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A Lightweight Approach for Designing Enterprise Architectures Using BPMN: an Application in Hospitals

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A Lightweight Approach for Designing Enterprise Architectures Using BPMN: an Application in Hospitals

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Summary. An Enterprise Architecture (EA) comprises different models at different levels of abstraction. At the higher levels, the business goals and process models are defined. At the lower levels, models become more detailed for implementing the supporting system. So, an integrated modeling approach is key for designing an EA. The different models must preserve the alignment to the business goals between the different levels. Since existing EA design approaches, e.g. MDA, use UML for modeling, the design of the architecture becomes complex and time consuming. In this paper, we present an integrated and lightweight design approach for EA that use a generic architecture and patterns, expressed in BPMN. The approach facilitates the modeling between the different levels. This has been applied in real cases in hospitals, demonstrating its feasibility and usability, reducing complexity and time for modeling. We also discuss the limitations and future work.

Key words: Enterprise Architecture, Business Process Management, Process Pattern, BPMN

1 Introduction

Enterprise Architecture (EA) captures the essentials of the business, processes and IT [9]. Many companies have been using EA for some decades [15]. Such companies have used different EA frameworks developed by industry leaders from different angles: Business and IT. Well defined processes are required for operationalizing business goals and aligning IT and people. Companies using EA as a management method have found that different representations of processes are needed according to the level of detail that managers want to know. Based on the reported experience of many companies [9, 15] and our own experience

with hundreds of redesign projects through the collaboration with industry [2, 3], the following levels of detail can be identified:

I. **Process Architecture, which is a high-level representation for communicating to executives**.

II. Business Process Patterns, based on the representation of value chains for communicating to process managers and business executives.
III. Process Logic that is a detailed representation of the process models for simulation and implementation for communicating to process specialists.
IV. IT Process Support that is the representation of the system supporting the execution of the processes for process and IT specialists

Different modeling schemes and tools can be used for each of these levels for process analysis and design. For example, for Level I, we can use simple diagrams as the one that are part of the first level of SCOR [6] or eTOM [8]. Next, for Level II we can draw informal Porter Value Chain diagrams [12] or more formal IDEF0 models [7]. Then, for Level III, we can use BPMN [16] or EPC [13] for more detailed models. For Level IV, depending on the type of implementation, we can use alternatives such as UML, Workflow diagrams or BPMN for implementing the supporting software application into a process-aware information system. Therefore, differences and inconsistencies appear as the models are designed by using different modeling languages at the different levels.

In this paper, we propose an integrative approach in which all the models are designed with BPMN and the process models are implemented in a BPMN-based system. We use a real case that is being developed in a hospital in the context of a Master thesis in Chile, an implemented with the opensource system BonitaSoft.

Related Work. Existing frameworks for designing Enterprise Architecture [11] use a similar approach. MDA [10] is based on UML for modeling the complete architecture, from business requirements to software architecture for implementing the supporting system. Since UML is not broadly used at the business level, the modeling becomes complex for not UML expert people and hard to communicate to business executives. MDA brings very detailed models to IT people for implementing the software system, but it still lacks a simplified communication feature for communicating the business elements. An analysis of a complex architecture, using MDA in combination with the Zachmann Framework [17] has been developed for investigating this gap and defining a mapping between them with a three-dimension approach [14].

TOGAF is a comprehensive framework for designing an EA, based on a iterative life-cycle which architecture modeling method (ADM) uses the Archimate language [9]. Although TOGAF does not force the use of Archimate, other modeling language can be used such as UML or even combining ADM with MDA [4]. In practice, TOGAF is generic and it can be

used for any company in any industry. Since TOGAF does not have any design pattern [5] for developing an architecture in a given domain such as healthcare, this process becomes complex and slow.

In previous research [1, 2, 3], we have developed patterns for designing an Enterprise Architecture in different industries such as healthcare. By using the patterns, the design process becomes faster than just using a generic framework as TOGAF or MDA. Preliminary versions of our approach used different modeling languages between different levels (I–IV) which was still hard to handle. In this paper, we present an EA design approach, using BPMN in the four levels in an integrative way.

Contribution. The contribution of this paper is an integrated and lightweight design approach based on patterns for accelerating the design process of an Enterprise Architecture in the healthcare domain, using BPMN.

The remainder of this paper is as follows. Section 2 explains the solving approach of the problem previously explained. Section 3 describes the approach for designing an EA with BPMN in a hospital. Finally, Section 4 describes the conclusions and future work.

2 Solving Problem Approach

The problem we consider is that the use different techniques and tools for de-signing the different models at the different levels of the EA (such as Levels I to IV) introduces duplicated work, inconsistencies, and lack of traceability. So, it is convenient whether the same modeling technique can be used for the different levels, maintaining consistency and traceability. In this paper, we propose such a scheme by using BPMN as modeling language for all models at all the four levels (I–IV). For this, we take the best of the different methods in which we have experience: Business Process Patterns (BPP) [1, 2] that are in line with the purpose of SCOR [6] or eTOM [8] but ad-hoc for different industries; BPMN modeling language, and process-aware information systems for implementing BPMN models.

The key ideas of our approach are:

1. In order to drive modeling at all levels of detail, predefined general process patterns are used. The patterns provide templates or general structures of activities and flows about how the process should be performed. Using these patterns, ad-hoc for different industries, the design or re-design process is accelerated.
2. We adopt a simple information flow representation and hierarchical decom-position of activities for gradually giving details of the process for Levels I and II.
3. BPMN is taken as the modeling language for all the models at all levels of details. This means that we use some of the simplest BPMN constructs to represent levels I and II, for flow type models.
4. We keep consistency and traceability with hierarchical decomposition: all the elements of any level should be details of an element of a higher level.

In the next section, we show how the levels I–IV can be modeled in an integrated way with BPMN, using examples from a real application in a hospital case that is being developed in Chile.

3 Designing the EA with BPMN

The approach that we propose is based on the integrated modeling of the different levels I–IV, using BPMN. We explain how each level is modeled for the case of a hospital. We first describe the Process Architecture Modeling (Level I) step, using flow diagrams in BPMN; see Figure 1.

Next, we explain the modeling of the Business Design (Level II) step, using Business Process Patterns for bringing more details of the process architecture. Next, we describe the Process Logic Design (Level III) step, using detailed BPMN process models of the business design. Finally, we show the IT Process Support (Level IV) step, using the system for enabling the execution of the process models. For simplicity, we select just one process model of the hospital case in Level III for its implementation in Level IV.

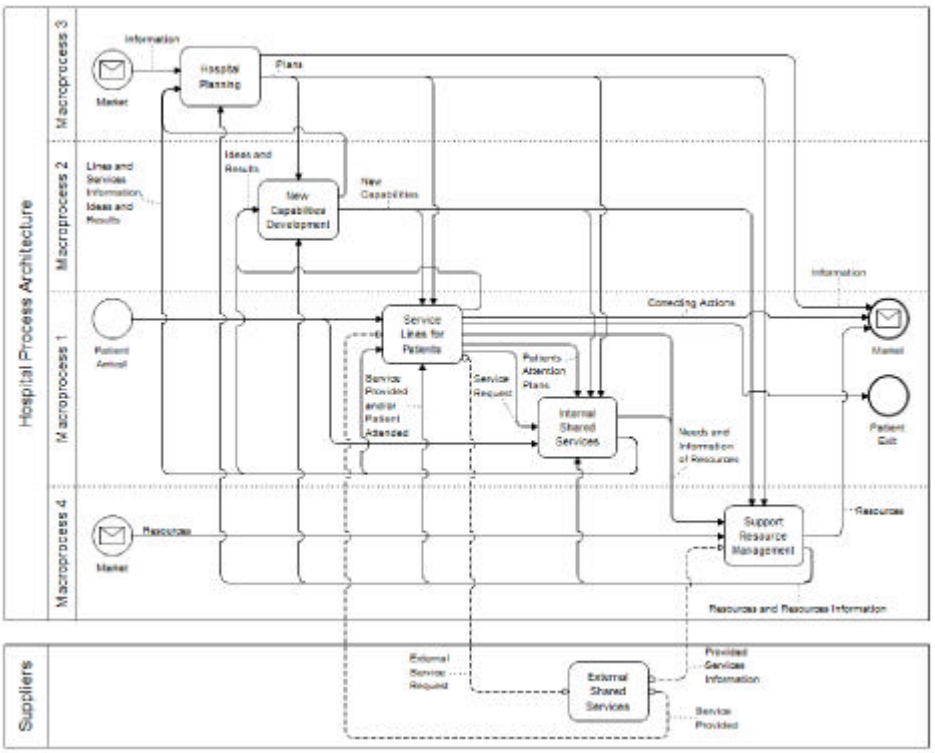

Fig. 1: Process Architecture for Hospitals (Level I)

3.1 Process Architecture Modeling (Level I)

We base the modeling of this level on general process architecture patterns reported on our previous research [1, 2, 3]. The patterns are based on the thesis that the architecture of any enterprise can be modeled by means of four general Business Process Patterns, which we call macro-

processes. In Figure 1 we show the resulting architecture for the type of hospitals we are working with, based on the macro-processes.

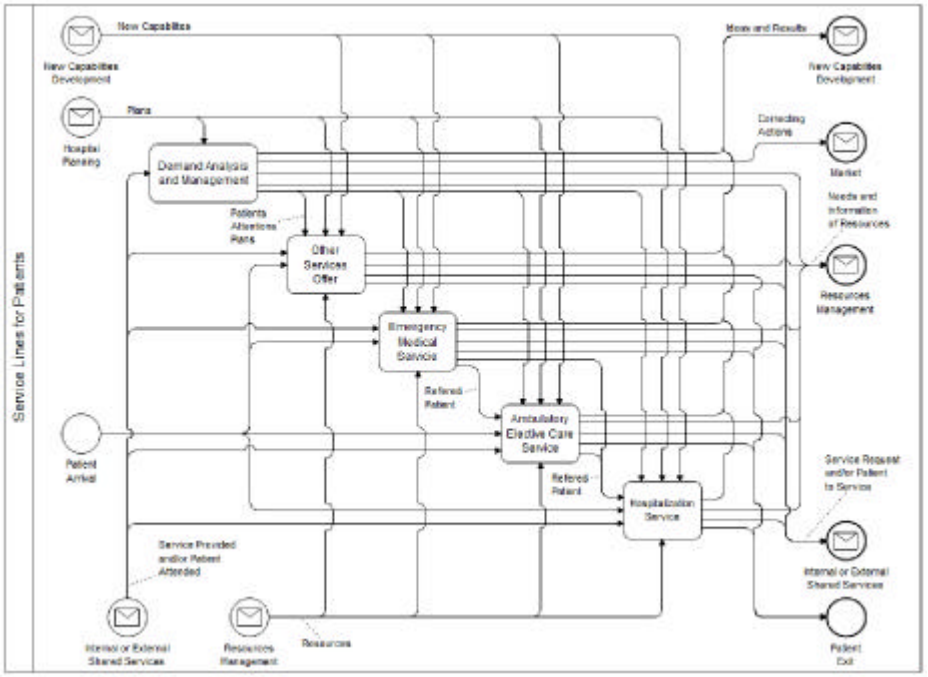

Fig. 2: Detail of Services Lines for Patients

The patterns we propose have been validated in hundreds of practical projects in several domains, where they have been specialized and used as a starting point to perform architecture and process redesign. In particular, we have been able to generate, starting with the general patterns, the solution for architecture for hospitals [1].

In Figure 1, we show the first level of the architecture (called macro-processes) that corresponds to a general model that establishes a structure that defines all the process groupings that are necessary to run any hospital [1], considering the minimal set of required services. Thus, Figure 1 shows the services lines or value chains that a hospital offers, which are then detailed, by hierarchical decomposition, in Figure 2. Next, in Figure 3 we illustrate that such service lines use shared services as modeled in Figure 1.

Different structures built with the macro-processes provide several typical architecture patterns that can be used for designing the architecture in particular cases or different companies and domains. Each macro-process is itself, a layered normative structure of processes. A macro-process gives, in several levels of detail, the processes, sub processes and activities that should be executed in order to produce a desired result. Moreover, a macro-process provides a solution for the design of the processes within a selected architecture.

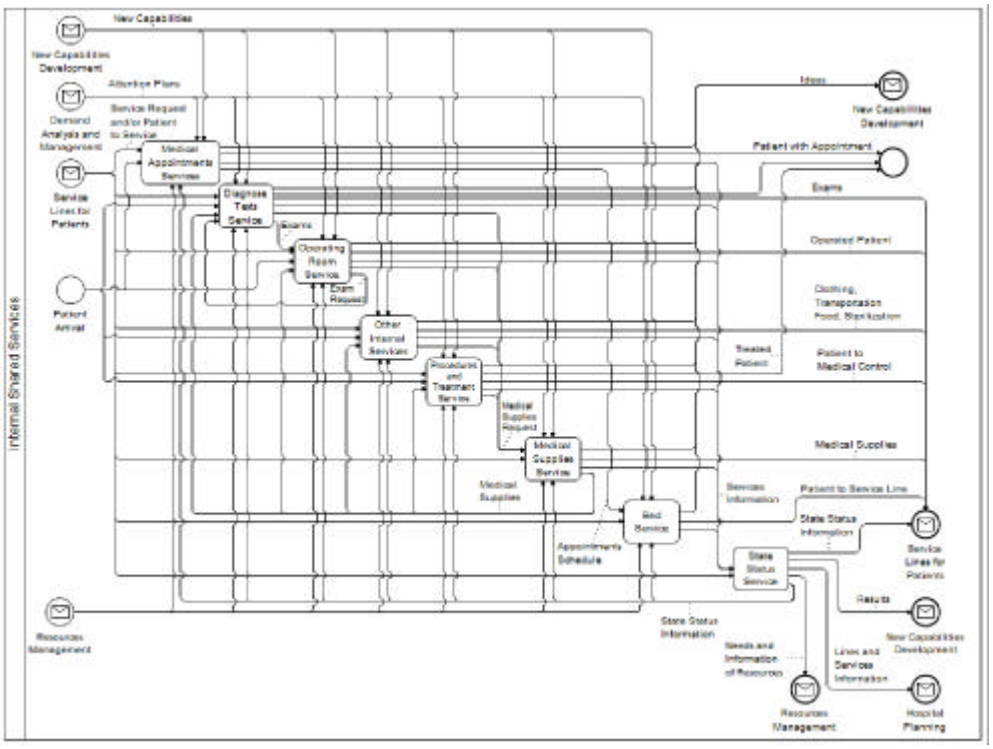

Fig. 3: Detail of Internal Shared Services

Both architecture and macro-processes patterns are modeled with BPMN, in a consistent and integrated way. This gives the components of the patterns, specifying their relationships by means of flow specifications. This is an innovation with respect to other approaches for designing a process architecture, which are based on reference models and frameworks that only provide hierarchies of components [13, 17].

An important point of our approach, validated by experience, is that the most important factor in designing the architecture is the modeling of the relationships that coordinate all the components and make them perform as a system.

3.2 Business Design using Patterns (Level II)

We design the different processes of the architecture, using Business Process Patterns (BPP) that define subprocesses and the relationships that should be present [1, 2, 3] in a hospital. For example, in Figure 4 we show the design model of one of the processes of Figure 2: Ambulatory Care Service. Next, we can give further details of its subprocesses in the corresponding models. For our running example, we choose the subprocess Patient Management that we illustrate in Figure 5. In this way, we model each subprocess preserving the consistency with the models of

the previous level. In the next step, we continue modeling the subprocesses with more details, using more BPMN elements.

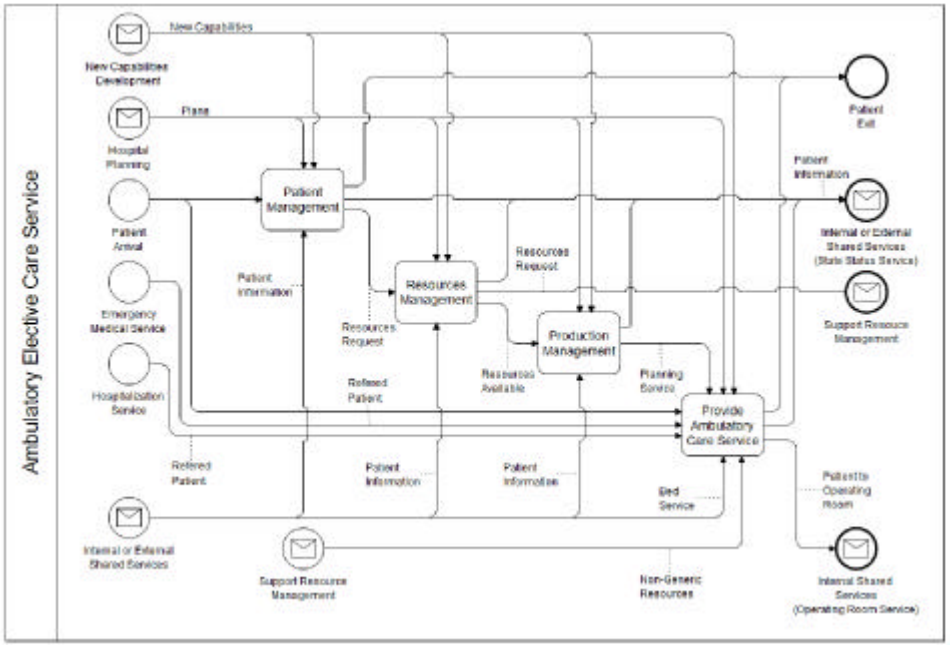

Fig. 4: Design of Ambulatory Care Service (Level II)

3.3 Process Logic Design (Level III)

Here we model with much more detail the subprocesses of the Patient Management process, for giving the procedural execution logic in full BPMN. For the last level of process design, a BPMN model with lanes is used, which presents the different organizational roles involved in the activities and how the are supported by the information system. For our running example, we detail the BPMN model for the process Attendance Control of the Patient Management in Figure 6. In the figure, we illustrate a Paramedic that interacts with the system to control the attendance of the patients.

The process model of Attendance Control that we have designed tries to solve one important problem currently observed at a given hospital, which is that 20% of medical visits reserved do not take place because of patient absenteeism. A better Attendance Control process improves the performance of medical booking service and permits to reduce the waiting list of patients.

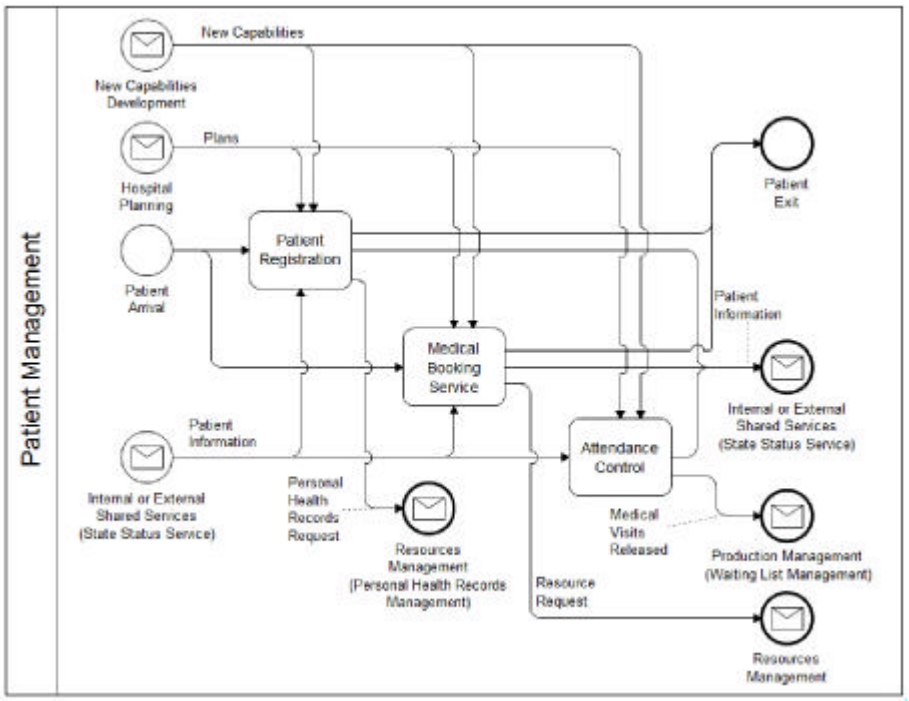

Fig. 5: Detail of the Subprocess Patient Management of Fig. 4

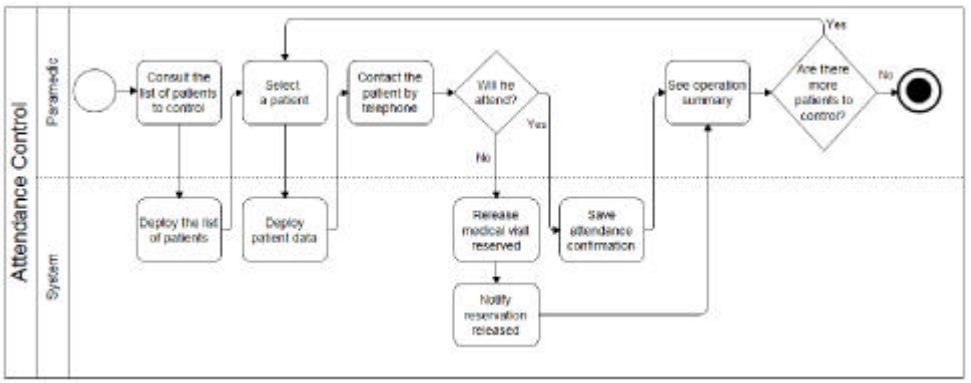

Fig. 6: BPMN diagram for Attendance Control (Level III)

The function of the Paramedic is to detect patients that will not attend their previously reserved medical visits, and release these unused reservations to be utilized for patients on a waiting list.

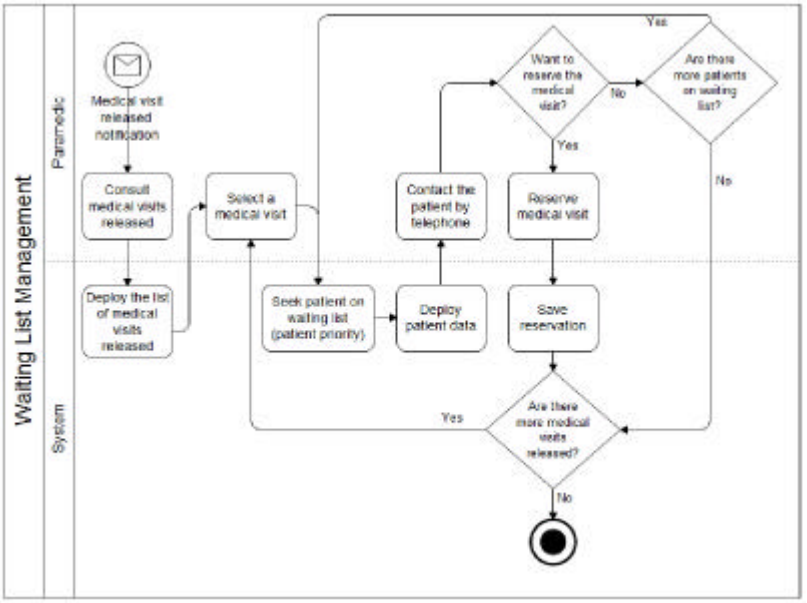

Fig. 7: Waiting List Management (Level III)

Once completed Attendance Control process, the Paramedic has some medical visits available for assigning to patients in the waiting list. This is the purpose of Waiting List Management process that is shown in Figure 7.

In the Waiting List Management process, the Paramedic contacts each patient in the waiting list, and asks whether he/she wants to reserve the medical visit that is available. The patients with longer waiting time have more priority to be contacted first.

A recurrent problem faced by hospitals, particularly public hospitals in Chile, is the over-demand for medical services. Given this, it seems reasonable to in-crease the hospitals capabilities to cover a much bigger amount of patients. However, this is not feasible for hospitals with limited capacity of resources, so the only solution is to increase the efficiency of internal processes in order to meet increasing demands.

With the purpose of improving the efficiency, our aim has been to generate two processes that allow better using the capacity and resources of the hospital. This is, to know who are the patients will not attend at their medical visits, and assign those slots to waiting patients.

Currently, the hospital does not take actions about the absenteeism of patients, so the medical visits are lose. In this circumstance, these capabilities could be reassigned to patients in waiting lists that ultimately means shorter wait times and better service.

By performing the design of the architecture of the Hospital from Level I to Level III, we have discovered several issues such as lose of resources that restricts the capacity for attending more patients. We have detailed the process models of Figures 6 and 7 in our running example for

illustrating one of these discovered issues. Moreover, no digital registers are available for controlling the patient attendance. So, we have proposed the implementation of these processes in an information system that provides BPMN modeling design features and easy automation of the processes.

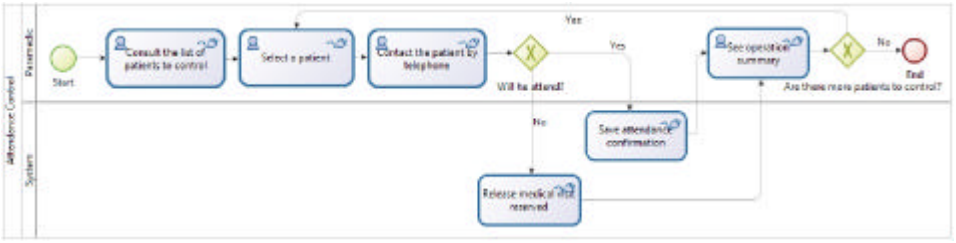

Fig. 8: Attendance Control Process in BonitaSoft, the same as Fig. 6

3.4 IT Process Support (Level IV)

We illustrate this level with the case in which we want to automatically generate the supporting system for the processes models in BPMN. For this, we use an information system that allows the execution of the BPMN models defined in the Level III. We illustrate this with BPMN-oriented systems that provide facilities for such an execution. This implies a semi-automated step for making the BPMN process models executable in the engine, including the design details that were not specified so far such as human interfaces and web services for accessing data in other systems and executing complex logic.

The BonitaSoft system is used to demonstrate the easy implementation of the processes from the models designed in Level III. As an example we use the model in Figure 6 for implementing the process in the system using the designer tool of Bonitasoft, which is illustrated in Figure 8.

The Attendance Control process that we developed requires interactions between a Paramedic and the system that supports the process. This IT system is the BonitaSoft prototype. The prototype system starts when a Paramedic selects the day he wants to control. Next, the system searches for patients that have reserved a medical visit for that day and deploys a list of patient to control their attendance. Figure 9 shows a screenshot of this part of the process.

Next, the Paramedic selects a patient and then the system deploys the contact information, as shown in Figure 10. Then, the Paramedic calls each patient by telephone and asks them if they will attend the hospital. In the case a patient will not attend, the Paramedic releases the reservation and it is available to be used by another patient, especially by people who are in the waiting list with high priority. Finally, the Paramedic continues until there are not more patients to control their attendance in that particular date.

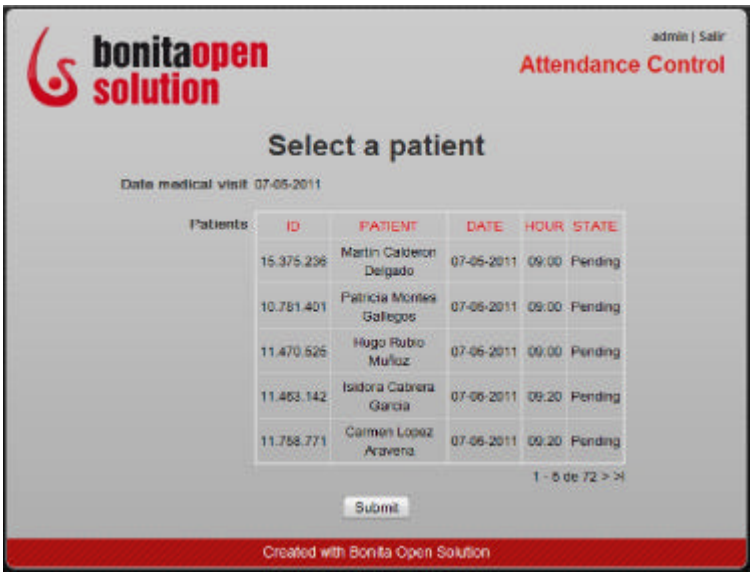

Fig. 9: Select a Patient Task

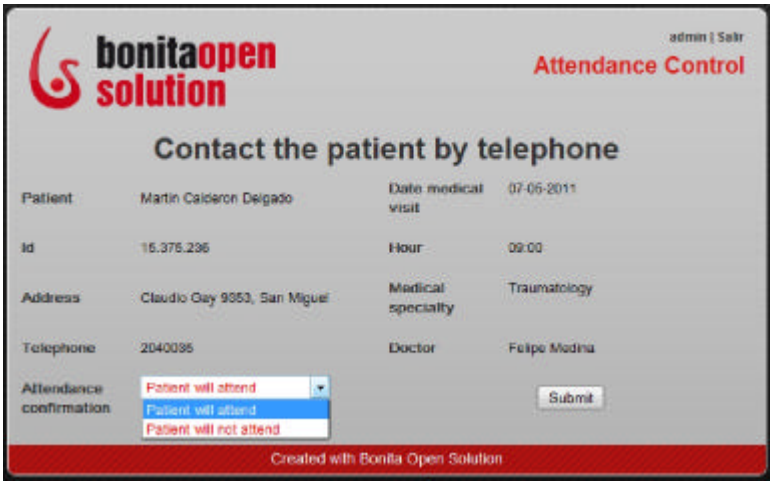

Fig. 10: Contact the Patient by Telephone Task

3.5 Discussion

All the steps performed from Level I to Level IV have taken just 4 weeks for implementing the processes in the prototype for our running example. This means, that in this period we have been able for designing the architecture of the hospital, developing the redesign of the critical processes, implementing the redesign processes in the supporting system and communicating all the changes to the different stakeholders at every level (I–IV). Compared to other EA design approaches as Zachman [17], MDA [10] and TOGAF [9] that take long and be-come complex due to the generic guidelines, our approach accelerates the design process of the EA by using process patterns and BPMN as the only modeling language. So,

our approach represents an integrated and lightweight design process for an Enterprise Architecture. Although this is preliminary result and need much more success cases, we have shown in a real case that indeed our approach is less complex, much easier to use and faster than existing approaches.

4 Conclusions

We have considered the problem of Enterprise Architecture (EA) that comprises different models at different levels of abstraction. An integrated modeling approach based on patterns has been proposed for designing an EA. The different models preserve the alignment to the business goals between the different levels and ensure consistence and traceability. The approach has been applied to real life process designs in hospitals that have been implemented or are under implementation. We have presented a small sample of such applications.

The experience generated with this project supports the conclusion that it has advantages, in terms of speed and quality of design, having patterns of the type that we have proposed for designing the architecture. Moreover, the combination with BPMN process models has also shown that the process implementation and execution in the supporting system can also be accelerated. This also has the advantage of providing flexibility for changes, since this can be done by editing BPMN process models.

There are several other directions for future work. We are currently implementing the prototype with more processes in several hospitals in Chile for redesigning and automating processes, aiming the improvement for using the resources with high patient demands. Moreover, we are extending our approach to include other domains as banking and manufacturing.

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