Bridging the gap between business process models and use-case models

Adam Przybyłek
Gdańsk University of Technology
Narutowicza 11/12, 80-233 Gdańsk, Poland
adam.przybylek@gmail.com

***Abstract*— Today's software development methodologies are equipped with a plethora of methods and techniques for business process engineering and Requirements Engineering. However, heavy investments in IT have not brought forth expected results. What seems to be lacking is a systematic approach that consolidates both disciplines to gain a synergistic effect. To address this challenge we extend Use-Case Driven Approach (UCDA) by binding use case models with business process models. Our approach begins with comprehending the business processes and creating their model. Then, it takes the stakeholders through identifying improvement opportunities in the processes and selecting these processes that are supposed to be computer-aided. Finally, system requirements are derived from the process model.**

Requirements Engineering, Business Process Modeling, BPM, use cases, UCDA, requirements traceability

I. INTRODUCTION

Today's software development methodologies are equipped with a plethora of methods and techniques for business process engineering and Requirements Engineering. However, experience has shown that these methods and techniques deliver disappointing results when being applied independent of each other [2]. A recent survey [29] reports that in 179 out of 372 organizations that were surveyed, the support provided by the existing software systems was never or occasionally consistent with the business processes.

There are two main obstacles to effective alignment of business processes and the Information Systems (ISs) that support them: (1) the ISs are not developed with a correct understanding of the business they are supposed to support; and (2) business processes are not linked to the system requirements and thus evolve independent from the IS.

To address the above issues we propose a systematic approach that integrates well-established methods and techniques from the disciplines of business process engineering and Requirements Engineering. This is the answer to the Jacobson's claim [11] that "a tight, seamless relationship is required between the process that develops the business model and the process that develops the information system". Our approach is an extension of Use-Case Driven Approach (UCDA).

The basic concepts of UCDA are actors and use cases [10]. An actor is a specific role played by a system user, and represents a category of users that demonstrate similar behavior when using the system. By users we mean both human beings, and other external systems or devices that interact in some way with the system; by definition, they are outside the system. By analyzing potential behavior of each actor different use cases are identified. A use case is a specific scenario of the system usage described as a sequence of actions (including variants) that actor and system perform in order to yield observable results of value to a particular actor [12]. The descriptions of actors and use cases form the use case model. Being use-case driven means that use cases bind together all the activities within a project. Our approach enhances UCDA by linking use cases with business processes in an explicit and traceable manner. It consists of three stages (see Fig. 1) that are explained in Section 3.

II. MOTIVATIONS

Surveys reveal that UK companies waste 40% of the total amount they spend on IT because the systems they build are not aligned with business strategies [16]. There are various possible sources of this misalignment. First of all, customers usually can not articulate requirements that truly reflect their business needs and are not involved enough in the requirements engineering process. Therefore, we support the viewpoint that business analysis must precede requirements elicitation in order to obtain a deep enough understanding about the organization.

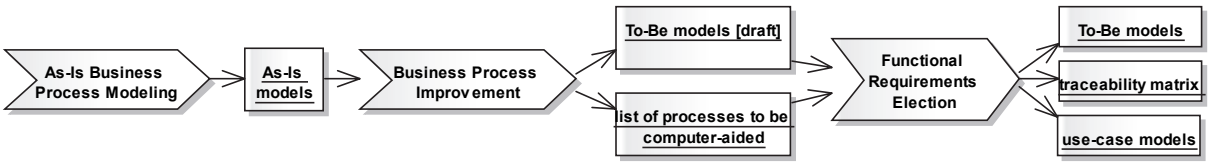

Figure 1. Overview of our approach

Second, even if business process modeling (BPM) is considered in the software development process, practice has shown that business processes are not consistently documented and that the different stakeholders tend to use different notations, conventions and techniques to represent them [18]. Having many notations cause miscommunications, rework and results in inefficiencies.

The situation is even worse when we consider that BPM is usually carried out using a different notation then software modeling. A recent survey [9] shows that the vast majority of business people (72%) use BPMN, while UML, which is a standard in software design, was listed only by 18% respondents (the respondents could indicate more than one notation; 8% chose EPC). If we could use the same notation through the whole project all stakeholders can share the same work products. In our previous work [20] we demonstrated that UML Activity Diagram and its extension called Business Process Diagram provide means to describe business processes at different levels of abstraction (if the reader is not familiar with these diagrams, we recommend reading Eriksson & Penker [5] and Wrycza et al. [30]). We also showed how to apply functional decomposition to Activity Diagrams to develop efficient business process models. In turn, Marcinkowski [17] pointed out several other advantages of UML over BPMN, in particular a support for modeling the structural aspects of an organization. Summarizing, we are convinced that UML builds a bridge between the business and the system development side.

Third, even supposing the business processes have been properly modeled and understood, the transition between business modeling and the next phases is still obscure [24]. There is a lack of established practices that would drive requirements elicitation based on the underlying business process models. This lack of requirements elicitation support is probably one of the main drawbacks of UCDA [13].

Finally, well-specified requirements that results in implementing adequate IS do not guarantee that the business processes remain in harmony with the IS forever. Organizations are in a constant change. They must respond to new legislation, pressure from competitors, and opportunities afforded by technological advance. The challenge for ISs is to be able to flexibly adapt to evolving business processes. There are two conditions that must be met to achieve this flexibility: (1) an IS must be designed and implemented in a modular way that supports evolution; (2) the documentation must link business processes to artefacts of an analysis, design and implementation in an explicit and traceable manner. Note, that the first condition is out of the control of our approach.

III. Research Design

This research reports on the action research project at a private university. The university was experiencing problems with an overwhelming amount of work during the admission and timetabling period. It was usual for administrative staff to work overtime, evenings or weekends. Moreover, the highly competitive market of educational services was forcing the university to improve the teaching process and communication among lecturers and students by leveraging IT solutions. Nevertheless, the authorities did not have a clear and detailed idea about the real needs and were not completely sure what they wanted.

The action research methodology aims at providing value to the participant organization but acquiring new knowledge at the same time [23]. The research objective was to develop a new approach that (1) supports requirements elicitation under conditions of uncertainty about client needs; and (2) makes that the system requirements are in alignment with and provide support for the underlying business processes. The practical objective was to analyze the business situation, identify opportunities for improvements, and specify the requirements of an IS that supports the business needs.

The participant organization was selected for this research due to: (1) its willingness to undergo a process of innovation; (2) its interest for the project that was founded from an external grant (it was free for the organization); (3) its accessibility, and (4) the application domain that was known by the researcher.

Four main approaches to data collection were used in this research. These were: semi-structured and unstructured interviews, observation, workshops, and document analysis.

The researcher met with seven customer representatives at every level in the organization. These representatives were selected by the research coordinator, who was an employee of the university and knew the staff. Then, the representatives were trained in business process diagrams, activity diagrams and use case diagrams. As part of their training, they had to model business processes and draw a use case diagram based on the given case study.

The customer stakeholders participated in the project to varying degrees. During As-Is business process modeling, the researcher created models and then the customer stakeholders were consulted to validate the models. This approach is called consultative participation. In contrast during business process engineering and use-case modeling, the customer stakeholders collaboratively developed models in facilitated group sessions. This type of participation is consensus-driven in the sense that it is the stakeholders who "own" the model and hence decide its contents [3]. The main role of the researcher was to present the findings from the data gathered earlier, facilitate the discussion, make suggestions, and gain feedbacks.

IV. Approach Description

A. As-Is Business Process Modeling

The first stage of our approach aims at understanding the organization for which an IS is going to be developed. Business process models are the main deliverables of this stage. To model an organization we need knowledge related to the organizational activities and the business environment. This knowledge can be acquired through observation or interviews with the staff participating in the execution of the business processes. Observational methods involve a business analyst viewing employees as they work. In turn, an interview can be guided by focus questions such as: What are the main processes of the organization?; How are these processes related?; What activities do these processes consist

of?; Which information and material flows do these processes consume and produce?; Which actors are responsible for performing and supporting these processes? [3]. A complementary way of obtaining information is by reviewing the various forms used in the organization or by process mining [21, 22].

The gathered information is used to outline an overall picture of the business on process diagram [5]. The diagram must include all fundamental enterprise-wide processes. Each complex process contains a number of activities that are performed as part of the process. Each of these activities can be considered a process of its own and as a sub-process to the containing process [20]. Thus, we can progressively apply functional decomposition and model the internal structure of each complex process at a lower level activity diagram. A process can be broken down into smaller sub-processes as long as an elementary level is achieved. A process is elementary if it is performed in one location at one time and leaves the business in a consistent state [6].

The obtained diagrams should be validated by the customer stakeholders. Usually, several iterations are needed to get the final versions. The resulted models (As-Is) describe how the business is working today at any level of abstraction from enterprise-wide processes to single tasks performed by single people. For various guidelines that can support business process modeling, the reader is referred to [26].

B. Business Process Improvement

Once the business processes have been modeled, we have to agree what part of the business is to be automated. Two important factors that must be considered are costs and benefits. Note, that automating processes for the sake of automation does not lead to significant improvements [28]. Thus, as suggested by Hammer [8], instead of blindly automating manual processes, the processes are reengineered while taking advantages of the possibilities for automation.

At this stage a workshop with key stakeholders should be held. The role of the workshop is to bring stakeholders together for a common purpose, for a short, intensive period. The role of customer stakeholders is to give feedback about the findings and suggestions presented by analysts, make their own proposals, and provide more knowledge about the current situation [15]. The most crucial technique at the workshop is brainstorming. Brainstorming contains two phases: the generation phase, where ideas are collected; and the evaluation phase, where the collected ideas are discussed [14]. To foster a creative atmosphere and get input from all stakeholders, no criticism or debate is allowed in the generation phase. Some of the ideas generated in a brainstorming session will be worthless, but they will have served their brainstorming purpose by inspiring other, more useful ideas. An idea may be impracticable as is, but a mutation of it need not be. When the idea-generation phase terminates, it is time to initiate idea reduction [14]. The facilitator walks through each idea and asks the submitter to provide an explanation. Then, the group discusses the ideas and eliminates those that are not worthy of further consideration.

The first step at the workshop is to identify improvement opportunities in the business processes. By analyzing the existing processes, the participants look for redundancies and bottlenecks. This step may be supported by dedicated software to simulate the modeled business processes [7]. Next, the participants identify and discuss new organizational needs that could be fulfilled by IT. They also analyze how IT can reshape the way business is done today in order to create an environment in which the staff exploits information more effectively.

The second step is to decide which elementary business processes (EBPs) and in what extent we are going to computerize. For each EBP there are three possibilities. A process may be either performed automatically by an IS, or supported by an IS, or performed manually. The abbreviations “A”, “S”, and “M” in the process descriptions represent these situations. A process is automated when the IS performs it without human participation. A process is supported when a user interacts with the IS to perform the process.

For each EBP the customer stakeholders consider how an IS may help a worker complete a process and assess the potential benefit using a Low-Medium-High scale. In turn, the technical stakeholders estimate the cost of the computerization. In many cases, one EBP can be computer-aided more readily as a result of having computerized another EBP. If computerization of a certain EPB is irrational without computerization of other EPBs the cost is estimated with an assumption that the closely dependent EPBs are also computerized. All closely dependent EPBs are explicitly listed for each process. Since new business processes may occur after this stage, the process models generated at the previous stage must be adjusted.

C. Functional Requirements Elicitation

At this stage, JAD workshop is still the main technique for gathering information and collaborative decision-making. The business processes that have been designated to computerization, are used to derive functional requirements that the IS should supply (and that the business needs). When reviewing literature, several concrete procedures on how to transform business process models into use case models can be found [4, 24, 27]. However, from our experience, it has seemed to us that the transformation process cannot be algorithmized, and so we provide only general guidelines that support this stage. First of all, we must look from both the perspective of the system (asking what will make up a well-defined use case?) and from the perspective of the business process (asking what is needed from the IS?) [5]. A well-defined use case must specify a complete functionality which yields an observable result of value for one or more actors.

We suggest to start the transformation from the processes labeled with ‘S’. Usually, we must create a use case for each such process. Then, the partition at which this process is occurring is mapped to an actor associated with the use case. Next, we move to the processes labeled with ‘A’. Usually, they are computerized as a part of the other use cases that have been already created. If we mapped an entirely

automated process to its own use case, the use case would not be associated with any actor. According to the UML semantics, this situation is not valid.

Note, that an organization may change due to the IS deployment, and the change may have an effect on the business processes. Usually, some EBPs disappear, and the new ones that reflect new ways of running the business are introduced. Thus, we must once again adjust the process models. The new models (To-Be) are designed from the original ones (As-Is) and the support that the IS provides [27].

It is important to ensure that the IS will solve the real business needs. Therefore each use case proposed for the system must have its origin in at least one business process (a use case is said to be traced from that/this process). Note that, it is possible to have several use cases coming from the same business process as well as a single use case supporting more than one process. Among numerous techniques for tracing use cases (summarized in [25]), we recommend traceability matrices. A traceability matrix is typically implemented as a table or a spreadsheet. The processes are associated to the rows and the use cases are associated to the columns of a matrix. When a process is related to a use case, a mark is placed in the intersecting cell.

When the use case diagram and traceability matrix are accomplished, the next step is to document every identified use case in detail. The additional information is discovered by interviewing potential users of the system. Then all use cases are analyzed to solve conflicts and inconsistencies. Here techniques and approaches from traditional requirements analysis may be applied. The resulted use case model specifies a software system that adequately supports the business processes of the organization and is the starting point for the rest of the development phases.

V. CASE STUDY

This section reports a project conducted in a private university in Poland. The university staff provided a set of narratives of the current business processes. The employee who was most knowledgeable about the issue of interest was interviewed. For the sake of space and brevity, we omit some of the processes, simplify others, and present only a few artifacts developed during the project. Figure 2 gives a top level overview of the core business processes, while a brief summary of each process is reported below.

Admission process (Fig. 3). As a formal prerequisite to be eligible for admission to the Bachelor's program, an applicant need to have a matriculation certificate. Admission to the Master's program requires the satisfactory completion of an undergraduate (bachelor's) degree. All candidates must submit an application form and a copy of the relevant diploma. They must also pay a non-refundable recruitment fee. The Admission Committee ensure each application is complete. If the number of applicants exceeds the number of available places, the applicants undergo a process of evaluation. Candidates for undergraduate level are evaluated on the basis of their matriculation grades. The Master's program require candidates to pass an entrance examination. The exam is prepared, conducted and reviewed by the Examination Board. Next, the Admission Committee draws up a list of the strongest candidates who are initially accepted. Each candidate is notified of the action in writing. Before the final list of the admitted students is announced, candidates must pay all tuition fees for the academic semester and send their original diplomas.

Marketing. The approved curriculums must be presented to a wide range of potential students. Thus, the PR staff create marketing materials that are disseminated through press, radio and TV. They also elaborate a content of the university's website.

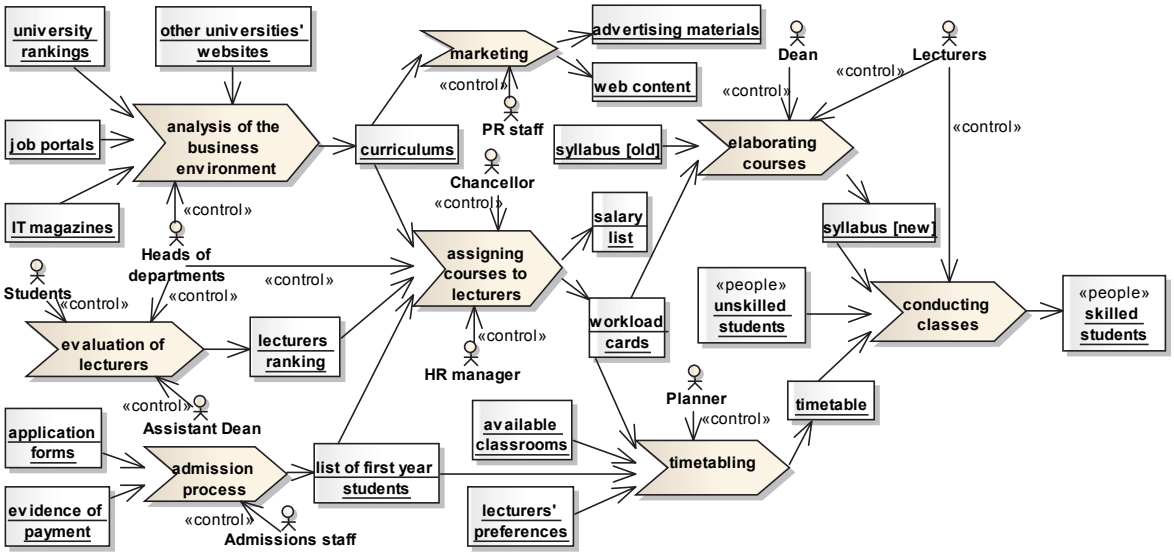

Figure 2. Top level As-Is business process model

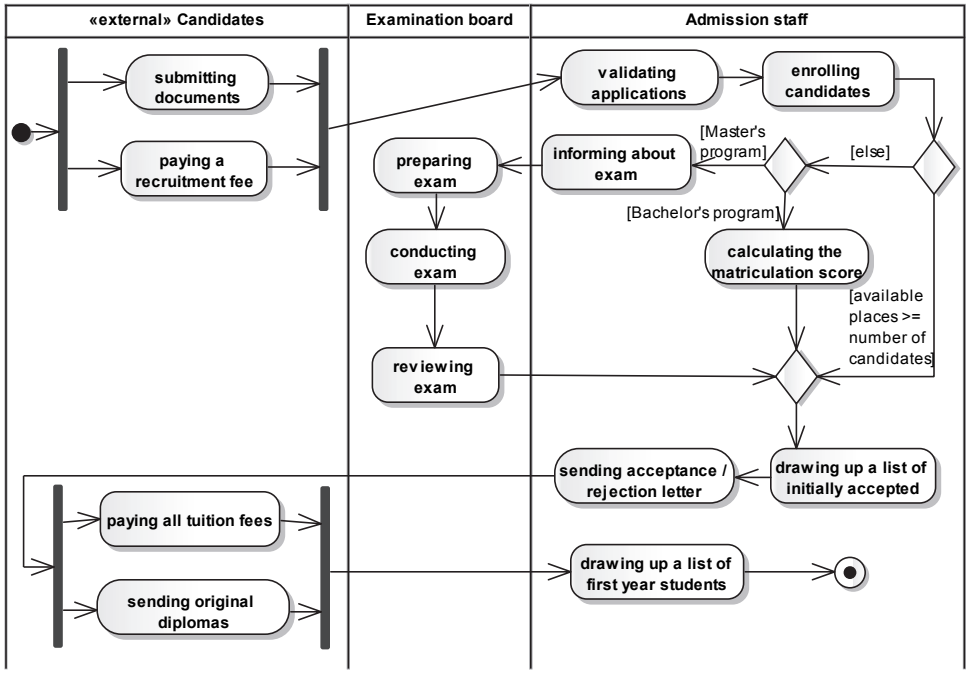

Figure 3. EBPs that make up the admission process (As-Is)

Analysis of the business environment. The heads of departments continuously track changes in job offers, to adjust the courses to needs of the market. IT magazines and job portals are main sources of the knowledge. The heads also watch other universities and colleges. Especially, the valuable information is gained from web sites of these institutions. The heads form curriculums.

Assigning courses to lecturers. The heads of departments have to map courses to lecturers. First, courses are offered to those lecturers who were employed in the previous academic year and who were highly rated by students. If a new lecturer is employed, his/her research background is evaluated and the payment is negotiated individually. The final decision about the employment is taken by the chancellor. The assignment of a lecturer to courses is set out in a document known as a workload card, which must be signed by the chancellor.

Timetabling. On the basis of the workload cards, the lecturers' preferences and classroom availability, the timetable is drawn up by the planner. Timetabling is mapping courses to time slots and classrooms.

Elaborating courses. Once the courses are assigned, lecturers have to prepare the syllabuses and the contents. A lecturer can follow the syllabus that was used during the previous year or custom it to his/her own vision. All syllabuses must be approved by the dean. Detailed course curricula, rules of obtaining credits, and lists of compulsory literature are displayed in the showcases.

Conducting classes. A lecturer familiarizes the students with the details of the course curricula, the rules of obtaining credits, and the individual consultation hours agreed with the students. The consultation hours are also reported to the Dean's office. A lecturer conducts the classes according to the timetable.

Evaluation of lecturers. After each semester an assistant to the dean ranks the lecturers on the basis of surveys and hospitations. The surveys are conducted among the students by the assistant, while the hospitations are carried out by the head of department.

During the workshop, stakeholders decided to computerize the following processes: admission, assigning courses to lecturers, timetabling, and evaluation of lecturers. Figure 4 shows the To-Be business model for the admission process, which describes the way in which the university wants to operate after deploying the IS. Note, that the IS is represented by a new partition, and that the university requires candidates to apply online. Instead of labeling each process with "A", "S", or "M", we express this information using background color.

Once the To-Be business models are accomplished, it is relatively simple to derive use cases as illustrated in Fig. 5. The resulted use cases must be traced back to their source. Table 1 lists all the EBPs consisting on the admission process down the left column. In the row across the top, it lists the use cases derived to support the stated processes. A traceability relationship is indicated with an X in the cell to record the fact that a specific use case has been defined for the purpose of supporting one or more business process. Note that a single process may be supported by multiple use cases.

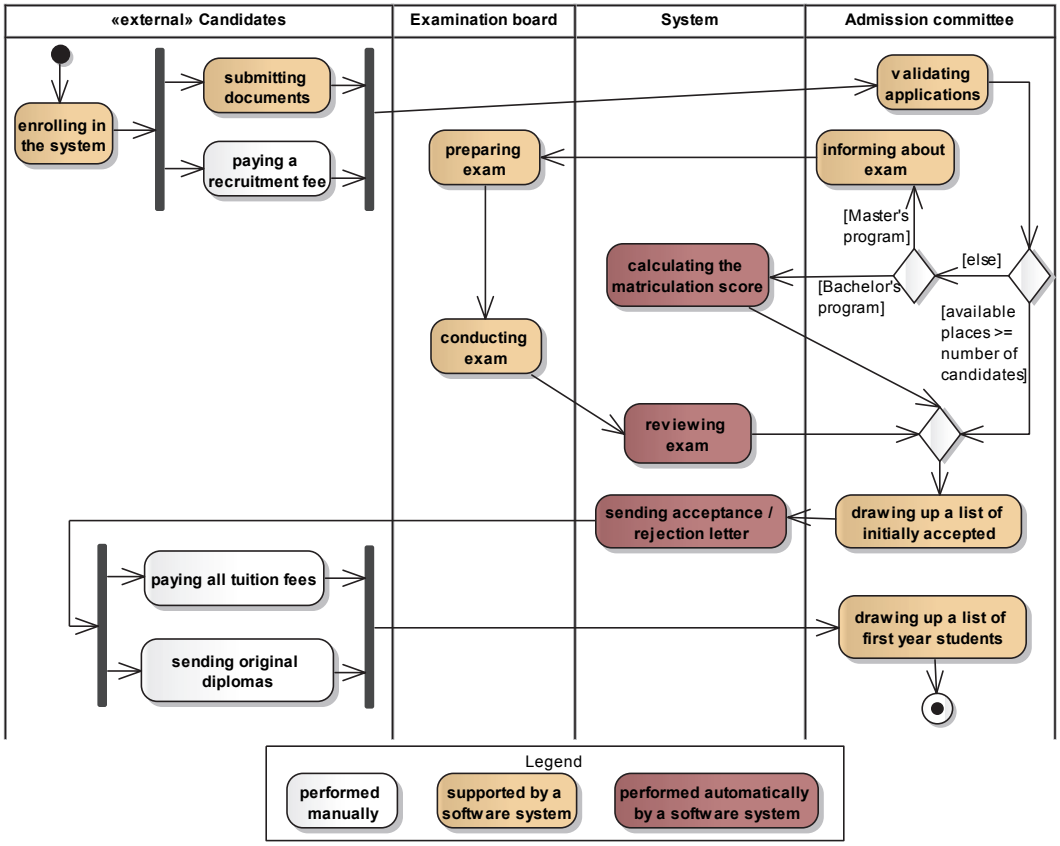

Figure 4. EBPs that make up the admission process (To-Be)

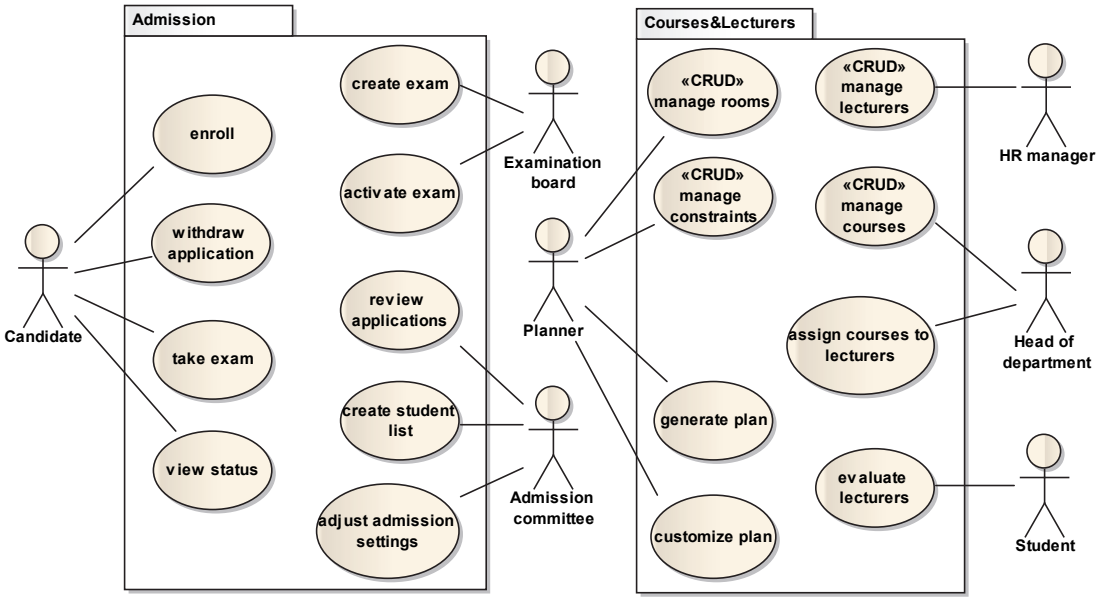

Figure 5. Use cases model

TABLE I. TRACEABILITY MATRIX FOR EBPS (ADMISSION PROCESS) TO USE CASES

	enroll	withdraw application	take exam	view status	review applications	create exam	activate exam	adjust admission settings	create student list
enrolling in the system	x	x		x					
submitting documents	x								
validating applications					x				
informing about exam								x	
preparing exam						x			
conducting exam			x						
reviewing exam						x			
calculating the matriculation score					x			x	
drawing up a list of initially accepted									x
sending acceptance / rejection letter									x
drawing up a list of first year students									x
paying a recruitment fee									
paying all tuition fees									
sending original diplomas									

VI. RELATED WORK

Our approach is designed on the basis of many existing techniques, ideas, guidelines and best practices in academia and industry as well as our experience from previous projects. Particularly, we gained inspiration from the work of Vara et al. [27] and Dijkman & Joosten [4].

Vara et al. [27] propose a business process based requirements analysis. Their approach combines BPMN and a goal-oriented notation called MAP. BPMN is used for modeling the business processes, and MAP is used for modeling the goals and strategies that lead to fulfill the users' requirements. Initial BPMN models (As-Is) are updated by the results of the analysis of the MAP model to get the To-Be business process models. The models are validated by end-users, and then analyzed in order to agree on the effect that the IS may have on the organizational needs. Finally, requirements are specified by means of the description of the business process tasks to be supported by the IS. Overall, their approach differs from ours in two key respects. First, they pay more attention to sophisticated business analysis, i.e. goals and strategies. Our approach focuses only on business processes. Second, their models may be difficult to link with the next phases of software development process due to different notations.

Dijkman & Joosten [4] compare the metamodels of use case diagrams and business process models. Then, they formally specify a procedure to transform business process models into use case diagrams, that complies to this mapping. Their procedure may be used to support our approach during requirements derivation.

A similar approach can be found in the work of Odeh & Kamm [19]. They propose a method to explore relationship between business process model and use case model. They use Role Activity Diagram (RAD) to model business. Their method leads for the derivation of use case system model from a process model. However, in contrast to our notation, RAD is incompatible with UML.

The work of Odeh & Kamm [19] is continued by Aburub [1] who propose a four-steps method: develop a business process model using RAD model, identity automated activities, link each business objective with automated activities, and develop use case model based on objectives and automated activities.

Štolfa & Vondrák [24] describe business process modeling as a tool for definition of requirements specification. They claim that there are repeatable situations during transition between business process modeling and requirement elicitation. Next, they demonstrate three patterns that can be applied to support the transition between business process modeling and other phases of software process. These patterns can be considered as a complement to the third stage of our approach.

Our approach also adopts several ideas from EKD [3]. EKD is an approach that provides a systematic and controlled way of analyzing, understanding, developing and documenting an enterprise and its components. The EKD Enterprise Model comprises six interrelated sub-models that describe different aspects of the enterprise. Links between sub-models make the model traceable. The objection to EKD is the same as to the Vara's approach. The EKD Enterprise Model is not compilant with UML.

VII. SUMMARY

Research in requirements engineering has produced an extensive body of knowledge, but there are still areas in

which the foundation of the discipline seems weak. In this study, we do not depreciate the value of any existing method, we just show how to gain synergetic effect from combining methods from different fields of business engineering and requirements engineering.

The main contributions of our research are twofold. On the one hand, it proposes a structured approach for deriving system requirements based on business process models. This approach is especially effective when system requirements are not fully knowable up front and must be discovered. Moreover, the built-in traceability supports impact analysis when an IS must be adapted to the evolving business processes. By providing seamless transition from business process modeling to use case modeling, our approach can be seen as a further step towards bridging the gap between business process engineering and requirements engineering. On the other hand, our study brings solutions that allow for improving administrative efficiency of the real organization. In Section 5, we demonstrated how it was successfully evaluated in practice.

ACKNOWLEDGEMENTS

The study is funded by Polish National Science Centre, project DEC-2011/01/N/ST6/02752.

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