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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 uses 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 and other domains, demonstrating its feasibility and usability, reducing complexity and time for modeling. We also discuss the limitations and future work.**

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

## 1 Introduction

**Enterprise Architecture (EA) captures the essentials of the business, processes and IT [11]. Many companies have been using EA for some decades [17]. 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 [11, 17] 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 Design based on the process representation of value chains for its presentation 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 [10]. Next, for Level II we can draw informal Porter Value Chain diagrams [14] or more formal IDEF0 models [9]. Then, for Level III, we can use BPMN [18] or EPC [15] 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 to exemplify our ideas.

Existing frameworks for designing Enterprise Architecture [13] use a similar approach to the one we propose. MDA [2] 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 non UML experts and hard to communicate to business executives. An analysis of a complex architecture, using MDA in combination with the Zachmann Framework [19] has been developed for investigating this gap and defining a mapping between them with a three-dimension approach [16].

TOGAF is a comprehensive framework for designing an EA, based on an iterative life-cycle which architecture modeling method (ADM) uses the Archimate language [11]. 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, this process becomes complex and slow.

In previous research [1, 2, 3], we have developed patterns for designing an Enterprise Architecture and processes 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. In this paper, we present an EA design approach, which uses BPMN to model designs based on our patterns at the four levels in an integrative way. We concentrate on

the Process Architecture, but other architectures such as the application, data and technical architectures are present in design Levels III and IV defined above.

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 Problem Solving Approach

The problem we consider is that the use of different techniques and tools for designing the different models at the different levels of the EA introduces duplicated work, inconsistencies, and lacks traceability. So, it is convenient that the same modeling technique is used for the different levels, maintaining consistency and traceability. In this paper, we propose a scheme that uses BPMN as a unique technique for designing and modeling all the four levels (I–IV) defined above. 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 [10] but valid 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, which are based on what we call macroprocesses, provide templates or general structures of activities and flows about how a process should be performed. 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 [1,2,3]. Each macroprocess is itself, a layered normative structure of processes. A macroprocess gives, in several levels of detail, the processes, sub processes and activities plus the relationships that should be executed in order to produce a desired result.
2. Using these patterns, ad-hoc for different industries, the design or re-design process is accelerated.
3. We adopt a simple information flow representation and hierarchical decomposition of activities for gradually giving details of the process for Levels I and II.
4. 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.

5. We keep consistency and traceability with hierarchical decomposition: all the elements of any level should be details of an element at a higher level.

Other authors such as Freund and Rücker [8] have proposed the use of BPMN for process modeling; they only concentrate on Levels III and IV of our approach. They do not consider the process architecture design of Level I by using frameworks as SCOR [6] or eTOM [10], nor the business design of Level II by using Porter Value Chain or IDEF0 diagrams. Therefore, their approach lacks the strategic and business alignment for designing processes.

According to the design guidelines of Hevner et al. [9], we propose an approach that produces an artifact that can be used by practitioners to provide solutions in a given domain. Our design domain is stated above and goes from strategy based process architectures to information systems that support such processes. This problem is very relevant since most organizations deal with process and information system design on a piecemeal basis, without considering the integration that we propose. The evaluation of our approach has been done in hundreds of real life projects in a mix of experimentally controlled cases and descriptive analysis [1,2,3] in several domains. So, the research rigor of our approach is founded for both constructing and evaluating the resulting artifacts. The research contribution is a well-defined hierarchy of design problems with rules and methods that guide the designer for going from one level to the following, and also on how to execute each level. A very brief summary of such rules is as follows:

- Level I: Architecture is designed by specializing a selected pattern that has options about components and relationships; a selection of these is based on business goals and resulting selection in modeled by flow models in BPMN.
- Level II: Each selected component in Level I is specialized starting with the macroprocess pattern that corresponds to such component; such patterns have options and also a selection should be made based on business goals and possibly an economic evaluation of alternatives, resulting in a selected sets of processes modeled in BPMN.
- Level III: Processes selected in Level II are designed in detail by means of procedural models in BPMN, having as objectives business goals as better management of resources and providing simulation capabilities to evaluate performance and results.
- Level IV: BPMN models of Level III are converted to be executed on a selected process engine.

Finally, our design approach is based on the search of a proper artifact that solves a problem in a given domain, using and reusing process patterns [1, 2]. Also, our approach provides the effective communication of models at every level (I–IV) for each different user.

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

We explain how each level defined above is modeled for the case of a hospital. We first describe the Process Architecture Modeling (Level I) step, using flow diagrams in BPMN. 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.

### 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 macroprocesses. In Figure 1 we show the resulting architecture for the domain of hospitals we are working with.

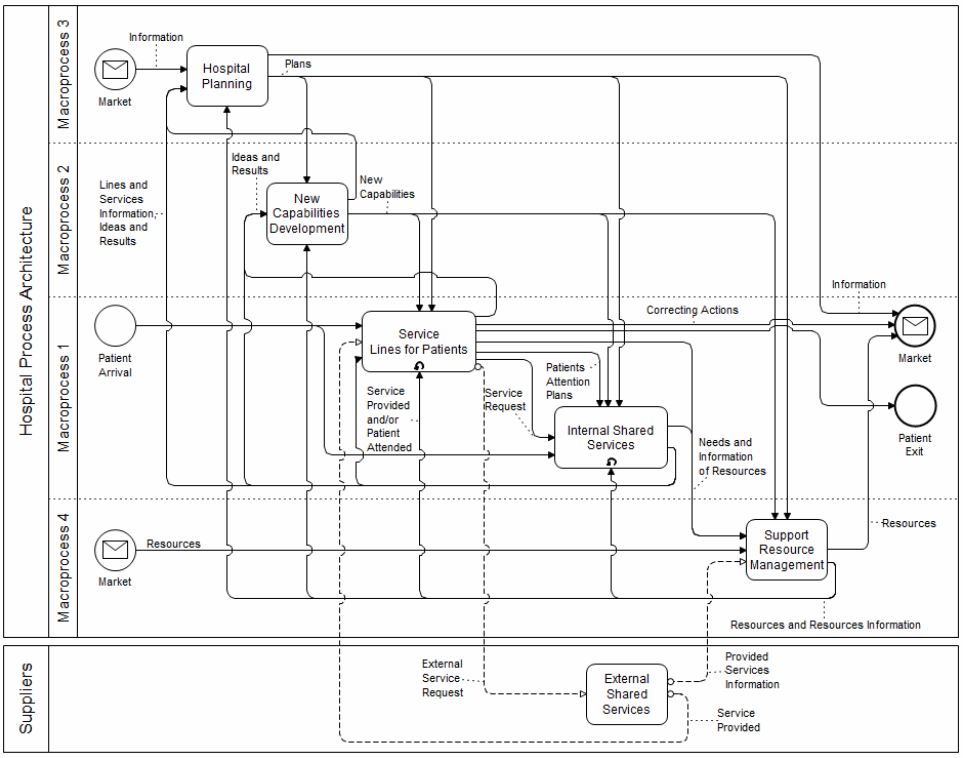



**Fig. 1: Process Architecture for Hospitals (Level I)**

**The architecture pattern we use in Figure 1 is called shared services, which has several value chains that share several common services. Each value chain and shared service is a macroprocess or group of processes connected by means of information flows, for which we have a general pattern [1,2,3]. Other macroprocesses, for which there are also patterns, that are part of the general architecture are Business (Hospital) Planning, New Capabilities Development (such a new facilities development), and Support Resource Management (such as human resource management). Then, Figure 1 provides 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.**

**From the architecture we select the macroprocess that are to be designed in detail, which is Service Lines to Patients , since the business goal in this case is to improve the service to patients and make a better use of resources, and it is considered that it can be done by designing this macroprocess. Such services lines or value chains are then detailed, by hierarchical decomposition, in Figure 2.**

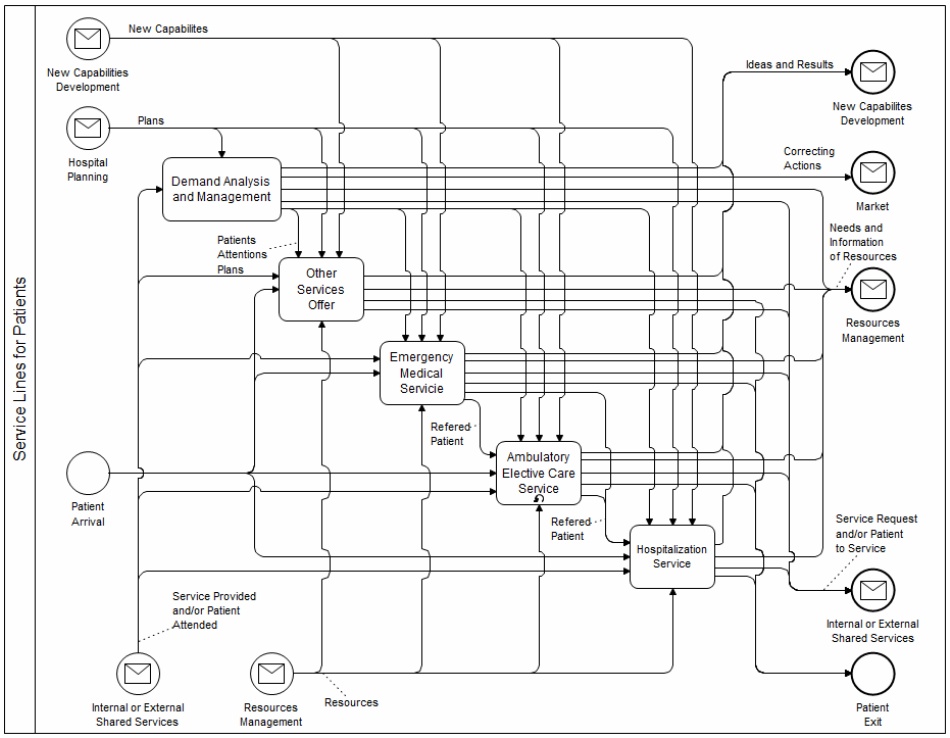



**Fig. 2: Detail of Services Lines for Patients**

**Both architecture and macroprocesses are modeled with BPMN, in a consistent and integrated way. This gives the components of the models, 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 [6,10,15, 19].**

**A key point of our approach 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)

**The basic rule that we apply for designing in this level is to take the structure of processes provided by the architecture of the previous level and design each of its components by using the process pattern corresponding to the value chain. This provides a set of sub processes that are necessary to execute. Then the components are specialized to the particular case; i.e. to establish how every sub process of the pattern is**

**currently executed, if at all, and then evaluating technically and economically the feasibility of performing it according to what the pattern prescribes.**

**For example, in Figure 3 we show the design model of one of the processes of Figure 2: Ambulatory Elective Care Service. This is the result of comparing the corresponding pattern with what it is currently done and deciding that sub processes in Figure 3 are the ones needed in this case. Next, we can give further details of these sub processes by decomposition. For our running example, we choose the subprocess Patient Management that we illustrate in Figure 4. 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.**

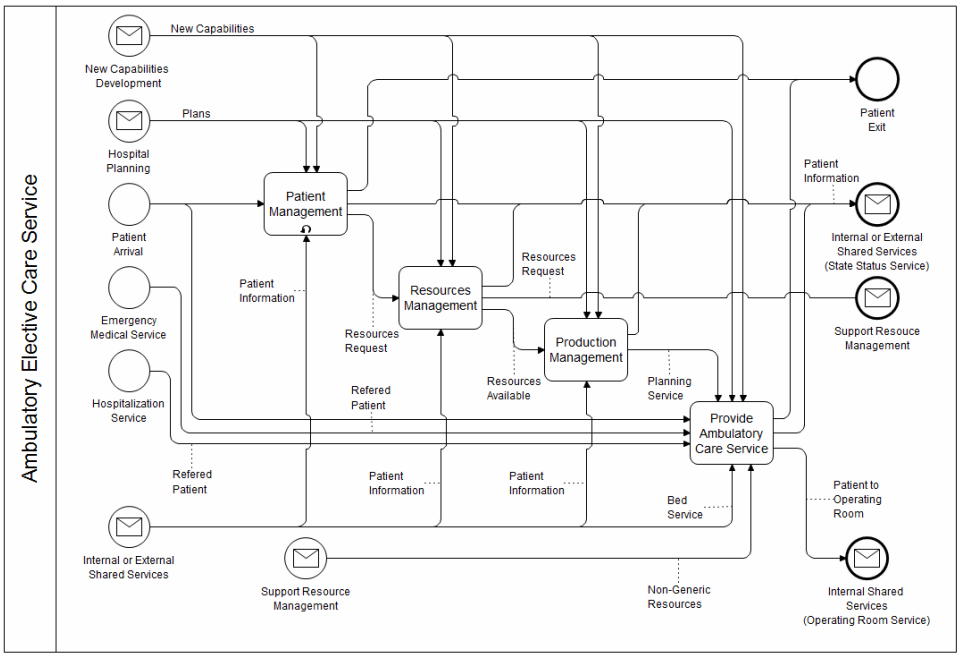



**Fig. 3: Design of Ambulatory Care Service (Level II)**

## 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 they are supported by the information system. The basic rule is that each of the sub processes designed in the previous level should be detailed in terms of who is responsible for each activity of the sub process, the business logic that will be executed by people or the information system and the workflow that establishes the relationships**

among activities. This should be consistent with the previous level in that all the functionality that a sub process provides at such level and the relationships it supports must be provided by the design.

For our running example, we detail the BPMN model for the sub process Attendance Control of Patient Management in Figure 4. In Figure 5, we illustrate a Paramedic that interacts with the system to control the attendance of the patients.

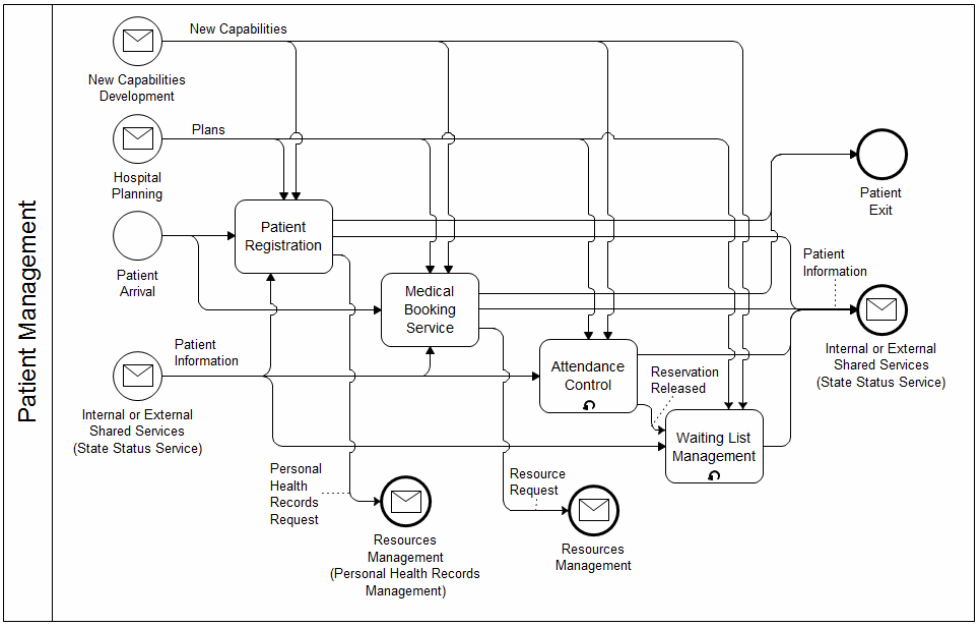
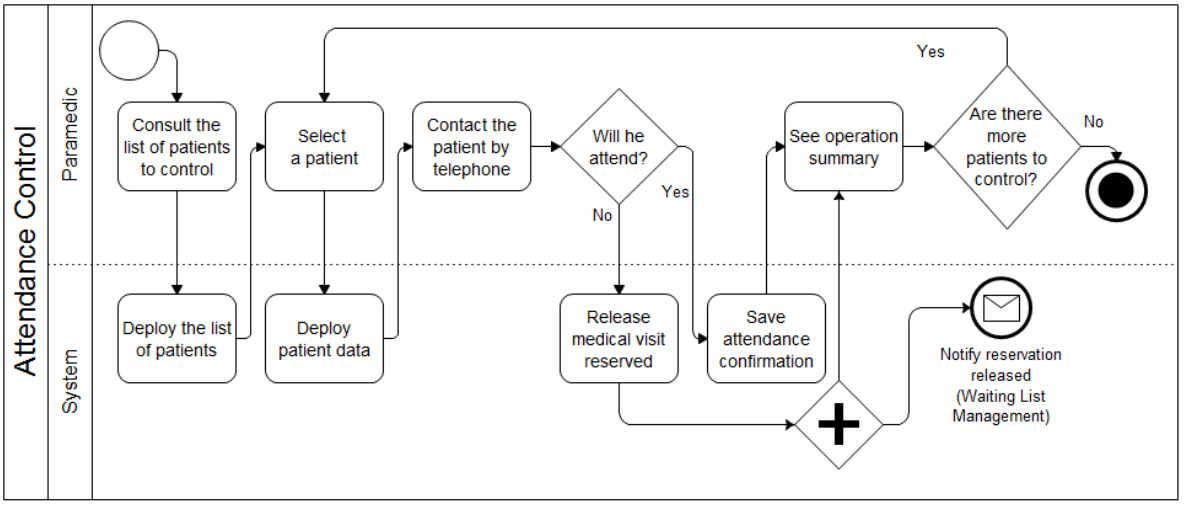



Fig. 4: Detail of the Subprocess Patient Management of Fig. 3

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 fail because of patient absenteeism. We aim to improve the performance of medical booking service to reduce the waiting list of patients. This is done by introducing a logic that detect patients that are likely not to attend and calling them to check them up. This generates the possibility of assigning liberated medical hours to patients in a waiting list that otherwise will not get attention.



**The Attendance Control process generates vacancies that are assigned to patients in the waiting list, according to the sub process Waiting List management, which is shown in Figure 6. In this 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 and are contacted first.**

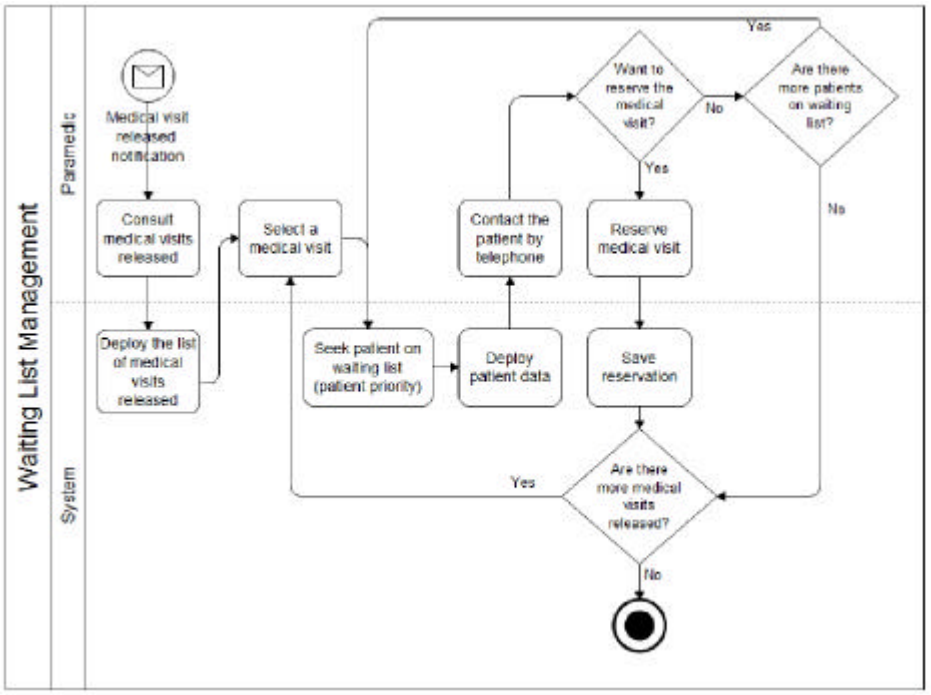
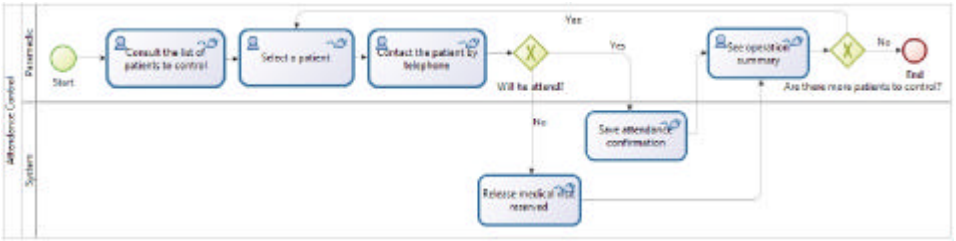



**Fig 6: BPMN diagram for Waiting List Management (Level III)**

## 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 a BPMN-oriented system that provides 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 5 for implementing the process in the system




using the designer tool of Bonitasoft, which is illustrated in Figure 7.

Fig. 7: Attendance Control Process in BonitaSoft (same as Fig. 5)

### 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 designed the architecture of the hospital, developed the redesign of the critical processes, implemented the redesigned processes in the supporting system and communicated all the changes to the different stakeholders at every level (I–IV). Compared to other EA design approaches as Zachman [19], MDA [12] and TOGAF [11] that take long and become 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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