THE BPMN APPROACH OF THE UNIVERSITY INFORMATION SYSTEMS

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Abstract
In this article we provide a new vision about the enterprise modelling in the context of Business Process Model and Notation (BPMN) and the university area. Although the flow objects, artefacts, connecting objects and swim lanes are very used in the process of Enterprise Modelling, they have specific roles in the university information systems. The paper will reveal a specific approach of BPMN in the context of university information systems based on a comparative analysis of some representative universities from United States and Central Europe. Our ideas are argued with a practical case study that includes 4 realistic and complex systems: study programs and curriculum, students' admission, student roadmap, students' exchange. The future directions of the article are some visions of BPMN orchestration of a SOA-based architecture for Student Record Systems.

Key words: *BPMN approach; enterprise modelling; university information systems.*

JEL Classification: *O33, O22, D83*

I. INTRODUCTION - FROM ENTERPRISE MODELING/ENGINEERING TO BPMN

The idea of enterprise modeling (EM) is founded on information systems modeling developed in 1958 by two electrical engineers (Young & Kent, 1958). According to them, in order to have "a precise and abstract manner for specifying the informational and time characteristics of a data processing problem", a precise notation is needed, useful for analyst "to organize the problem around any piece of hardware". Considering modeling for information systems from a historical perspective, some authors (Bubenko, 2007) appreciate that the work of the two pioneers has led to further research like those of CODASYL, Peter Chen or Douglas Ross. Continuing the efforts of Young and Kent, CODASYL, an IT industry consortium created in 1959, has laid the foundation of information algebra, a modeling approach based on three concepts: entity, property and value. Later, in the 1970s, Peter Chen (Chen, 1976) developed the entity-relationship model in which data is represented by entities linked through relationships, while Ross (Ross, 1977) proposed a Structured Analysis and Design Technique (SADT) through which systems were described from a hierarchical or functional point of view. In the 1980s, the emergence of computer-integrated manufacturing (CIM) has led to the appearance of several methods of enterprise modeling.

Along with the development of specific techniques for enterprise modeling, multiple attempts were made for defining and characterizing the process itself. In 1996, (Ostic & Cannon, 1996), aiming to enable engineering analysis of enterprise activities, have proposed a number of enterprise simulation software models. In their view, the expression enterprise model, although related to the enterprise notion, is used only to illustrate different enterprise representations. The same opinion is shared by (Vernadat, 1997) who considers enterprise modeling a process of building models for an enterprise, in parts or as a whole, based on previous and/or reference models, knowledge about the enterprise and domain ontologies. A more complex definition of the concept has been made by (Leondes, 1992). According to him, enterprise modeling represents the process of understanding and improving an enterprise business by creating enterprise models. This process involves the use of information technologies, distinguishing the relevant business domain, and the knowledge of the business processes. As stated by the same author, while modeling the relevant business domain is usually easier due to the relative stability of an industry, following the business process tends to be more difficult as a result of its increased volatility. In consequence, the complexity of enterprises has led to the development of numerous enterprise modeling approaches, each of them being best suited for modeling businesses from a specific area.

(Frank, 2014) considers that there are three premises invoked by early studies in what concerns the enterprise modeling:

1. The joint analysis and design of software systems in order to increase the business efficiency;
2. The development and usage of abstractions for reducing complexity;
3. The involvement of competent people from different fields in order to have a unified view of the business.

Although enterprise modeling included the idea of analyzing business processes in order to have a global view of what happens in an enterprise, the concept of business process modeling (BPM) was introduced by (Williams, 1967) with the idea of improving administrative control. According to (Hill, Sinur, Flint, & Melenovsky, 2006), business process management consists in a management discipline which requires organizations to shift to process-centric thinking, and to reduce their reliance on traditional territorial and functional structures. Later, in the 1990s, the term "process" has become highly popularized, companies being encouraged "to think in processes on behalf of functions and procedures" (Rolstadås, 1995). Analyzing enterprises in terms of processes was considered to improve the quality and efficiency of the business. In order words, describing the business as a process helps analyst to understand what the system is doing as it is, in the current state, and what the system should do, namely, what must or can be improved. The wide adoption of BPM reflected in several techniques used for describing the process. Among them, it can be distinguished one of the most modern methods, highly used nowadays, namely Business Process Model and Notation (BPMN).

The development of BPMN is due to Business Process Management Initiative (BPMI). BPMI promoted BPMN as a standard for business process modeling using Business Process Diagram (BPD). Therefore, BPMN consists in a graphical representation of processes in a business model. Its primary goal is to offer a general notation which can be understood and used by all the involved stakeholders. Therefore, BPMN has become a common language which improves communication between analysts, in charge with the design of systems and application, and programmers, responsible with the implementation of requirements of the analysts. According to (White, 2004), BPMN will contribute to the unification of both basic and advanced business concepts.

While BPMN is considered to be very useful in improving business processes, the notation has its constraints given by the concepts with operates, namely those applicable only in modeling business processes. As a result, from BPMN data models, organizational structures and functional breakdowns are excluded. Generally, BPMN operates with four basic element categories represented by flow objects, artifacts, connecting objects and swim lanes. Their use enables the analyst to created business process diagram in order to reflect what the system should do.

In order to understand the BPM life cycle several researchers proposed different approaches (Hill, Sinur, Flint, & Melenovsky, 2006), (van-der-Aalst, Don't go with the flow: Webservices composition standards exposed., 2003), (van-der-Aalst, Business process management: A personal view., 2004). As we can see in figure 1, there are some differences between the life cycle stages identified by authors in relation to BPM.

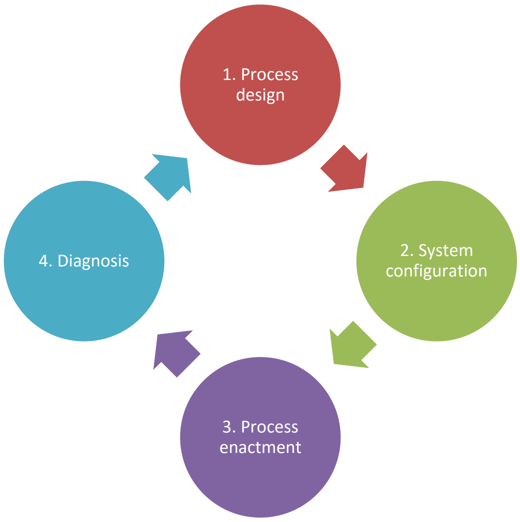

Figure 1 - BPM life cycle according to van-der-Aalst [14]

Referring to life cycle of BPM, van-der-Aalst [14] considers that there are four main stages that should be followed by analysts. In comparison, Gartner Group identified in 2006 eight stages of process cycle. Taking into consideration the instruments used in modeling, while Gartner Group does not make any reference to the subject, if we consider the methodology proposed by van-der-Aalst, UML and BPMN are used in the first stage, the process design, being used as graphical standards in order to model the business.

Figure 2 - BPM life Gartner (2006)

UML has been adopted as a standard modeling language in order to define the architecture of software systems. (Eriksson & Penker, 2000) consider that UML provides activity, state, object and class diagrams to capture important business processes and artifacts. Furthermore, using UML profiles analyst can built more detailed BPM models. According to the same authors, an UML profile is used to define a set of stereotypes for working with Business Activities, Processes, Objects and Information flows.

BPM differs from software system modeling in a number of important ways. The key difference between system modeling in UML and Business Process Modeling is that the emphasis on how the work is done within an organization, rather than what work is done. It is an important tool in understanding the activities a business undertakes, and the kind of information it needs to successfully engage in those activities. Also, they serve the important function of situating new and existing software systems within the business context.

II. UNIVERSITY INFORMATION SYSTEM AND STUDENT RECORD SYSTEM

According to (Dospinescu, Tătăruşanu, Butnaru, & Berechet, 2011), the competition that exists among higher education institutions involves great efforts to adapt to the new requirements of the modern society.

University information system (UIS) is a special category of information systems. University is an institution which follows some procedures and is running some typical processes. These processes and procedures determine the design and implementation of a good information system.

A process is a set of partially ordered steps intended to reach a goal. A process is decomposable into process steps and process components. The former represents the smallest, atomic level; the latter may range from individual process steps to very large parts of processes (Marshall, 1999). Also, (Hurbean, Fotache, Pavaloaia, & Dospinescu, 2013) consider that the efficient data sharing between different functionalities generates efficient processes. In the same time, (Greavu-Şerban, 2015) promotes a balance between security and functionality.

Information systems are interrelated components working together to collect, process, store, and disseminate information to support decision making, coordination, control, analysis, and visualization in an organization (Burgeois, 2014).

The basis for an information system comes from the business process management and modelling which determines the components, systems or modules used in the case of designing an information system. Universities are guided by regulations, but in the same time, some processes taking place inside them are the same like the ones met in each business, while others are specific only to this type of organization. To help organizations running well the business processes, Enterprise Resource Planning (ERP) systems were developed to run a company entire business, with modules specialized for each process: accounting, human resources, inventory and finance (Burgeois, 2014). But this type of implementation seems to stop the organizations to maintain their own identity, while processes are designed in a standard manner and ERP system may or may not be customizable.

Some companies though developed special solutions for the universities, while some universities prefer in-house solutions. The in-house solutions may be successful with a good design and a proper analysis before and after the implementation. (Denis, Wixom, & Roth, 2012) identified four important steps in the development of an information system: planning phase, analyzing phase, design phase and implementation phase, each of them split into smaller steps.

As we have discussed before, the basis for an information system is a good business process modeling. This means that the analysis phase must identify and organize the core processes taking place inside a university and identify the requirements from the process flow. These may become modules in a future system implementation or standalone applications, able to use available APIs to communicate with other related applications inside the future information system.

To manage to determine the basic processes into an UIS, some implementations or proposal of implementation were studied. The cases from University of Colorado from US, Central European University from Hungary and Technical University from Cluj-Napoca Romania and a proposal of Komka and Daunoravicius from year 2000 which provides some basic processes involved into an UIS. Further, the results will be synthesized to provide an overview and a proposal over the SRS and its components, by adding existing models of implementation from Faculty of Business Administration from Iasi, Romania.

An example of UIS implemented at Technical University from Cluj-Napoca, Romania, was developed and implemented in about three years. This system was designed as a unique database system (centralized or distributed) viewed as a main computer data source (Lelutiu, 2013). The data collections used in this project were designed for specific goals:

- The organizational structure – implemented as a set of organizational UNITS of different types (university, faculty, department, student group, financial);
- The persons – identified by different ROLES (teacher, student, candidate, employee etc.).

The project also identified two data collections which must be available in any UIS:

- Time: describing the location in time of each event and activity;
- Place: describing the location in space of each event and activity.

Summing up characteristic features identified in this approach, the author states that UIS:

- Are management information systems;
- Are designed for client/server architectures and different software platforms;
- Provide an own advanced user interface that supports: user friendliness and a productive programming environment.

Some software solutions specially designed as UIS were developed and implemented in University of Colorado. UIS provides the tools and applications that support campus-wide business and academic applications. These include student applications used by all campuses and the common business operations tools used by faculty and staff across all campuses. UIS also supports the computers, phones, networks and software used by the Office of the President and provides technical assistance to campus departments.

Other software solutions were implemented by Central European University from Budapest, Hungary. The implemented UIS is an integrated, intranet-based database system, the main purpose of which is to serve the central administrative needs of the university. In order to provide state-of-the-art services, the system is under continuous development.

(Komka & Daunoravicius, 2000) identified a series of advantages of implementing UIS like the ones below and identified the processes presented in the comparative table 1:

- Increase of competitive ability of the university;
- Improvement of the university management;
- Decrease of administration expenses;
- Effective and precise presentation of information;
- Transparency of financial and economic activities.

The three perspectives of implementation or proposal for implementation are presented in table 1 from a comparative point of view, and unified into more simple components.

Table 1. Comparison between different types of proposed or implemented UIS (UIS Description, 2016), (Komka & Daunoravicius, 2000)

Module/process	*University of Colorado solution*	*Central European University solution*	*Komka & Daunoravicius*
Student Record System	Campus solutions International student and scholar system Online admission Offering Electronic Research and Administration System	Student records module Student Welfare module Admission module Student Interface Coordinator interface Alumni module	Enrollment Modules Fees Tuitions Studies program
Human Resources System	Reporting system Document Management Employee portal Human resources systems	Staff Related services	Human Resources
Administrative System	Reporting system Document Management Travel & Expense System	Staff related services	Management and administration Archiving
Financial System	Reporting system Document Management Finance system	Staff related services	Financial and accountability Economic activity
Campus System	Campus solutions	Student Interface Coordinator Interface Alumni Module	Library services Science activities Social activity Publishing

A SRS or Student Recording system is a system which works with data about students. The implementations may be various, depending on the place where each designer, architect or analyst places the operations for students. They may be various and inter-correlated with many other modules or systems of an UIS. From the previous implementation at Technical University of Cluj-Napoca, the student was correlated with all the other entities of the system.

The Faculty of Economic and Business Administration (FEBA) from Alexandru Ioan Cuza University (AIC) from Iasi, Romania, having a number of approximately 6000 students each year, has a number of tools involved in this system, which are not interconnected and they work independently. Some of the features/modules identified in table 1 are missing and that's why an improvement may be required. The existing modules in this university are presented in table 2.

Table 2. Existing modules in SRS from Faculty of Business Administration from Alexandru Ioan Cuza University from Iasi, Romania

Module/Subsystem	*Process*	*Frequency*	*Workload over the academic year*
Admission	Admission	Once per year	High
Esims	Grades/Evaluation	Anytime over the year	High in some periods
Portal	Publishing	Anytime over the year	Low
Blackboard	Evaluation	Four times per year	High
Timetable	Timetable	Twice per year	Low
Library	Library	Only over the academic year	Medium

It's easy to see that a SRS is a part of UIS and it may be seen as a subsystem of the latter one. Each SRS contains other subsystems which allow the handling of different processes. Each implementation is unique and adjusted to the needs of each institution, letting us know that a standardized ERP solution would not be suited in any way to help universities maintain their identity and uniqueness.

III. CORE BUSINESS PROCESSES PROPOSAL FOR STUDENT RECORD SYSTEMS

A system for student records may be very complex. Each process can have a major impact or importance or not. This is why we identified some core processes and some additional ones, being a part of the SRS. As we have seen in tables 1 and 2 above, some specific processes and components were identified to support student recording system, and they are synthesized in table 3.

Table 3. Example of possible processes and components of a SRS

Process	*Type of process*	*Possible components*
Study programs & curriculum	Core	Professor, curriculum, study programs, modules, timetable
Admission	Core	Student, studies program, modules, grades
Student roadmap	Core	Student, grades, disciplines, tests, location, time
Document exchange	Core	Student, professor, secretary, documents, announcements
Student exchange	Core	Student, personal dates, grades, courses
Welfare	Additional	Student, fees, tuitions, payments
Library access	Additional	Student, books, location, time
Campus activities	Additional	Student, activity, location, time, topics

The processes identified in table 3 can be synthesized into a comparative table to show the unique and though somehow common way to implement and manage processes from SRS inside universities.

Table 4. The comparison between implementations in different SRS implementations

Module/process	*University of Colorado solution*	*Central European University solution*	*FEBA from UAIC University solution*
Study programs & curriculum	Campus solutions	-	Timetable
Admission	Online admission	Admission module	Admission
Evaluation	Campus solutions	Student Records Module	Blackboard, Esims
Document exchange	Document Management	Microsoft Office 365	Portal
Student Exchange	Electronic Research and Administration System	-	-
Welfare	Campus Solutions	Student Welfare module Medical Database	-
Library access	-	Student Interface	Library
Campus activities	Campus Solutions	Flat Database Catering Module Room Booking	-

A study conducted on a SRS used in a university from UK uncovered a wide range of failings with the student recording system, including incorrect and ambiguous information, and a failure to provide information for some of the key academic activities and for external university returns. Some issues were operational but others were more strategic in nature: organizational structure, organizational culture, resources management, information needs analysis, management of strategic change (Yongmei, Cao, & Lehaney, 2012).

The same study revealed the following important factors in a good functioning of this type of system, presented in table 5.

Table 5. Identified "musts" in designing a SRS (Yongmei, Cao, & Lehaney, 2012)

Element	**Ought**
Organizational structure	The attempt ought to be made to allow emergent strategy to develop
Organizational culture	A 'caring and sharing' culture ought to be encouraged
Resource management	There ought to be in place some sort of applicable resource strategy to monitor the adequate allocation of resources

Element	Ought
Information needs	There ought to be analyzed and prioritized before any system development took place
Strategic alignment	There ought to be adequate alignment between information strategy and other strategies (IT, Learning, Teaching)
Managing strategic change	Strategic attention ought to be paid to strategic change and wider participation ought to be included
Evaluative structure	Feasible evaluative structure ought to be established

While UIS include not only the software resources but also the material and human resources involved in this huge ecosystems, SRS are specially designed for students and operations with data related to the student. This data must have consistency, accuracy, necessary information and must be processed as correct as possible, avoiding system errors. While human errors are natural, system errors may have as a root cause the poor system design. The implications are enormous: from information exchanged through the universities, to an error in evaluation which may force the student to pay tuitions to continue studies, the consequences are from immediate to long term. It is very clear that the literature review highlights the importance of a good information system design.

IV. Core Business Process Modeling for Student Record Systems

We chose BPMN2 Modeling Language and jBMP platform because BMPN2 is a standard language for business modeling and jBMP is an open source platform that is used by many enterprises and public institutions around the world. Also, jBMP platform implements all the elements described by the modeling standard.

Study programs & curriculum

The *study programs & curriculum* business process focuses on the management of the staff work plans according to the dimensions of the student groups and formations. Also, the work plans are synchronized with the curriculum of study programs proposed by faculties and departments. Our design takes into consideration a scenario where the data is used by the course holder and the management of the university. Figure 3 shows the main actors involved in that process.

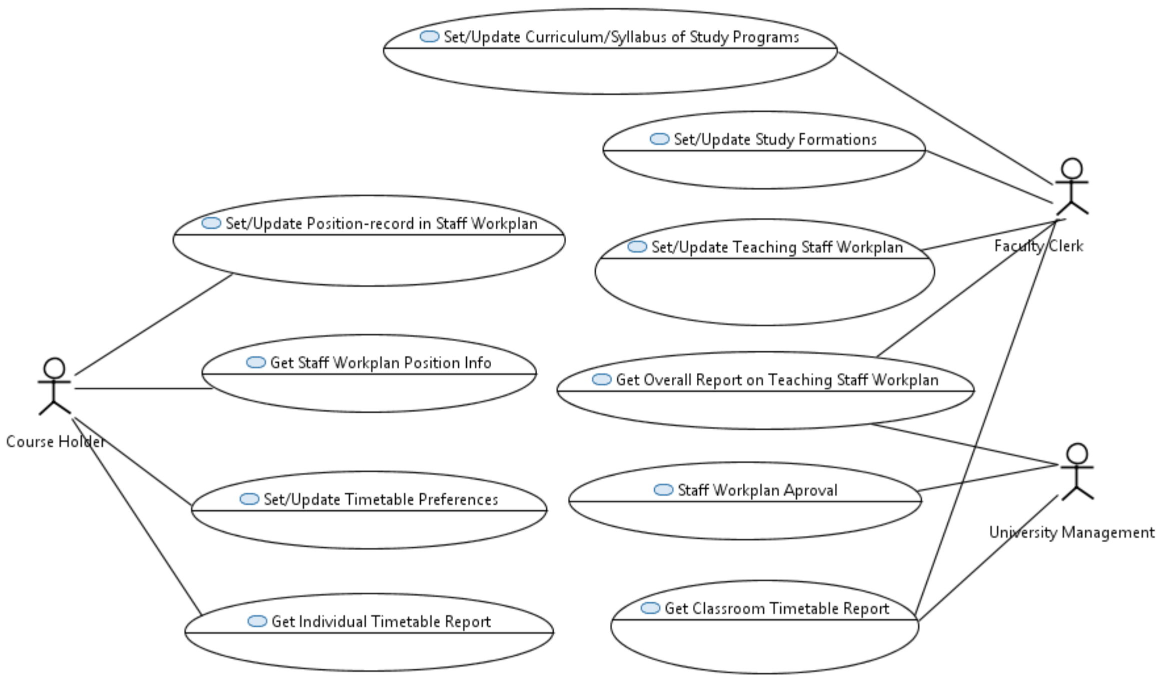

Figure 3 - Use case diagram – study programs & curriculum

From the BMPN perspective we've split the process in three sub-processes covering (1) initial settings, (2) staff work plan and (3) the timetable's generation process.

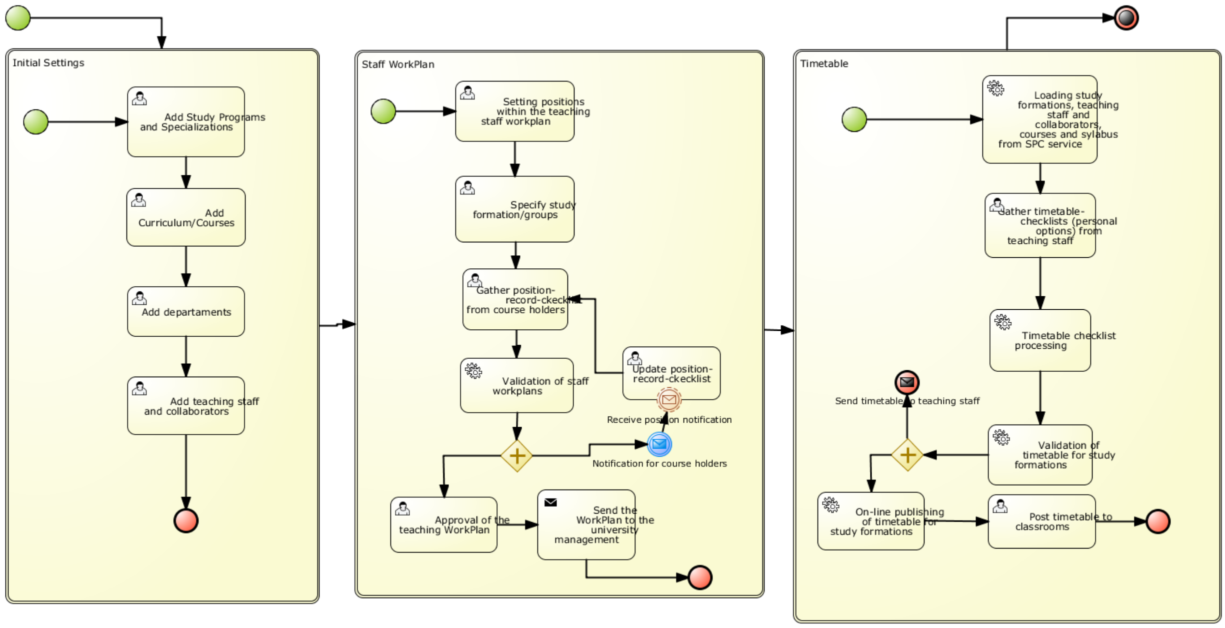

Figure 4 - Business processes: BPMN diagram

These 3 sub-processes presented above are the core of the study programs & curriculum process and they represent a very important component.

Admission

The *admission* business process focuses on candidate application management on specialization within study programs proposed by faculties. Our design takes into consideration an on-line application scenario where the candidates could fill faculty application and could upload the required documents via web. This way, the user-stories could be like in figure 5.

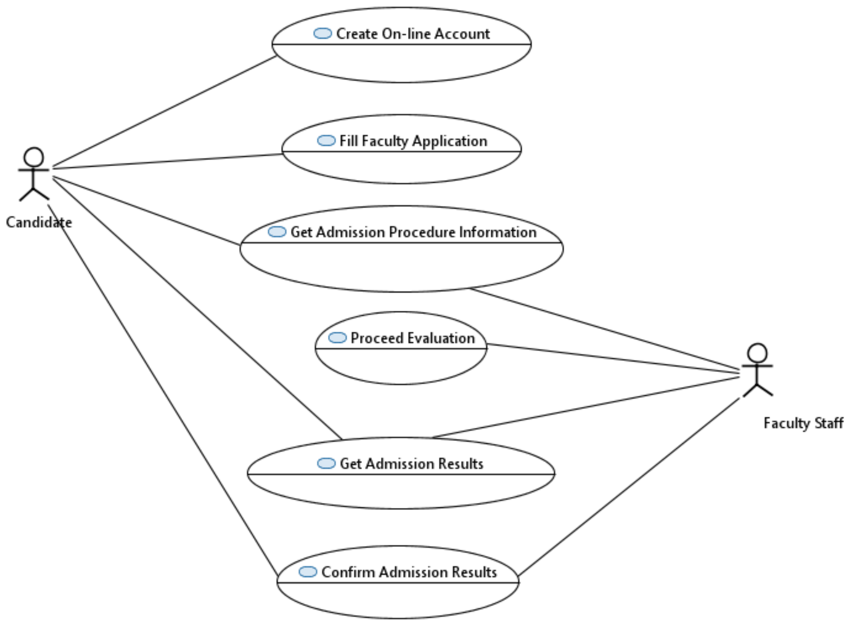

Figure 5 - User-stories – UML approach

From the BMPN perspective we've split the process in three sub-processes covering (1) on-line registration and application stage, (2) the actual candidate evaluation stage and finally (3) the notification and confirmation procedure of the admission process results.

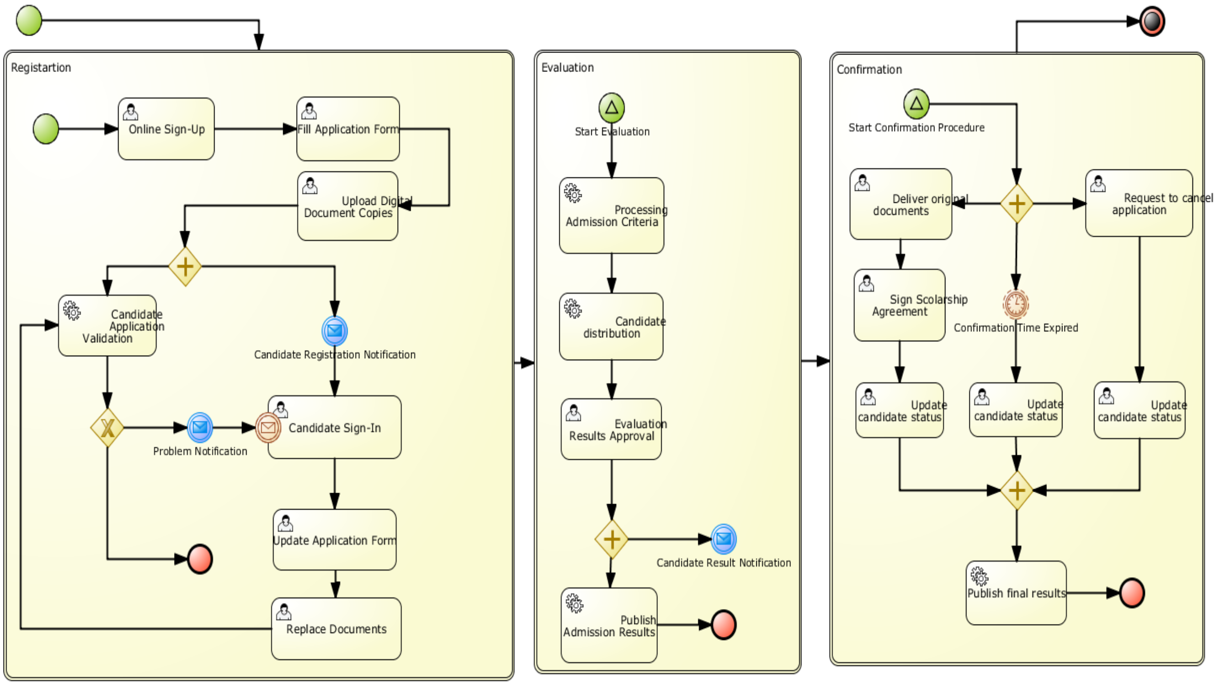

Figure 6 - BPMN for Admission Process

We have suggested a somehow simplified version of this generic process, therefore we are aware that there are some detailed activities which could be added, e.g. how candidates will proceed some ability tests or skill tests in order to accomplish some admission criteria.

Student Roadmap

Student Roadmap is a process that covers the student route from the first registration, which occurs after admission, until he graduates, in other words he presents in public his license/dissertation.

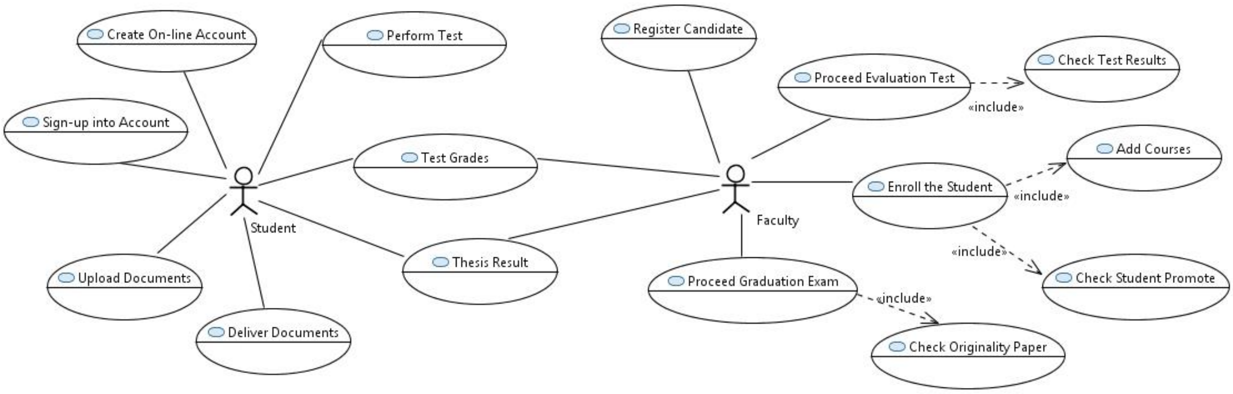

Fig. 7. Student roadmap in a graphical representation

For this model it is proposed a representation in BPMN schema of 4 sub-processes that occurs in the main process.

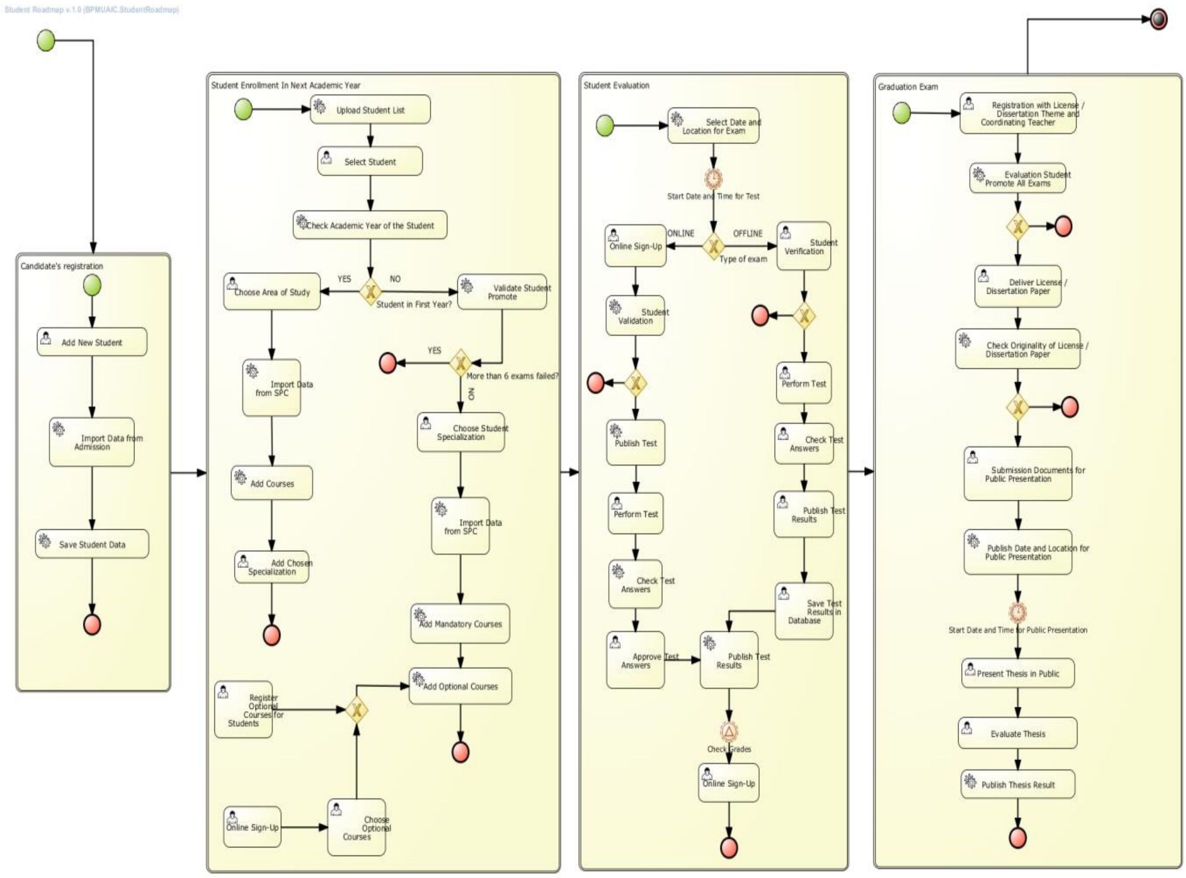

Figure 8 - Sub-processes in the student roadmap process

This process is conditional from Admissions Process (AP) and Study Programs and Curriculum (SPC) Process because we need candidate's data for his registration and study programs and curriculum data for student enrollment in the next year of academic study. For these situations we have tasks that import data from these processes. On the other hand we have two sub-processes repeating each year of student study, so we can affirm that Student Roadmap is a continuous process as long as student doesn't withdraw, isn't expelled or not present their license/dissertation paper.

The flow of the each sub-process is split using tasks made by users or by system, timer event to identify when the next task starts and XOR operations to identify yes or no situations. Every task is independent and depends either by the successful completion of the previous task, either by a time event.

Student Exchange

Student Exchange is a very complex process. The proposals for this model can vary from one university to another, but the proposal presented in this BMPN schema shows very clear the implication of each role. While the student is involved in the whole process, from beginning to the end, the host university has only few steps to follow, while the parent university is the link between the student and the host university.

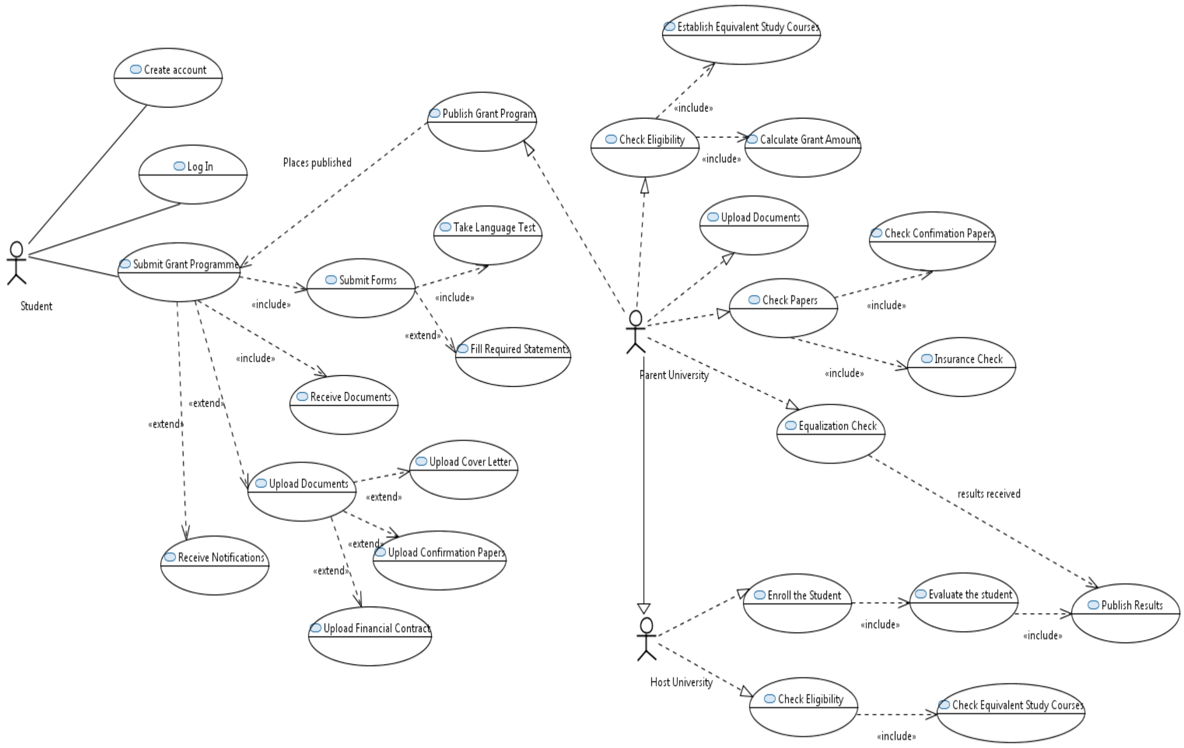

Figure 9 - Student Exchange in a graphical view

The diagram is split by roles, because the process itself involves three distinct roles: the student, the parent university and the host university. The flow of the process is split using tasks, event triggers, event catchers, parallel gateways and XOR operations to identify yes or no situations. The communication between tasks and roles is done either by using event triggers and catchers, either by direct interdependence and connections between tasks of each role.

We have signal events like request SPC data, send E.S.C., send confirmation papers, and give departure order, which are catch by other signal events which make possible the flow of each process like: receive SPC data, receive S.P.C, receive confirmation papers, and receive departure order. These apparent tasks were identified as being signals or triggers for other events, this is why they were chosen as events and not tasks. The catch events like Receive financial contract, receive confirmation papers and others, are some key events. Without those events being triggered, the flow of the processes is interrupted until these events occur.

The student, the host university or the parent university can perform all the tasks completely automated or manually. The types of tasks were not suggested in the BMPN schema presented, to avoid confusions or process limitations. From this schema we could identify some use cases available for a use case schema which completes this process modeling.

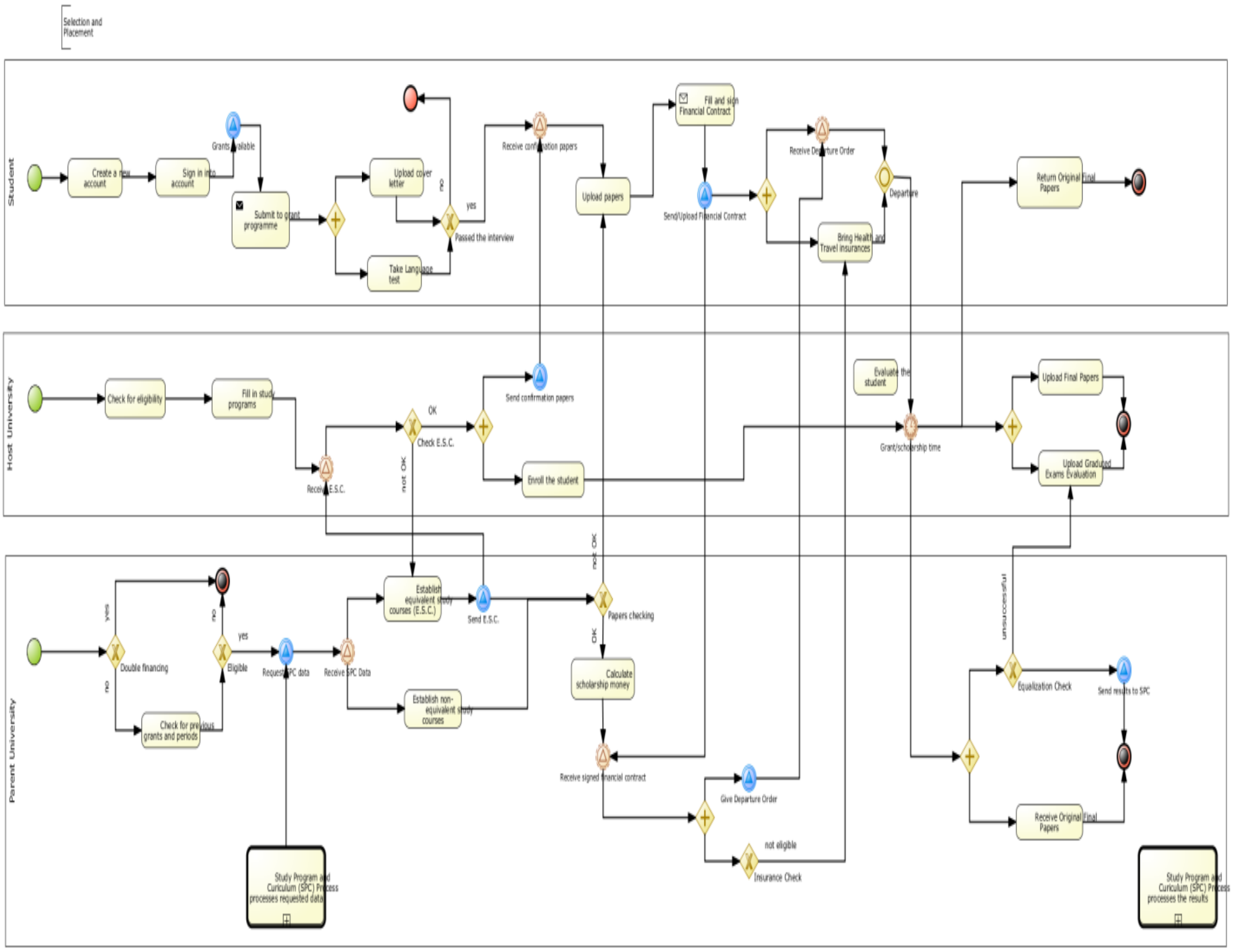

Figure 10 - BPMN for the Student Exchange process

We can observe that this modeling is available only for exchange with scholarship programs, but this schema can be extended to the case of student transfer or other type of process which involves the share or transfer of student data. We can easily notice that the Study Program and Curriculum process is involved in this process too. The task of checking equivalent study courses is applicable to a transfer process too, while document uploading, online form submitting or other features related to student exchange tasks can be steps in this kind of similar process.

V. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

The University Information Systems have their own peculiarities and the processes that are running inside must be carefully analyzed and designed. The four main processes are: admission, study programs and curriculum, student roadmap, student exchange. They represent the core of a university information system and the implementations in UML and BMPN describes the whole educational and administrative activity.

The BPMN approach reveals the sub-processes and the components of the flows, as the UML diagrams highlight the actors involved in every activity. Also, this approach allows specifying the dependencies between processes. For example, the Student Roadmap process depends on Admissions Process and Study Programs and Curriculum. According to the case study described in the article, it is very clear that BPMN can be applied in order to model a university information system and to catch the specific situations of the educational "business". Our article proved that having a set of very clear specifications from the educational area, the processes can be emulated and implemented by using Business Process Modelling Notation.

Based on the practical results of this paper, we consider that a future research direction could be the BPMN orchestration of an SOA-based architecture for student record systems.

Also, starting from these premises, the next challenge will be transforming processes in BPMN standard type services Service Oriented Architecture.

VI. ACKNOWLEDGMENTS:

„This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS – UEFISCDI, project number PN-II-RU-TE-2014-4-0748”.

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