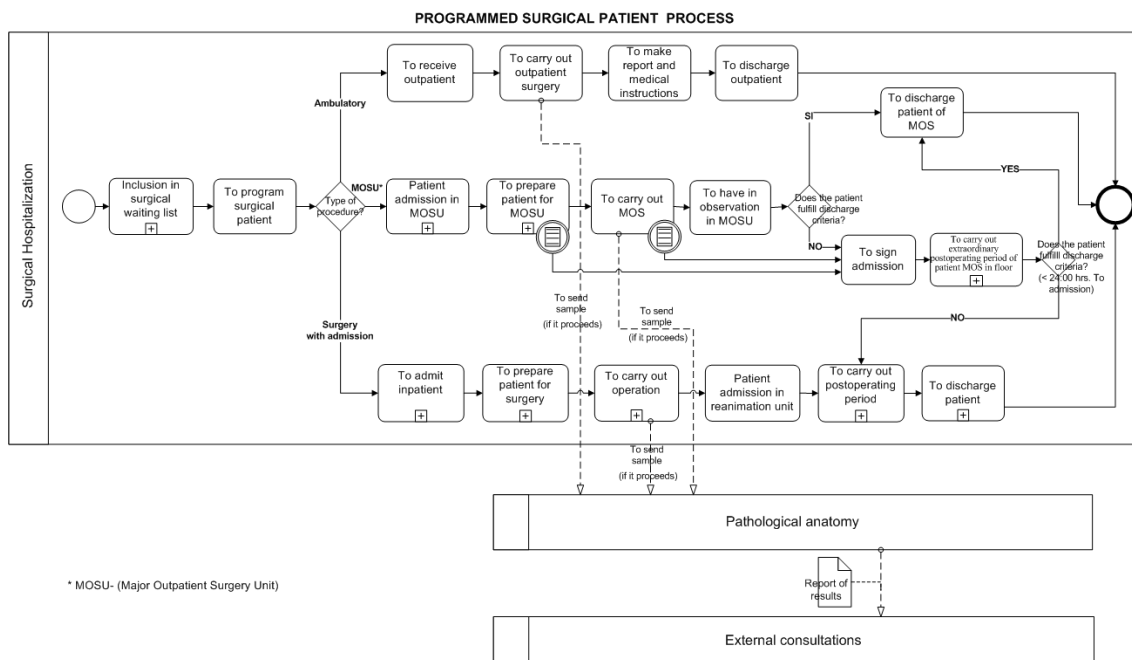


Figure 1: Programmed surgical patient process model.

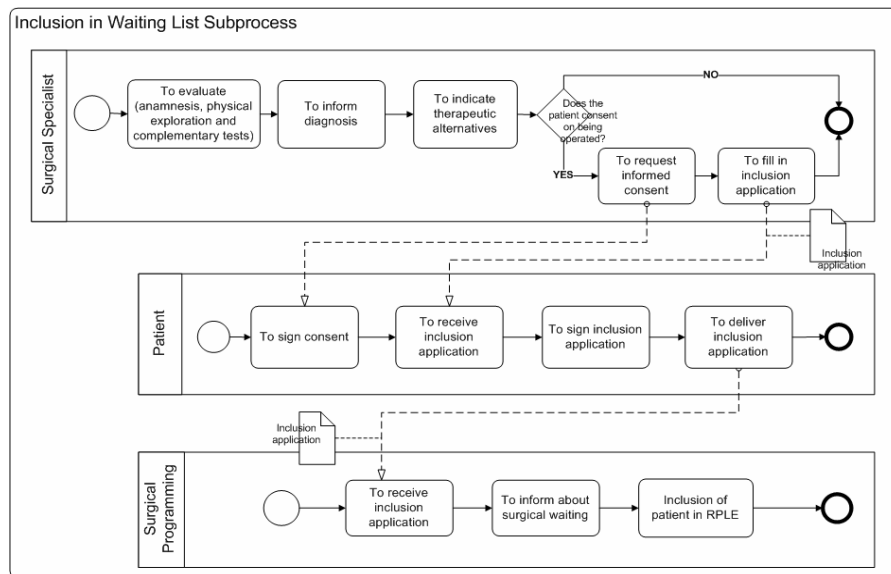


Figure 2: Surgical waiting list subprocess model.

- In the chosen process, diverse roles from different organizational departments which also work with certain degree of autonomy with respect to the others take part. This fact represented a problem at the time of efficiently designing the process.
- Variability of the process: Due to the fact that it is applicable to all surgical services of the hospital and to all patients who are going to take part in any surgical pathology except for urgent surgery, which entails many exceptions in decision making.
- There were some discrepancies between the participant professionals in the process at the time of the description of its activities, which partly reflects the absence of a model bases for the process.
- When the roles of the active people in charge in the process were not well defined a conflict was generated in the identification of the activities.
- In some cases the asynchronous communication by means of email was necessary.

Nevertheless, it is also important to emphasize the advantages that the application of business process modeling using BPMN in the health sector provides such as:

- The most important aspect was than with the training on BPMN that received the hospital staff, they had a clearer vision of their processes and the form in which they had to express it.
- Before creating the business process model, the textual description of processes had not a clear structure. After receiving the course, the personnel from the hospital could develop a more structured

description of their processes in accordance with our objective consisting of modeling them by using BPMN.

- The process modeling serves as a reference as well as a starting point for the documentation of the processes that it carries out. In addition, the process modeling is able to be the basis for the certification of this process within the program of continuous improvement of the hospital.
- Through the graphical representation of the processes, the understandability of the model is facilitated being in addition a basis for decision making, as well as for redesigning future new processes.
- Having the models of the processes facilitates the incorporation and integration of new personnel into the working areas and processes of the hospital.
- Within the phase of analysis, some steps of the process were clarified such as that stating that members of the work group were different.
- It was possible to identify the different roles interacting between themselves within the process.
- Being a practically recently opened hospital it has inherited processes of the sanitary institutions that previously formed it. This is the reason why the design and modeling of its present processes come to represent an evolution approaching the quality of the service.
- With the detection of failures and bottle-necks in the present process will allow us to take corrective measures in the rules from this process, therefore, facilitating the management of its processes.

## 6 CONCLUSIONS AND FURTHER WORK

In this work we have presented an example of the application of business process modeling to the health sector. The main objective is in the first instance, to show on the basis of the accomplishment of this work the experience acquired in business process modeling applied to health sector processes and with the active participation of hospital staff (business people), and on the other hand to show the results obtained in the modelled and graphical visualization of some of their processes to starting off mainly by the received training. Once the first selected model was created, it was possible not only to determine the utility of process models for managing these processes but also to propose improvements of the same.

The experience in process modeling using the BPMN notation in the health sector has been interesting and fruitful for the work group. In addition, it was demonstrated that it is easily applicable and also, that it would be easily applicable in any other enterprise field and simultaneously understandable by all the users of the process.

This work and the lessons learned will be the starting point for the development of the models of those processes that the institution considers to be the most relevant ones in the fulfilment of its mission. Besides, this will allow the institution to have reference models that will be, among other things, the basis for: the certification within the program of continuous improvement of the hospital, the analysis and redesign of its processes, the evaluation of the efficiency of the process, the elaboration of hospital information systems, etc. In future works, we will complete the three processes chosen by the GHCR work group.

## ACKNOWLEDGEMENTS

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