

INTEGRATING BUSINESS PROCESS CONCEPTS INTO UML ACTIVITY MODEL

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ABSTRACT- The Unified Modeling Language (UML) activity model is widely accepted for modeling processes from pure technical views. Because it's rich high level design language and supported by standard body; OMG which involve most of top worldwide IT players. It turns out in modeling information systems, business processes are main component so needs suitable modeling language such as Business Process Model and Notation (BPMN) that is originated in organization domain. However, learning new language has the cost of learning curve. Since UML activity model has commonality with BPMN as both share the core principles of process modeling, this paper proposes sustainable change to UML activity model by introducing business concepts so technical modelers can speak with UML activity a different language. This synergistic relationship not only doubles the benefit of UML activity and reduces the learning curve, but also highlight the differences that add value to editor providers. A light weight extension or profile has been designed and evaluated using a real case study.

Keywords: *Business Process Modeling, Business process Model and Notation (BPMN), Unified Modeling Language (UML), Activity Diagram (AD), Business Modeling Languages*

المستخلص- نموذج الأنشطة التابع للغة النمذجة الموحدة يستخدم على نطاق واسع لنمذجة الاعمال- وتوصف به الأعمال من وجهات نظر فنية خالصة. نسبة لكونه يمدنا بنماذج تصميم عالية وغنية -وفرتها لغة النمذجة الموحدة- بجانب أن هذه اللغة قياسية تتبناها جمعية ادارة الكائنات ، فإن معظم مؤسسات تقانة المعلومات تستخدم هذا النموذج في الجانب الآخر تستخدم لغة ترميز نمذجة الاعمال لنمذجة الأعمال أيضاً و لكن من وجهة نظر مجردة حيث يستخدمها ويفهما خبراء و مصممي الأعمال. ايجاد لغة موحدة مشتركة بين مصممي الاعمال (الذين لديهم المشكلة) و مصممي البرمجيات(الذين لديهم حل المشكلة ببناء نظام معلومات) يقلل من تكلفة تعلم لغة اضافية. هذه الورقة اقترحت تعديل في نموذج الأنشطة باضافة بعض مفاهيم معالجة الاعمال - التي تقدمها لغة ترميز نمذجة الاعمال. بالتالي يستطيع نفس مستخدمو لغة النمذجة الموحدة التحدث بلغة أخرى في بناء النماذج. هذا التكامل بين اللغتين لا ينعصر في تقليل زمن تعلم لغة جديدة وإنما يتعداه ليظهر الاختلاف بين اللغتين بالنسبة لمنتجات لغات النمذجة. هذا وقد تم التعديل في نموذج الأنشطة باضافة بروفائل يحوي بعض مفاهيم نمذجة ادارة الأعمال التي يفتقر اليها النموذج ، تم اختبار و تقييم النموذج المعدل بدراسة حالة واقعية و نمذجتها بواسطته.

INTRODUCTION

Information systems nowadays have become more complex and large. This complexity need to be understood well to state requirements and processes of systems. A good elicitation of systems requirements inevitably results into development of coherent software or re-design business processes. Extracting of requirements relay on awareness of system business processes.

To obtain goals and objectives of organizations, business operations should be carried out in a defined way. This specific way is called

business process, which is defined as an ordered set of activities performed by organizational resources to transform inputs into outputs ^[1]. Business process is structured action that can be considered as a particular ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs ^[2]. Modeling is suitable way to describe organizations processes, and make business experts communicate with software architects ^[4].

Business Process modeling is playing the basic role in understanding and documenting the processes flows of systems-specially in

collaborative environments. So, it is often the starting point for defining requirements for systems to be designed or re-engineered. Modeling will lead organizations to gain high productivity; because models tend to be easier and clear than textual statements [7; 8]. In addition, using models to automate software production can emphasize the promising of software development which aims to move from document centric to model centric and this would reduce cost, time and risk to develop and deliver software systems [5]. In last decades UML, had become a de-facto standard language for modeling systems [3]. It consists of rich models used to model systems from different views but basically can be classified into two sets: static and dynamic. Among these the UML activity model, a- common dynamic model in UML model that is used to model processes [9].

UML has rich notations and technical concepts which were familiar for users are among factors makes it acceptable to the technical layer of professionals. For instance concepts like control flow and actions, etc. are runtime concepts. This abstraction level is more relevant to software developers which makes it difficult to be understood by business experts [6]. On the other hand, BPMN is established from organizations context. This to say the communication among stockholders is much the same the communication among computing objects. In order to reduce the cost of learning time and amplifying UML models, this paper suggests re-using UML metamodel in modeling business aspects. To reach this goal we have to identify and define the current gap in UML activity meta model in terms of running it as a business process modeling language.

UML has great machinery for extension or tailoring it to a new domain. This structure is called profiling. A profiling has an advantage of making light-weight extensions by re-using the same UML structure while defining new concepts of a specific domain. This feature makes UML a more powerful language because it enables cost less extension as the same tool infrastructure will be re-used.

The profiling has been practiced by OMG for engineering complex systems in what is known as SysML. SysML is developed for specification, analysis, design, verification, and validation of a broad range of complex systems. Its purpose is to unify diverse modeling languages used by systems engineers and can be used with a wide variety of discipline- and

domain-specific modeling languages [11]. SysML has reused UML by introducing new diagrams, merging others and extending some diagrams. This work is inspired by this best practice in re-using UML structure and adopting extensions.

In the following section, a respectable related work that has been conducted in this area will be reviewed. Then section 3 investigates in business process background with emphasis on famous modeling languages. The proposed solution that has been presented as a UML profile is shown in section 4. The last section sets the conclusion to this work and mentions some benefits that could be gained if the activity diagram is enriched.

RELATED WORK

Appreciated work has been done to integrate facilities of BPMN into UML activity model. Referring to various researches related to this topic, the efforts of authors can be categorized into three classes: 1-Comparison and Evaluation, 2- Extension and 3-transformation.

Some researchers had studied the relationships between BPMN and UML activity model, while others had *evaluated* BPMN to examine aspects of its power to model business process. Michael Rosemann et al. [13] had compared BPMN vs. Petri nets and studied representational capabilities between them. Their findings showed that both are good in representation of business process. Dariusz Badura [12] had described BPMN and UML activity diagram in term of modeling logistics processes. The study came up with result that UML activity diagram concentrates on presentation of information flow and resources, regarding object-oriented attributes of the process, whereas BPMN focuses on the processes. Stephen A. White [14] also had compared between UML and BPMN and checked if they have ability to represent workflow patterns besides their readability. The study had uncovered that they both provide similar solutions in most of patterns that have been tested against them. Daniela C. C. Peixoto et. al [15] had studied readability of both UML activity models and BPMN, they found that both have no significant difference. Birkmeie et. al [16] had evaluated usability between UML activity models and BPMN for business users. The result had shown that UML activity models are least usable than BPMN. Issues that can be raised in semantic when using natural languages to label transition systems have been overcome by approach presented in [17]. This method provides

business designers with a way to specify their business processes without obstacle to define their models. However, in this study, both software and business modelers are still stand in a separate island; whereas our study aims to bridge this gap between modelers by integrating business facilities into activity model.

Other researchers^[18, 19] had made an *extension* to UML in order to leverage it to model business process perfectly. Peter Rittgen^[10] suggested a proposal for extending UML activity model with business process semantics. He merged some features of Event-driven Process Chains (EPCs) with UML activity model into Petri net metamodel. In^[20] authors had unified set of UML consistency rules in order to provide sufficient rules for modelers who use activity models to describe software systems' processes. The variation of this study from our research is that it concentrates on software development, which it considered a technical level, while business modelers specify their business processes in abstract view.

On the other hand, some important researchers have studied the possibility of *transforming* and mapping UML activity models to BPMN. Maria Agustina Cibran^[5] has presented an approach for transforming BPMN models to UML activity models to bridge the gap between business users and IT experts. Marion Murzek and Gerhard Kramler^[21] had provided general framework model for transformation between several business process languages. Ondrej Macek and Karel Richta^[22] Had presented a method for transforming UML activity models to BPMN, but they had found that UML activity model hasn't contained all needed information, so some manual effort must be done to achieve the transformation.

The researchers mentioned above had spared no effort to enhance modeling of the business process by using different ways. They concentrated on integrating BPMN and UML activity language, but they did not provide a unified modeling language that can be understood by both business and IT experts, so they can easily communicate. A rich language that can be recognized by all stakeholders is necessary. Our research aims to design a language for modeling business process, which could be used by both business analysts and software designers. The proposed solution didn't come with a new language; rather, it has extended UML to make it rich to model business process.

BUSINESS PROCESS BACKGROUND

This section provides a background about business process concept and clarifies its relationship with workflow. The role of business process models in facilitating understandability of collaborative and complex systems is also discussed.

It can be mentioned that ancient functional view of enterprises has now changed into process view^[23]. This is due to growth and complexity of systems which lead organizations to think about systems from a process point of view.

Business process can be considered as well-understood interrelated activities to accomplish certain goals. Hammer and Champy in^[40] had defined business process as "*a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer*", while authors in^[41] declared it as "*a group of logically related tasks that use the resources of the organization to provide defined results in support of the organization's objectives*". Also Fingar^[38] clarified that business process is "*complete and dynamically coordinated set collaborative and transactional activities that deliver value to customers*". Moreover, Jang et. al^[25] has defined business process as: "*a flow of activities creating value by transforming some inputs into more valuable outputs*". Practically workflow is synonym concept to business process^[23]. Regarding those definitions it clear that all of them insured that business process is a set of ordered tasks that must be conducted to realize a certain goal to an organization. The notion of the business process had come from a business domain and it is closely related to workflow. Referring to David Hollingsworth^[28] workflow is "*The computerized facilitation or automation of a business process, in whole or part*".

As A. Terry Bahill & Rick Botta^[35] argued that, the first principle for good design of systems is to model its operations. Modeling is a suitable way to represent system processes. By the model, we can represent whole or part of reality. Modeling of systems is a new trend of building software systems which is resulted in various advantages such as: increasing productivity and decreasing risks of software failure.

Business process modeling is a way to visualize system processes graphically. In the beginning organizations used workflow diagrams to represent their systems processes (concentration here is on activities performed by each

department). Afterword's business process models were developed (they focus on activities performed by an organization) ^[29]. Business process modeling is a “*set of interrelated tasks, roles, and resources working in concert to achieve a business objectives or goal*” ^[9]. Business process modeling came to bridge the gap between business stakeholders and software modelers ^[27]. It could be feasible to facilitate communication between business stakeholders who have the problem and software modelers who will find the solution.

BUSINESS PROCESS MODELING LANGUAGES

A language is a system of symbols and rules that communicate specific meaning to agents. Languages are recognized in computing as well as in human being. Although they are different, they share the common principles. For example, Abstraction is an important attribute in both. On other hand there is a difference between a model and language. For both engineers and users, when we imagine in one domain such as business process some concepts will become necessary, like having a conceptual model for abstraction. There are several business modeling languages that have been developed for modeling business process. These languages had emerged from various backgrounds. Calin and Avram ^[37] declared that these languages had come from heterogeneous traditions which tend to serve different purposes and show several things. Strength of modeling language is insured by its ability to simplify the real world and supporting designers with understandable models ^[37].

It's worth mentioning that Business process model and notation (BPMN) and UML activity model are prominent business modeling languages ^[26]. In addition, several modeling languages had been developed in this area. It is clear that whole these languages implement concepts of business process theory- but their concentrations are different. Since UML and BPMN are standards and have much in common, as well as UML has a very rich structure, and the ability to add facilities using profiles, while BPMN has much richer concepts not present in UML, this work had chosen UML activity as a base and import extra facilities of BPMN on it.

BUSINESS PROCESS MODEL AND NOTATION

Business Process Model and Notation (BPMN) is standard visual modeling language – has been adopted by OMG. Its primary goal is to provide a notation that is readily understandable by all business users, from the business analysts that create the initial drafts of the processes, to the technical developers responsible for implementing the technology that will perform those processes, and finally, to the business people who will manage and monitor those processes ^[35].

BPMN elements were divided into five categories: **Flow objects** which are used to define the behavior of business process. There are three flow objects: events, activities and gateways. Second category is **Data**. It represents objects, input, output and data stores. Third category is **connecting object** which is used to connect flow objects or information to each other. There are four ways for connecting: sequence flows, message flows, associations and data associations. Forth category is **Swimlanes** which are used to group basic modeling elements. Grouping is represented in pools and lanes. The last category is **Artifacts** which is used to provide extra information about process. Artifacts involve group and text annotation ^[33].

UML ACTIVITY MODEL

This part clarifies the basic elements of UML activity model.

UML (Unified Modeling Language) is a graphical modeling language that has been designed to be used by different systems modelers to describe and design their systems ^[9]. UML consist of several modeling notations represented in diagrams that are used to model systems. Each one is used to model the system from specific point of view. One of these constructs is Activity diagram which is used to model processes.

Activity model is composed of two things: **nodes** and **edges**. Nodes are used to model individual steps in behavior that is specified by an activity, while edges are directed connection arrows between two ActivityNodes along which tokens may flow, from the source ActivityNode to the target ActivityNode^[9].

Action node: Is the basic unit of behavior specification in UML. It may take some inputs and produce some outputs. Sometimes action take and produce nothing. Part of actions may

modify the state of the system in which the action executes. **Object Node:** Is an ActivityNode which used to hold value-containing object tokens during the course of the execution of an Activity. **Control Nodes:** Used to control the flow of tokens between other nodes in an Activity. They compose of Decision, fork, join, merge, initial final and flow final nodes^[34].

SYSTEMS MODELING LANGUAGE

Systems Modeling Language (SysML) is a graphical language developed by OMG. Its purpose is to provide a standard modeling language that can help in bridging semantic gap between systems, software and other engineering disciplines. SysML can be used to generate specifications in a single language for heterogeneous teams. It is based on UML (Figure 2.), so it reused a subset of UML and added other extensions as follows:

- Diagrams that meet the requirements of SysML were remained as they are.
- New diagrams were defined when needed.
- Some diagrams were merged together.
- Some diagrams have been extended according to profiling in UML.

This work had imported facilities of BPMN into UML along the lines of the SysML project. That project has developed a new language which imports much of UML, and also makes extensive use of profiles. The approach has been applied by keeping the structure of activity metamodel as a base and adding some extra new components in the same model. So activity metamodel has been remained as it is and has been enriched with additional elements. Mechanism of profiling has been used but not in traditional fashion. Traditionally, profiling is applied by adding a separate collection of elements in one category called profile. This profile is using to model a new domain which has been added. But SysML idea intends to add new constructs to the same metamodel (not identify new one) to complete its shortage.

Gaps between Activity and BPMN Models

This section illustrates some gaps of activity models in a context of modeling business process. Through comparisons between BPMN and Activity model there were weaknesses appeared.

The approach of this study is conducted by investigating a UML activity diagram to examine

its adequacy to model business processes. Exploring had come up with following differences:

a) Conflict in modeling messages exchanging between external and internal participants:

UML activity model has no distinct notation for external messages, control flows and object flows; they are all represented by similar arrow. Regarding business process principles; its worth mentioning that there is a difference in the semantic of sequence flow, data association, text annotation and message flow (internally or externally). So it's more elaborated. For instance, Figure 3. shows the difference where only one notation is used to denote two different things in UML AD (Figure 3.-(i)). This means if you want to model external entity communications the consequences of that will yield ambiguity for both human and machine if automation is a target. In contrast, BPMN has different notation for each class of communications (Figure 3.-(ii)).

b) Nonexistence of transactions concept

UML activity models lack concept of transactions. This can be considered as shortcoming, because many systems depend on the result of a transaction in their processing. It is important to show this concept in the business process to emphasize the validity of data to be transferred. Especially, nowadays systems have become complicated and collaborated with each other. In many cases, such collaboration is conducted through transaction. So, this phenomenon is very important to be included in UML AD. Figure 4. shows business process model for flight booking using BPMN notations; whereas UML activity model lack to model this phenomenon^[33]. The business process of booking is implemented as follow: when transaction is executed, either it completes (commit) or it is undone (rollback). For instance, booking of both (car and hotel) either committed entirely or cancelled. This facility (modeling of transaction) cannot be modeled in UML activity model.

c) Problem of Chaining and Choreography

Choreography process is a kind of control flow usually happens between businesses and is used to:

1. Formalize the way business Participants coordinate their interactions.
2. Be viewed as a type of business contract between two or more organizations.
3. Model process chaining, e.g. supplying chain operation.

In business process modeling, choreography is represented by exchange of information (Messages) between Participants^[33]. “Choreography is an ordered sequence of B2B message exchanges between two or more Participants. In a Choreography, there is no central controller, responsible entity, or observer of the Process”,^[33]. Therefore, choreography concept can be used to model process chaining. Referring to UML specification, activity model does not allow representing chaining of processes concept which is obviously formed by choreography. Figure 5. illustrates example for interaction between patient and doctor in choreography manner.

d) Multiple Instances Activities:

UML activity models also unable to model multiple instances for activities. Multi-instance (MI) Activity is a type of Activity that acts as a wrapper for an Activity which has multiple instances spawned in parallel or sequentially. In this case activity will be executed multiple times concurrently. This mechanism is useful when the same activity needs to be executed for multiple entities or data items, such as:

- Request quotes from multiple suppliers
- Review result for several students
- Send and gather questionnaires for multiple witnesses in an insurance claim

Figure 6. represents a business process for procurement (using BPMN), in this scenario, a quote is to be obtained from various suppliers (assumption: five preferred suppliers exist). After all quotes are received from suppliers, they are evaluated, and the best quote is then selected. A corresponding purchase order is then placed. Compared with UML, this facility (modeling of multiple instances) is not supported in UML activity model.

UML PROFILE FOR ENRICHING ACTIVITY MODEL

The aim for designing UML profile is to enhance UML activity diagram to overcome weaknesses, which are explained in previous section. By handling such shortcomings, activity models will become capable to model new

concepts that amplify the power of Activity Model.

THE PROPOSED PROFILE

In fact, UML had become de-facto modeling for specifying and documenting information systems. Because UML is a general-purpose modeling language it has obstacles to model domain specific systems. This situation leads designers of UML to add mechanism to the language in order to tailor and adapt it to new domains. This mechanism is called profile^[39].

A profile is a light weight and extension mechanism consists of three components: **Stereotype**, **Tagged value** and **Constraint**. **Stereotype** is used to extend UML by adding new model elements that can be used in specific domain. **Tagged value** is used to define the properties of stereotype. For instance, Property +Text in stereotype Text annotation (Figure 7.). **Constraint** is used to clarify some semantics by using natural language. In profiling process only metaclasses model elements such as metaclasses "*class*" and "*property*" are subject to change or extensions.

Advantages of profile appear in extension flexibility, because it provides a way to add or modify an existing model with a less cost as it re-uses UML metamodel. Besides, profiling guarantees that the model will remain consistent with the UML standard. Figure 7. illustrates the proposed -Enriched Activity model- profile ((Enriched AD).

To distinguish between several edges that are use to link elements, stereotype-<<**Choreography**>> has been proposed to represent a set of one or more message exchange. Each Choreography action includes two Participants. There are two or more participant bands and one action name band. Choreography is a control flow which inherits abstract class "**Activity edge**" -Figure 7.

Beside choreography stereotype there is <<**MessageFlow**>>, which is used to depict the contents of a communication between two Participants. The tagged value "**Type**" determines if message is (reply) or (send). It extends Control Flow class (Figure 7.). The proposed notations for both send and reply message are shown in table 1.

<<**Text annotation flow**>> is a stereotype used to link text annotation. It extends abstract class activity edge. It is an artifact element that provides additional information for a business process of a system. Its proposed notation is shown in table 1.

Stereotype <<**Transaction**>> which is introduced as a new concept has no corresponding in Activity metamodel to represent a transaction which is supported by a special protocol that emphasizes parties involved who have complete agreement that the activity should be completed or cancelled. The proposed notation is shown in table 1.

Stereotype <<**MultiInstance**>> is used when the same action needs to be executed multiple times concurrently for entities or data items, such as:

- Request quotes from multiple suppliers
- Review result for several students

MultiInstance is an executable node which extends activity node (Figure 7.). The proposed notation is shown in table 1.

Referring to proposed extension, we can easily re-used UML Activity model elements that are augmented in this proposed profile collectively with original elements to model business processes with its different basic features without learning new language. By adding these enhancements, there will be a chance to bridge the gap between the programmers and business experts. The idea expected to help and make it possible to build a unified language, which can be used by both business modelers and software architects. Regarding business process model example in figure 8. : It is clear that activity diagram had become flexible to model collaborated participants that use messages to exchange information between external systems in a distinguishable manner. Besides, facilities like transaction and multiple instances could be modeled using Enriched AD.

Figure 8. illustrates an example of how to use this Profile for modeling a business process using the extended activity model. It depicts registration process in Kordofan University. First, each student must check his status; if he is legal he will fill a form of registration and send it to the registrar who will permit him to pay tuition fees. Then student sends the permission to his bank to withdraw from his account. If transaction of withdrawal succeeds, the bank sends a confirmation to both registrar and

student. The registrar sends file of any registered student to Health Insurance Company.

CONCLUSION

Activity model is a famous UML set of modeling styles among IT professionals while the business process modeling language -BPMN is originated in organization community. It turns out from user point of view. Learning new language will bring the cost of learning curve. Since both languages are adopting the principles of process view, it would worth providing a capability of speaking about business processes using the same activity model. This work proposes extending the activity metamodel after investigating the commonality and differences between both languages. A UML profile has been designed in this work. It aims enriching activity model to make it capable for modeling business process. The proposed profile has been developed by taking the experience of SysML project. Since business process and activity models are from different domain, building synergistic relationship is valuable not only to technical modelers but also for editor providers where we can see where they are different. The gaps in UML activity model are identified such as concept of transaction, messages between external participants, process chaining, flow of data and activities and multiple instances of activity. The real value of this extension is an opportunity to amplify the power of activity model by enabling business processes modeling. This will enable software modelers to model business processes with the advantage of reducing the learning curve.

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Table1 : Notations for the proposed enriched activity diagram

The proposed element	Notation
Send message	
Reply message	
Text annotation	
Transaction	
MultilInstance	

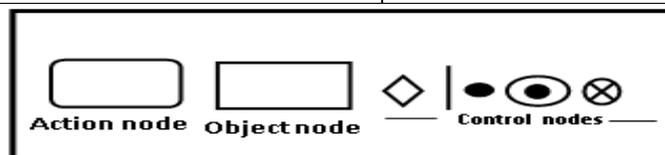


Figure 1: Activity diagram nodes

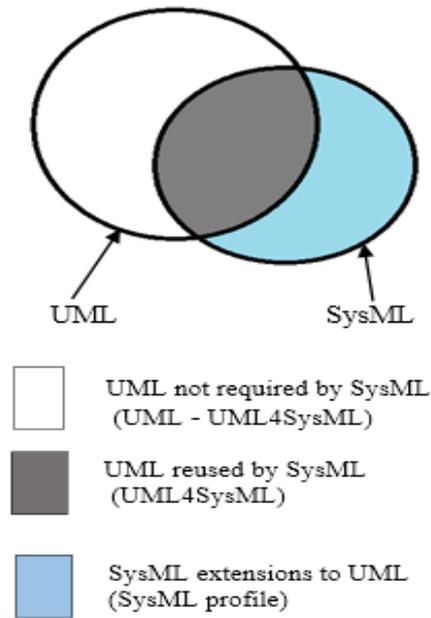


Figure 2: Relationship between UML and SysML

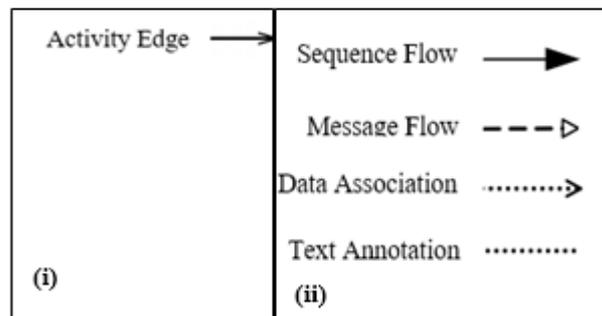


Figure 3: Conflict of notations

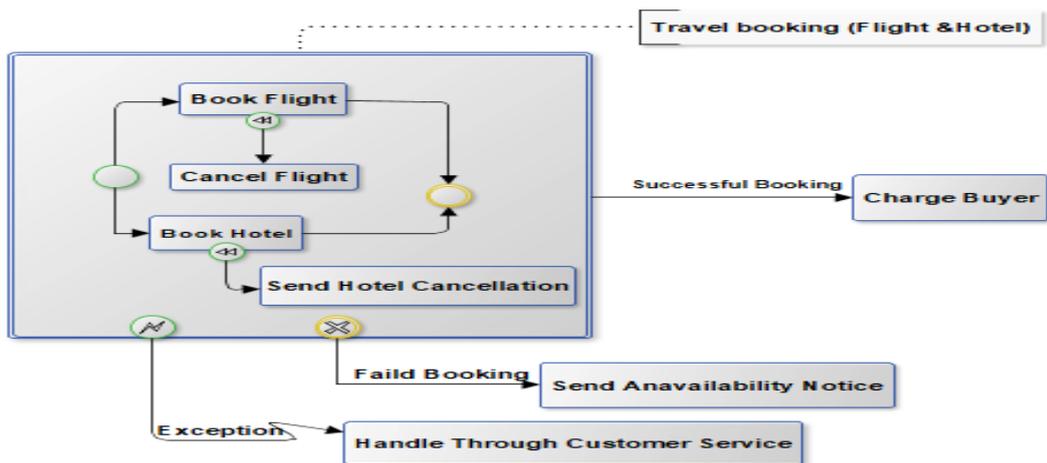


Figure 4: Modeling transaction process using BPMN

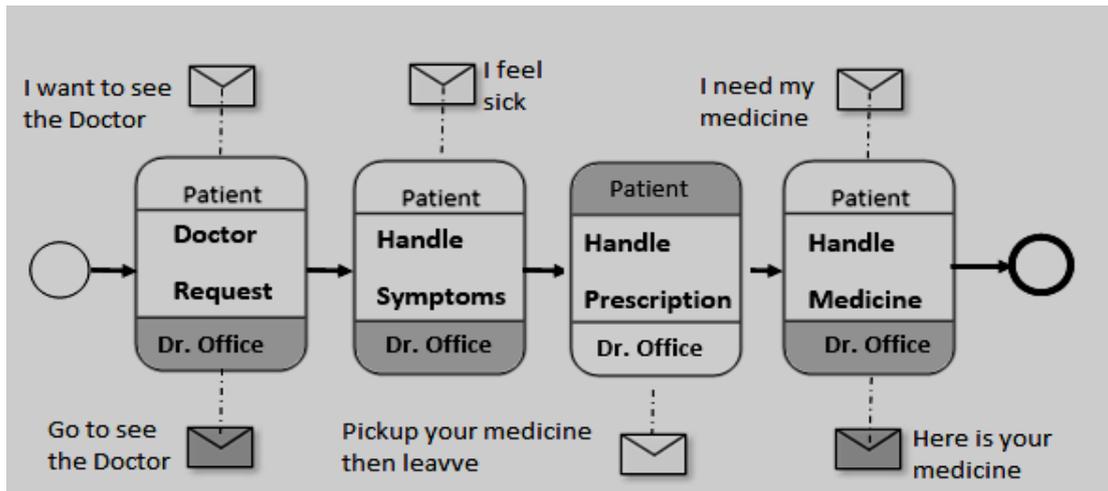


Figure 5: BPMN model for Choreography process

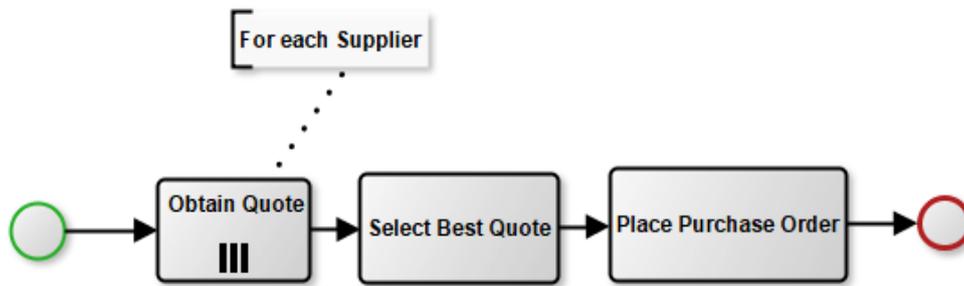


Figure 6: Selection of best Quote - Using BPMN

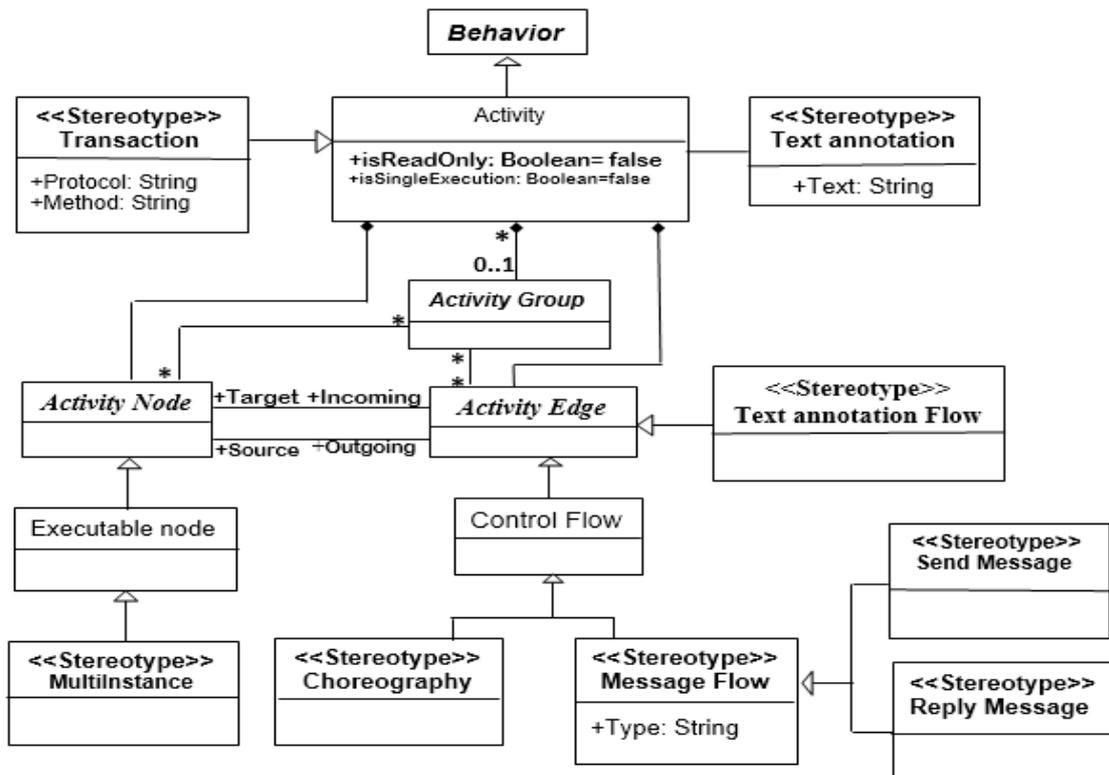


Figure 7: Enriched Activity Diagram Profile

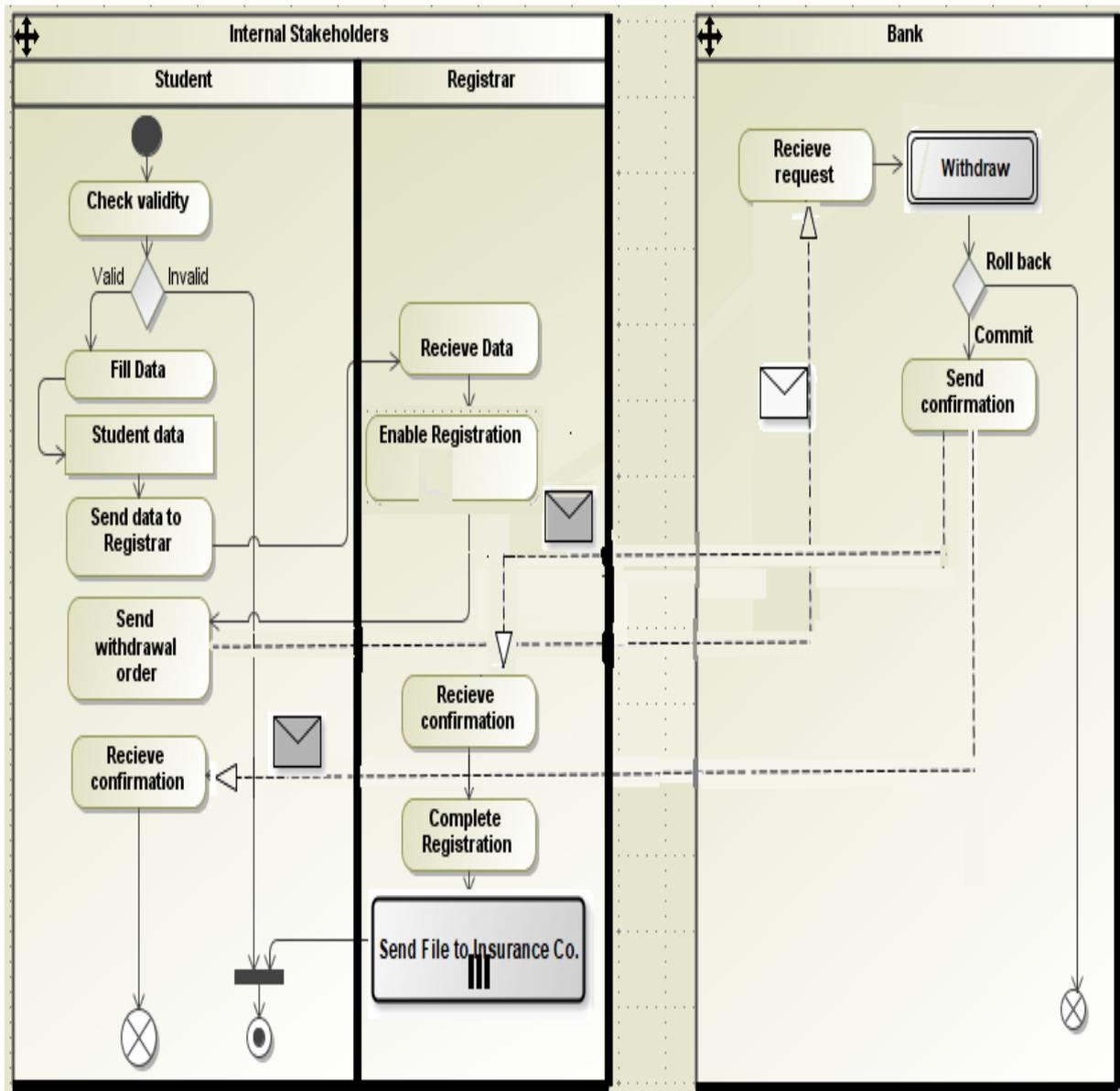


Figure 8: Student registration in Kordofan University