Business Process Model Recommendation as a Transformation Process in MDE: Conceptualization and First Experiments

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Abstract: Business Process (BP) model repositories have been proposed to store models of BP and make them available to their stakeholders for future reuse. One of the challenges facing users of such repositories concerns the retrieval of models that suit their business needs in a given situation, which is not provided by current repositories. In order to overcome this lack, one important issue to investigate is to provide recommendation of BP models based on the user profile as the most important way to better meet his business needs which promote BP model reusability. In this paper, we propose a conceptual framework of BP model recommendation based on the user social profile and implemented as a transformation process in model driven engineering (MDE). In our experiments, the LinkedIn social network is used to extract the users' business interests. These user business interests are then used to recommend the appropriate BP models that could fit to the user. Our proposed framework is based on model driven architecture (OMG MDE approach) where techniques of models, metamodels, transformation and weaving are used to implement a generic recommendation process.

1 INTRODUCTION

A Business Process (BP) modeling is fundamental part of Business Process Management (BPM) lifecycle for improving organizational efficiency and quality of business processes (BPs) in enterprises (Gerth, 2013). However, modeling BP from scratch is fallible, complex, time-consuming and error prone task (Markovic, Pereira, and Stojanovic, 2008). One of the promising solutions to these issues is the reuse of BP models (Elias and Johannesson, 2012). Therefore, it is important to provide a repository to store thousands of BP models for business reuse (Gao and Krogstie, 2010).

Re-use techniques facilitate the use of existing BP models in order to simplify the development of new models or the improvement of existing BP models. Reuse of BP models is designing BPs by using existing process models (Gao and Krogstie, 2010). Exploiting already designed BP models is one of the promising solutions to reduce the time and cost consumed to model new BP, minimize errors and increase BP model quality and flexibility (Gao and Krogstie, 2010), (Fellmann, Koschmider, and Schoknecht, 2014), (Shahzad et al., 2009), (Mendling et al., 2017). To reuse BP models, it is important to provide a BP models repository to store BP models for future reuse. Fortunately, many organizations have establish BP model repositories to maintain and reuse existing BP models (Elias and Johannesson, 2012),(Gao and Krogstie, 2010), (Fellmann, Koschmider, and Schoknecht, 2014), (Shahzad et al., 2009). For example, SAP, MIT.

Recent works (Elias and Johannesson, 2012), (Shahzad et al., 2009), (Yan, Dijkman, and Grefen, 2017),(Yan and Grefen, 2010) show that the existing repositories do not adequately support reuse of BP models. So, it is difficult for business actors to find the relevant BP models in BP model repositories and share process knowledge. The lack of an efficient models retrieval system (Yan, Dijkman, and Grefen, 2017), the different process repositories classifications, the heterogeneity of repositories

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structure and the potential size of existing repositories do not allow their users to find easily models for future reuse. On the other hand, process model retrieval from a process repository still suffer from much manual work (Li et al, 2014) and cannot relieve business users from the highly complex, time consuming, and error-prone task of building new BPs from scratch.

Considering the above issues, there is a need for an automated approach which can recommend BP models to help repository stakeholders to find and therefore reuse models to build new one. Recommender systems have been widely used as an effective answer to these difficulties. Recently, Recommender systems became a hot topic and have been widely used in both academic research and industry applications. However, its applicability in the field of BPM remains very modest, there are only a few works (Li et al., 2014), (Deng et al., 2017), (Hornung, Koschmider, and Oberweis, 2009),(Imad, Elkindy, and Corea, 2019), (Schonenberg et al., 2008),(Setiawan, Sadiq, and Kirkman 2011) (Laurenzi et al., 2019) in BPM domain.

We claim that by integrating recommender system into BP model repository, we can increase the accessibility of BP models for repository users. Furthermore, integrating recommender system into current BP model repositories presents an effective mechanism that can help users, to find BP models easily and reuse the available knowledge of BP model repositories to reduce time and effort, and improve the quality of newly designed models. Motivated by this idea, SBPR, a Social Business Process Recommender for BP model reuse, is proposed.

According to the study presented by Shahzad, et al. in (Shahzad, Elias, and Johannesson, 2010), in order to reuse BP models, it is important to know the environment in which a process can or is intended to work. This environment consists of the business context in which the BP can be applied, the goals of the process, and the actors of the process. We believe that the business environment in which stakeholders are involved can influence the BP models that may interest them. The LinkedIn social network is used to extract the business profiles of users. Research has shown that LinkedIn is the primary business-oriented social networking site that professionals use (Salman, 2019). LinkedIn had more than 630 million members making it the largest online professional network (Salman, 2019). A LinkedIn profile contains a member's current and past work history, education, career information and projects which reflects the business environment in which the users are actually involved.

In this paper, we propose a novel recommender system, which generates predictions simply by combining the user business profile to determinate the business environment in which user is actually involved with the metadata of BP models stored in repository. The power of our recommender system lies in its ability to make a recommendation of BP models in real time from users' business profiles. Our approach is based on model driven development (MDD) through model driven architecture (MDA) where metamodels allow to define a generic representation of user profiles in one side and BP models in other side. Taking advantage as much as possible of existing MDA technologies, we have implemented our recommender system as a transformation process which takes as input a LinkedIn user profile and proposes in output a set of potential BP models.

In this paper, we propose a conceptual framework of BP model recommendation to help users find new BP models from repository in an efficient and accurate way. The proposed framework is based on the user social profile and implemented as a transformation process in model driven architecture (MDA).

The remainder of this paper is organized as follows: Section 2 presents related work. Section 3 gives an overview of our SBPR framework. Section 4 presents our Model Driven Approach where metamodels for both user business profile and BP metadata are presented. Section 5 presents a case study, results and discussion. Finally, section 6 concludes and outlines our future research directions.

2 RELATED WORK

Recommendation has already been investigated in BPM to assist stakeholders in choosing the suitable BP for a given activity. Presently, there are two kinds of work on process model recommendation (Deng et al., 2017):

- Complete process model recommendation by reusing existing complete process models and
- Process model fragments recommendation in order to model new process models by reusing process model fragments.

2.1 Process Model Fragments Recommendation for Modeling

A lot of work has been devoted to Process model fragments recommendation. For example:

H. Schonenberg et al. in (Schonenberg et al., 2008) proposed a recommendation service, which, when used in combination with flexible PAISs[1], can support end users during process execution by giving recommendations on possible next steps. Recommendations are generated based on similar past process executions by considering the specific optimization goals.

Hornung et al. in (Hornung, Koschmider, and Oberweis, 2009) have proposed a recommender system that suggests a list of correct and fitting process fragments for an edited BP model, which can be used to complete the process model being edited. The benefit of such a system is to assist users during process modeling by reusing process fragments from a process repository.

M. Andri Setiawan in (Setiawan, Sadiq, and Kirkman, 2011) presented an approach to assist process designers and promote process improvement by the development of methods for multi-criteria based process ranking and personalized recommendation, the approach intended to assist users by learning from already existing successful practices.

Ying Li in (Li et al., 2014) proposed a workflow recommendation for improving BP modeling that precede associate rules mining between business activity nodes and process fragments within the workflow repository, and provide decision support for modeling processes. The associate rules mining refer to pattern extraction. Extraction of those patterns from the workflow repository is based on graph-mining technique. which is the foundation of workflow recommendation. Based on measuring similarity and calculating distance between reference model and process patterns, technique could recommend appropriate nodes for modelers to automate the construction of BPs.

Rangiha et al. in (Rangiha, Comuzzi, and Karakostas, 2015) described a recommender task system that uses social tagging to collect relevant information from discussions between process actors during process execution. Analysis of these tags allows the system for recommending new tasks when the same process must be executed again.

Deng et al. in (Deng et al., 2017) have proposed a process recommendation system that can assist BP analysts build new BPs from scratch. It can recommend proper nodes (fragments) based on patterns mined from existing process repositories.

E. Laurenzi et al. in (Laurenzi et al., 2019) proposed a process modeling approach that assists domain experts in the creation and adaptation of process models. To get an appropriate assistance, the approach is driven by semantic patterns and learning. Semantic patterns are domain-specific and consist of process model fragments (or end-to-end process models), which are learned from feedback from process modeling experts.

2.2 Complete Process Model Recommendation

Complete process model recommendation helps to reuse process models by discovering or retrieving such process models from repository that satisfy users' explicit requirements or conform to their implicit intentions.

A. Koschmider et al. in (Koschmider, Hornung, and Oberweis, 2011) proposed a system for supporting users at modeling time by providing a recommender component and search functionality for process model parts stored in a repository. The recommendation-based modeling support system is based on users' tagging behavior and intentions, this system implements other functionality, such as a search interface.

K. Kluza et al. in (Kluza et al., 2013) presented several machine learning methods which can be used for recommending features of BP models. Furthermore, the study in Kluza et al. (Kluza et al., 2013) suggests a classification schema to the recommendations.

Bobek et al. in (Bobek et al., 2013) presented a method that uses Bayesian Networks for recommendation purposes in process modeling and configurable models, such a method can help in speeding up modeling process and producing models that are less error prone compared to these designed from scratch.

Ariouat et al., in (Ariouat, Andonoff, and Hanachi, 2018) has addressed process recommendation in crisis management field. The Process recommendation uses data observed in the field, i.e. risk and damage of the crisis, along with business knowledge of actors involved in crisis resolution in order to recommend different strategies with observed facts depending to the context and then build processes corresponding to chosen strategies.

[1] Process Aware Information Systems

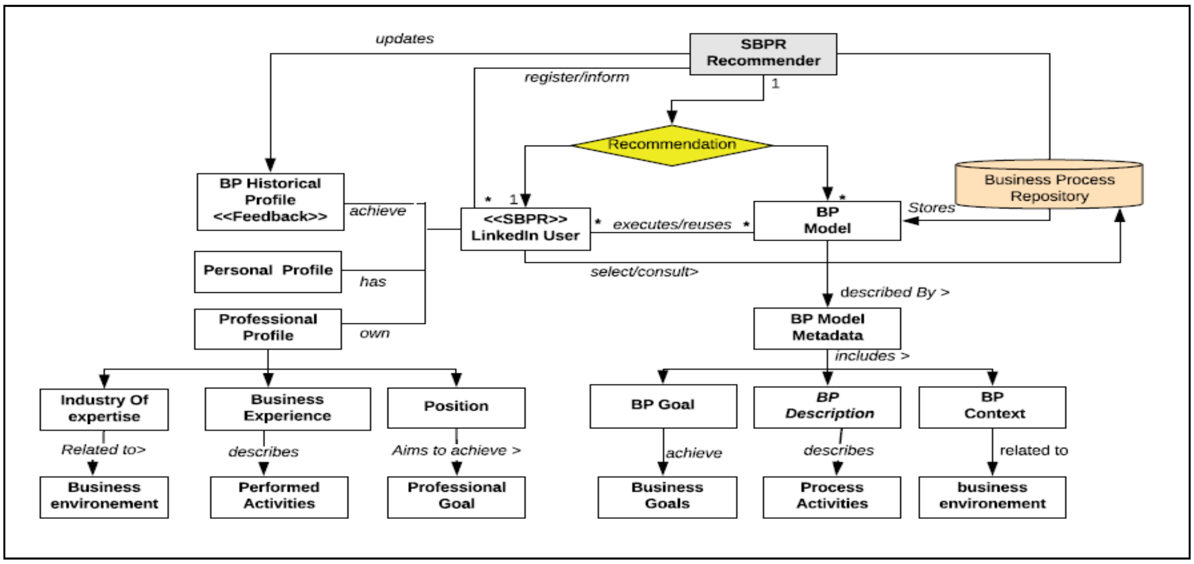

Figure 1: SBPR Framework Source: (Khider et al., 2018).

2.3 Synthesis and Positioning

However, the above-cited approaches use recommendation suggestions during design time and usually focused on how to guide the modeler during the modeling process on possible next activities to create. Furthermore, those approaches ensure a certain degree of modeling support but yet with little focus on the user interests. The recommendations provided is based on factors as labels of elements, current progress of modeling process, and additional information, such as process description. but they never take the business interests of the user into consideration (Kluza et al., 2013). In this paper we propose a process recommender system to help business users find new process models from repository in an efficient and accurate way. Furthermore, our approach is not limited to designer or modeling experts but it is destined to any user who accesses a repository of process models in order to find a BP model to reuse. Moreover, the power of our recommender system lies in its ability to make recommendation based on business profile of user and implemented as a transformation process in model driven architecture (MDA). Our proposition is not limited to the modeling stage but it can be spread on all stages of BPM. To our knowledge, there are no approaches that have proposed the integration of a recommender system to current process model repositories to help their users find models easily and according to their business needs.

Moreover, till now, according to our knowledge there is no an approach that uses the MDA model transformation process for the recommendation of BP models. Thus, recommending the appropriate BP models that could fit to the user would be implemented as a transformation of a user business profile into BPs models.

3 OUR SBPR FRAMEWORK

In this section, we propose the Social Business Process Recommender (SBPR) Framework in order to overcome some of problems that affect the actual BP model repositories. The figure 1 illustrates the different elements characterizing this framework and their relationships. On the left hand side of this figure, we find the main properties of a user profile according to LinkedIn. On the right side, the metadata of BP model are presented. SBPR recommender aims to recommend to the users of process models repositories BP models for reuse. LinkedIn User profile is the source of social data for SBPR recommender; BP models are target items to be recommended to user. SBPR recommender recommend BP models based on the business environment of user which is learned from his LinkedIn business profile.

4 A MODEL DRIVEN APPROACH

In conformity with MDD approach we have defined two metamodels, the first one is the LinkedIn user profile metamodel and the second one is the BP metadata metamodel.

4.1 LinkedIn User Profile Metamodel

LinkedIn is an online professional social network which may represent real-world professional relationships. We have chosen LinkedIn[2] for the reason that LinkedIn is a business-oriented social networking site where users post their professional and career information, which allow us to have an image of the user's business environment. Figure 2 presents a potential meta-model for the LinkedIn User profile (fragment).

The meta-model defined in this section was designed as a synthesis of concepts proposed by several authors, and more specifically the work of Jean-Marie Favre presented in (Jean-Marie Favre 2007). The main elements of this metamodel are: (as shown in figure 2)

- **The LinkedIn User Profile:** LinkedIn is used for professional networking; it allows members to create profiles. LinkedIn user profile is formed by a set of profile fields[3] predefined in LinkedIn.
- **LinkedIn User Business Profile:** from the fields that constitute the full user profile we have chosen those that reflect his business environment. The main elements that make up the business profile are: Industry, Position, Skills.
- **Industry:** the user on LinkedIn can specify his industry according to the reference table of industry[4] codes available on LinkedIn. the 10 top industries in LinkedIn are: Information Technology and Services, Marketing and Advertising, Human Resources, Computer Software, Financial Services, Staffing and Recruiting, Internet, Management Consulting, Telecommunications, Retail[5].
- **Business Experience:** includes information about the business accomplishments, skills, company, industry, area of expertise and professional competencies of the user.

4.2 BP Metadata Metamodel

Figure 3 presents a possible meta-model for the BP metadata (fragment). The BP metadata metamodel (Figure 3) captures these elements and their relationships in detail.

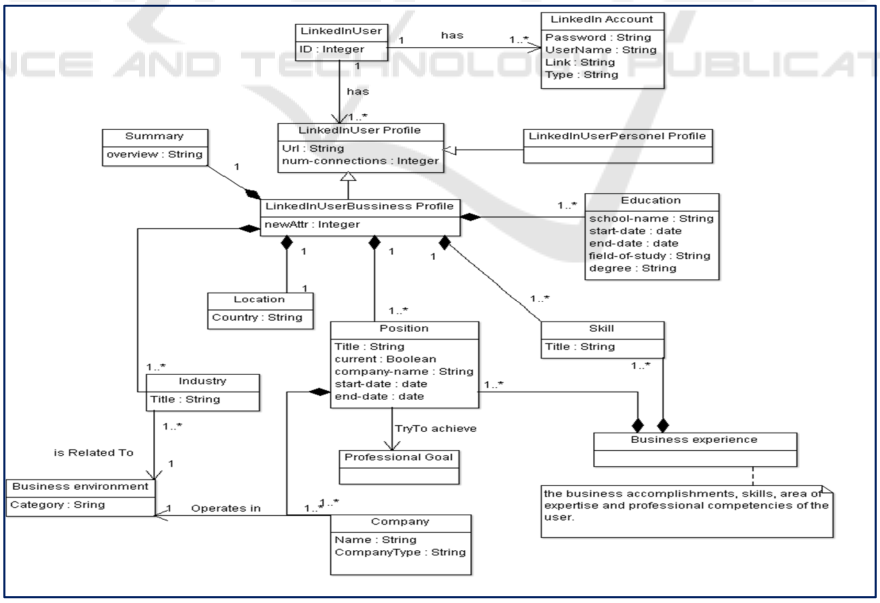

Figure 2: LinkedIn User profile metamodel.

2 https://www.linkedin.com/
3 https://developer.linkedin.com/docs/fields/full-profile
4 https://developer.linkedin.com/docs/reference/industry-codes
5 https://www.linkedin.com/pulse/linkedin-industry-rankings-see-which-tops-list-joshua-waldman

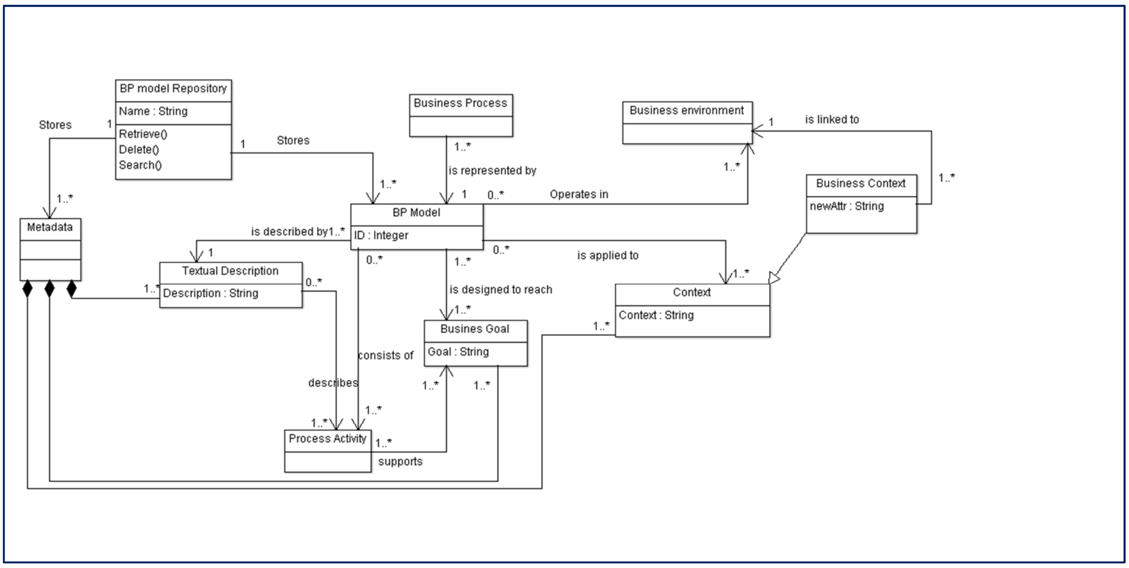

Figure 3: BP metadata metamodel (Fragment).

This metamodel is based on set of proposed developed metamodels in literature among which the metamodel developed by zur Muehlen in (Zur Muehlen, 2004), the metamodel developed by M. Rosemann (Rosemann, Recker, and Flender, 2008) and metamodel developed by M.Elias in (Elias, Shahzad, and Johannesson, 2010). The main elements of this metamodel are:

- **BP Description**

Many organizations complement their BP models with textual descriptions specify additional details that describes the activities of a process, the involved entities and their interaction. Process repositories in practice do not only consist of BP models, but often also contain textual BP descriptions (Leopold et al., 2019). Taking the information from textual descriptions into account may provide a clearer view of the BP models that may interest the user in order to reuse them. By taking into account the semantic of textual descriptions of BP models in our recommendation process allows us to identify more relevant models from repository.

- **Business Context**

To reuse a BP model, it is important for a user to understand the business environment in which a BP is aimed to work. The business context in which the BP takes place is specified by a set of categories and their associates values (Hofreiter and Huemer, 2006). e.g. Industry, Manufacturing. SAP repository classifies BP models according to their business context. According to Born et al. (Born, Kirchner, and Müller, 2009), the context defines the environment in which a BP is used.

- **Business Goal**

BP model describes activities conducted in order to achieve business goals. Business goals express what the organization wants to achieve from the business perspective (Markovic, Pereira, and Stojanovic, 2008). As defined by M. Weske in (Weske, 2019) a business goal is the target that an organization aims to achieve by performing correctly, the related BP. Relating BP models with goals in the repository can help users to understand and thereby reuse BP models.

4.3 A Methodology for Transformation Process

In our proposed approach the transformation process of a User business profile metamodel (source) into a BP Metadata metamodel (target) aims to find correspondences between the elements of two metamodels source and target, and then generate metadata to allow us to predict models that fit to business environment of the user for reuse.

In conformity with the research work discussed in (Hammoudi et al., 2010), the transformation process is structured in two phases: mapping specification and transformation definition.

A mapping specification is a definition of the correspondences between two metamodels. From a conceptual point of view, the explicit distinction between mapping specification and transformation definition remains in agreement with the MDA philosophy, i.e. the separation of concerns. Moreover, a mapping specification could be associated with different transformation definitions, where each transformation definition is based on a giving transformation definition metamodel. Figure 4 hereafter represents a mapping specification from LinkedIn User business profile into BP metadata. We have used ATL transformation language (Bézivin et al., 2003) to define transformation rules.

4.3.1 Generation of Transformation Rules

This phase aims to automatically generate transformation rules from mappings, and format them into a transformation models. According to Figure 4, we have the following mappings:

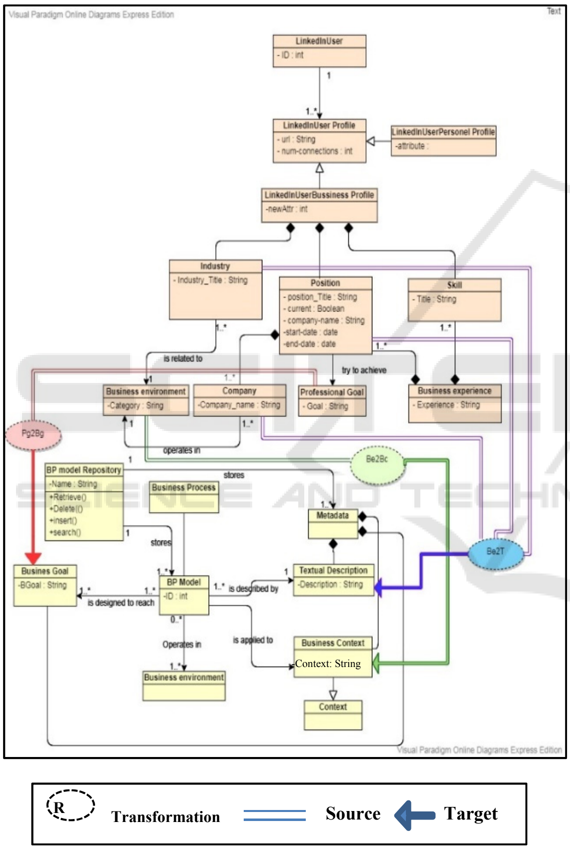

Figure 4: Mapping from User business profile into BP model metadata.

The User business profile business `environment` is mapped into BP metadata `business context` through the rule `Be2Bc`.

The User business profile `business experience` is mapped into BP metadata business `textual description` through the rule `Be2T`.

The User business profile *`Professional Goal`* is mapped into BP metadata `Business Goal` through the rule `Pg2Bg`.

The table 1 below show the different rules generated.

Table1: Transformation Rules from mappings.

Transformation rules in human language	Transformation rules in ATL
R1 Be2Bc: *Business environment in LinkedIn User business Profile corresponds to business context in BP metadata*	rule Be2Bc { from be*:* User business profile! business *environment* to bCxt$_{Grtd}$: BP metadata! business context(context<- Be.category) - - Cxt$_{Grtd}$: name of local variable referencing the instance created at the output of the rule }
R2 Be2T: *Business experience (industry, company, position) in LinkedIn User Profile corresponds to textual description in BP metadata*	rule Be2T { from bxp*:* User business profile! *business experience* to Des$_{Grtd}$: BP Metadata! Textual Description (description<- bxp.industry_title+bxp.position_title + bxp.company_name) - - Des$_{Grtd}$: name of local variable referencing the instance created at the output of the rule}
R3 Pg2Bg: *Professional Goal from LinkedIn User business Profile corresponds to Business Goal in BP metadata*	rule Pg2Bg { from *Pg*: User business profile! *professional goal* to Gl$_{Grtd}$: BP Metadata! business goal (BGoal<-pg.Goal) - - Gl$_{Grtd}$: name of local variable referencing the instance created at the output of the rule}

5 A FIRST EXPERIMENTS

5.1 Dataset Description

To test our approach, we have established dataset of BP models and related metadata. The dataset we use for applying our approach for recommendation of BP models consists of 600 BP models modeled in the Business Process Model and Notation (BPMN).The collection of BP models is collected manually from different BPM platform like Signavio[6],Apromore[7] and other sources. In addition to the BP models, the dataset contains 600 textual BP model descriptions in the text format. Table 2 summarizes the key characteristics of our dataset collection. The BP models cover various business domain including manufacturing process, selling process, booking process …etc.

Table 2: Characteristics of dataset collection.

No. of BP models	**600**
Format	BPMN
No. of BP model textual descriptions	600
No. of words (average)	64 800
No. of words / model (average)	108
Format	.txt

5.2 Case Study

For the purpose of evaluation, we conduct a case study to evaluate the effectiveness of our recommender system by conducting experiments applied to our dataset of 600 BP models in BPMN format when user invokes a query about a claim process. We have the following user: Patty Adel with the following LinkedIn profile (view the table 3 below). In our case study the user enters 'claim' as a keyword using the classic search functionality available in repository to specify that he needs models on claim process.

Table 3: LinkedIn user business profile.

Positions Title: Assistant, Business Development positions/is-current: true Positions/company-name: The Economical Insurance Group Public-profile-url:/pub/patty-adelvard-eig/39/90b/631 Location: Calgary, Canada Area First-name: Patty Last-name: Adel Industry: Insurance Skills: null Current project: no specified

User inquiry (search keyword): claim
Probably results: for the user inquiry we have the following results as shown in Table 4 below:
P70LR, P122HR, P70NC, P11 ...etc. denotes BP Models.

Table 4: Case study results.

User keyword	claim
Repository collection	Ours (dataset)
Process models founds (by the classic search functionality)	P70LR, P120LR, P116LR P122, P120, P119, P116, P113, P70, P11 P122HR, P119HR, P116HR, P113HR, P70HR P70NC, P122NC, P120NC,113NC, P86NC
Number of the BP models found (classic search)	20
BP models format	BPMN
Recommended BP models according our approach Social recommendation + user inquiry	P120LR P120, P113 P113HR P120 NC P113NC
Number Of BP models found via our approach+ user inquiry	6
Total BP models in dataset	600

5.3 Evaluation

To evaluate the performance of the proposed SBPR recommender system in terms of Top-N recommendations, we have chosen the following metrics (Nadee, 2016) (i.e. Precision at N, Recall at N, F1 measure) for the evaluation of the recommender. We have chosen to evaluate the accuracy performance of our recommender system in terms of top-5 recommendations. We ask recommender to provide five BP models (we have chosen top 5 recommended BP models).

We hide some BP models relevant to user U (our user 'Patty Adel' case study) as a testing set.

Testing test= {P120, P113, P113HR, P120 NC}

[6] https://www.signavio.com/
[7] https://apromore.org/

- Precision on top-5:

$$Precision = recommended\ (U) \cap Testion(U)/Recommended(U)$$

- Recall on top-5:

$$Recall = recommended\ (U) \cap Testion(U)\ /\ Testing(U)$$

- F1 measure:

$$F1 = (2 \times (Precision \times Recall))/((Precision + Recall))$$

Table 5: Accuracy performance metrics computing for SBPR recommender.

Accuracy performance metrics (for SBPR Recommender)	values
Precision	4/6=66.667 %
Recall	4/4=1=100 %
F1 measure	0.8

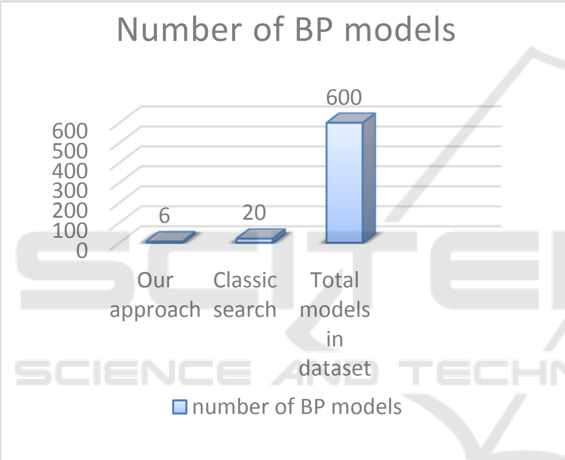

Figure 5: BP models found (results of the case study).

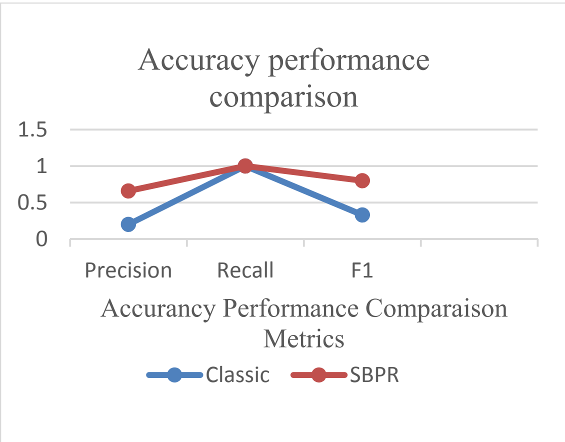

Figure 6: The accuracy performance comparison between SBPR recommender and classic search functionality.

Table 6: Accuracy performance metrics computing for classic search functionality.

Accuracy performance metrics (for classic search functionality)	values
Precision	4/20=0.2=20%
Recall	4/4=1
F1 measure	0.33

5.4 Experimental Results and Discussion

Results: The results indicated that after combining the proposed SBPR recommender system (as mentioned in the case study) based on the user's LinkedIn business profile (Patty Adel in the case study) with a user's inquiry about the process model he wants, (claim process) the accuracy of the BP model recommendations can be further improved.

Discussion: As we see in the Table 4 the number of BP models recommended to user when applying for our recommender system is decreased to six BP models while it was at twenty BP models found via the classic search functionality provided in repository. The results show (as mentioned in figure 5) that the number of BP models found that fit both user business profile and manual inquiry of user (where the user specified the process he wants by keyword 'claim') is decreased by 70 percent compared to the number of models found via the classic search functionality. The case study presented is conducted on our established dataset of 600 BP models.

6 CONCLUSIONS

In this paper we presented a conceptual framework of BP model recommendation based on the user social profile and implemented as a transformation process in model driven engineering (MDE). The benefit of such a Framework is to facilitate the process modeling by reusing existing BP models from the BP model repository. The recommended BP models are based on business profile of user. The users' business profiles are captured from their online LinkedIn social network.

We have proposed to integrated our SBPR recommender to current process model repositories. without any modifications in repositories' current structures. Most of actual repositories offer simple interfaces, where users can only search by keywords such as MIT repository or explore the available content via taxonomical navigation such as in SAP repository. The performance metrics have shown that the precision metric in our SBPR recommender system is more relevant compared to the classic search functionality. Furthermore, the number of models recommended is decreased compared to the number of models found via the classic search functionality. In this paper also, we have proposed to implement our SBPR recommender system as a MDE model transformation process, consequently we have proposed two metamodels User business profile metamodel and BP metadata metamodel, to find correspondences between the two metamodels we have relied on the mapping specification. Therefore, we proposed a metamodel for mapping specification between the two metamodels. We have briefly presented transformation rules with ATL transformation language to specify the model transformation. Once mappings are specified between the two metamodels, metadata (that reflect business environment of user) are generated automatically. these metadata are then used to find the closest matches in the BP model repository.

We discussed the application of our approach to a case study where user search for specific BP model and specify it as a keyword. The results show that the number of BP models found that fit both user business profile and manual inquiry of user is decreased by 70 percent compared to the number of models found via the classical search functionality. The case study is conducted on a dataset of 600 BP models. In our future research, we will use a transformation tool to facilitate the transformation from User profile into BP model metadata metamodel and then, we will develop a prototype to validate our approach.

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