An Empirical Assessment of the Effect of Context-Based Semantic Annotation on Process Model Discovery

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Abstract. CPSAM is a context-based process semantic annotation model for annotating business processes in a process model repository. The purpose of the annotation model is to facilitate searching process models, navigating a process model repository and enhance users' understanding of process models. The annotation model has partly been evaluated through an empirical study to test the annotation consistency and correctness. The purpose of this paper is to examine the effect of the process annotation (based on CPSAM) through a controlled experiment, where a prototype of the repository is used, to annotate and store process models based on the CPSAM. The evaluation is supposed to test whether process annotation based on the CPSAM can facilitate searching, navigation and understanding of process models stored in a repository. The results show that annotating business processes using the annotation model positively affects searching process models, navigating the repository and understanding process models.

1 Introduction

Business Process Management (BPM) has become one of the most important instruments that help modern organizations meet their business goals and achieve competitive advantage. Business process modeling plays a vital role in BPM. Motivations for modeling business processes include documenting current business processes, redesigning and improving processes, aligning business and IT, etc. Modeling of business processes is a complex, costly and time consuming task [1, 2], however, the efforts made to model business processes are seldom reused beyond their original purpose. An attractive alternative to modeling business processes from scratch is deriving them by redesigning existing models. Such an approach requires the use of business process model repositories that provide a location for storing and managing process knowledge for future reuse.

There exists a number of efforts to build process model repositories, e.g. the MIT Process Handbook [3], SCOR [4], SAP's Business Map [5], and IBM's Patterns for E-Business [6]. However, the use of such repositories is still limited and fragmented [7]. In order to investigate the reasons for this limited use, a number of requirements on business process repositories were elicited in our previous study [8]. These

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requirements were then used to review and compare a number of existing repositories [9]. A main finding was that any repository requires effective instruments for searching and navigating its contents. In order to address this challenge, a context-based process semantic annotation model (CPSAM) [10] was developed for semantically annotating business processes in the repository. The purpose of the annotation model is to facilitate searching process models, navigating the repository and enhance understandability of process models. The annotation model (CPSAM) consists of the following annotation elements, *process type*, *process area, resource*, *actor*, *organizational level*, *process phase*, *process relationship*, *business context*, and *goal,* as shown in Figure 1.

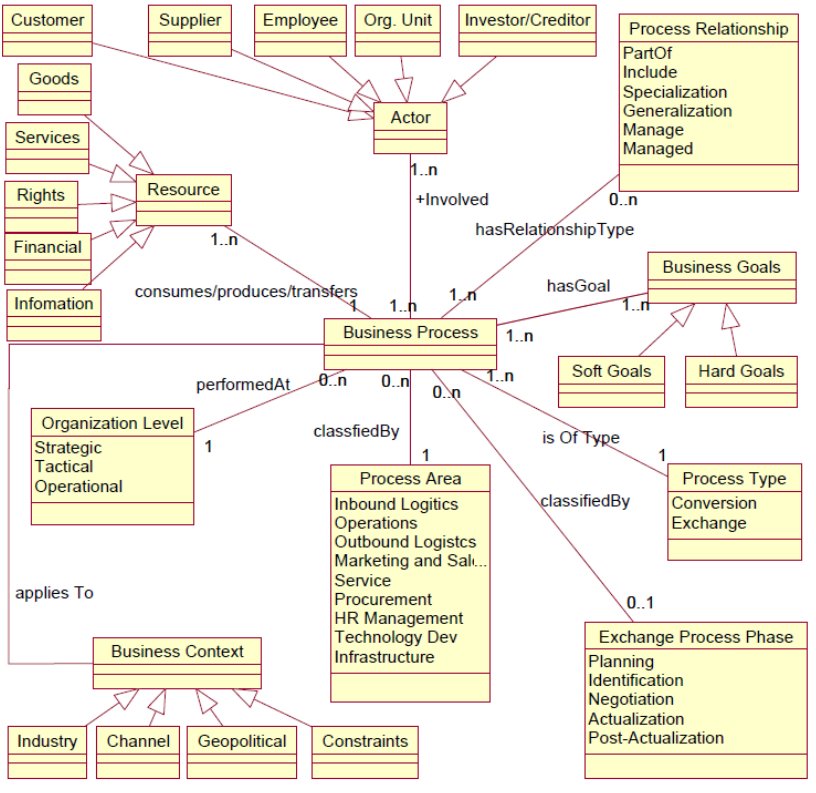


Fig. 1. A Context-based Process Semantic Annotation (CPSAM) [10]

- The *business process* is the main concept that is described. It captures some basic information such as version number, process name, etc.
- *Process Area* element classifies business processes by their function in the value chain or core competence.
- The *organizational level* element describes the level in the organization at which a business process is performed.

- The *process type* element classifies business processes according to whether they aim to exchange or transform resources.
- *Exchange Process Phase* element classifies processes based on activities needed for exchanging resources that extend over several phases from initial planning to follow-up activities after the actual exchange has been completed.
- *Resource* describes the resource that is being consumed/produced by a conversion process or exchanged by actors in an exchange process.
- *Actor* describes an entity such as a person or an organizational unit involved in the realization of a business process.
- The *process relationship* element describes how business processes are related.
- A *business context* defines the circumstances in which a process may be used.
- The *business goal* element describes the business goals that a process model is intended to achieve.

The annotation model extends existing process classification schemes, [11, 12] by incorporating elements from well established frameworks in accounting [13, 14], organizational theory [15, 16], and enterprise modeling, [17]. A detailed description of the annotation model can be found in [10].

The CPSAM was evaluated in our previous study [10], however, the scope of the study was limited to evaluating the consistency and correctness of annotating business processes by using CPSAM i.e. the model has not been evaluated to measure its objective (searching, navigation and understandability). Therefore, the aim of this study is to evaluate the effect of the context-based process annotation through a controlled experiment to measure its performance and users' perception.

Against this background, the remainder of the paper is structured as follows. In Section 2, the exemplar application of the annotation model using a repository prototype is presented. Section 3 introduces the evaluation framework and the experimental settings. In Section 4 we present the results and discussion of the study. Finally, the paper is concluded in Section 5.

2 Exemplar Application of the CPSAM

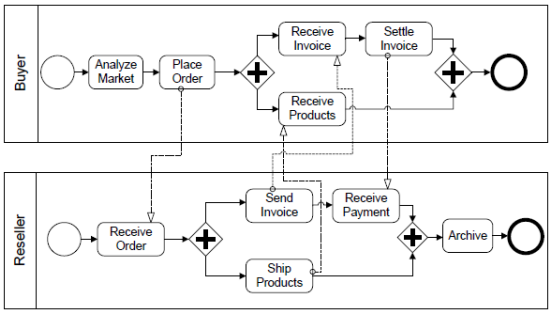
In this section we demonstrate the use of the implemented Context-based Process Semantic Annotation Model in the repository. For the demonstration, an order-to-cash business process is used as a running example. An order-to-cash is the business process where goods are: ordered, delivered and received, as well as invoiced and paid for. All order-to-cash processes include activities related to invoicing, delivery and payment, however, they have several differences. For example an order-to- cash process for the delivery of goods (e.g., personal computers) is different from the one for the delivery of services (e.g., consultancy services). The use of CPSAM for classifying and describing these processes captures their similarities and differences, thus enabling a repository user who is searching for one of the two processes, to find a relevant process model.

An example scenario starts with a business analyst who uses the tool to annotate an order-to-cash process model for the delivery of goods, and stores it in the repository. The scenario is followed by another user who performs a search in the repository to find an order-to-cash process model for delivery of service.

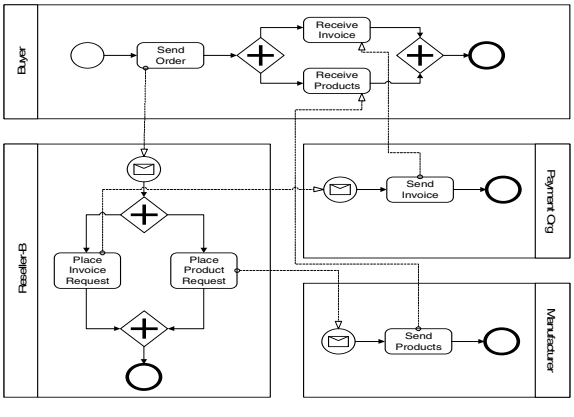
Task 1: Annotating a Process Model

Suppose the analyst has already designed an order-to-cash process model shown in Figure 2 (a). Before storing the process model, the analyst is required to annotate the process model using the annotation service provided in the repository. To ensure correct annotation, the help service in the repository provides definitions of each annotation element. Thus the analyst annotate a process model as follows:

- The analyst is the process owner, so he provides the *process name* and *process description* of a process model. The *version number* is assigned automatically.
- The main activities of this process regards getting buyers to purchase products i.e. selling, therefore the "Process Area" is "Marketing and Sales".

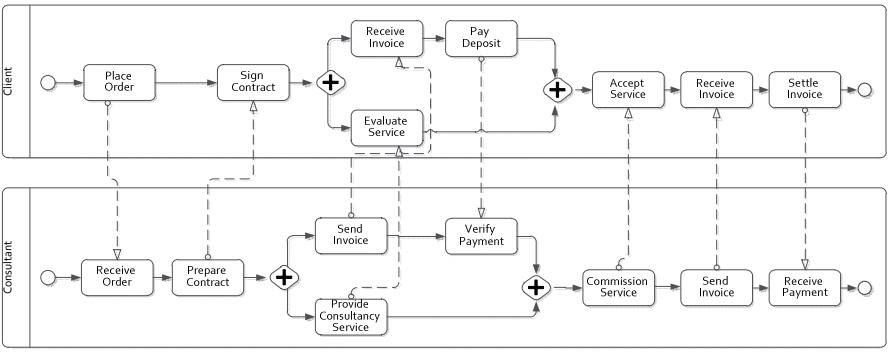


(a)



(b)

Fig. 2. Order to cash process models



(c)

Fig. 2. (*Continued*)

- It includes day-to-day activities, therefore "Organization Level" is "operational"
- The process involves exchange of resources, hence "Process Type" is "Exchange"
- The process includes activities for preparing and performing the exchange, therefore "Exchange Process Phase" is "Actualization".
- The actor involved in the exchange identified as "Principal Actor" is "Supplier", whose role is a reseller and "Other Actor" is "Customer", whose role is a buyer.
- The reseller receives payment (i.e. cash, cheque) and ship products (goods) to the buyer, therefore the resource being exchanged identified as "Resource Received" is "Financial" and "Resource Provided" is "Goods".

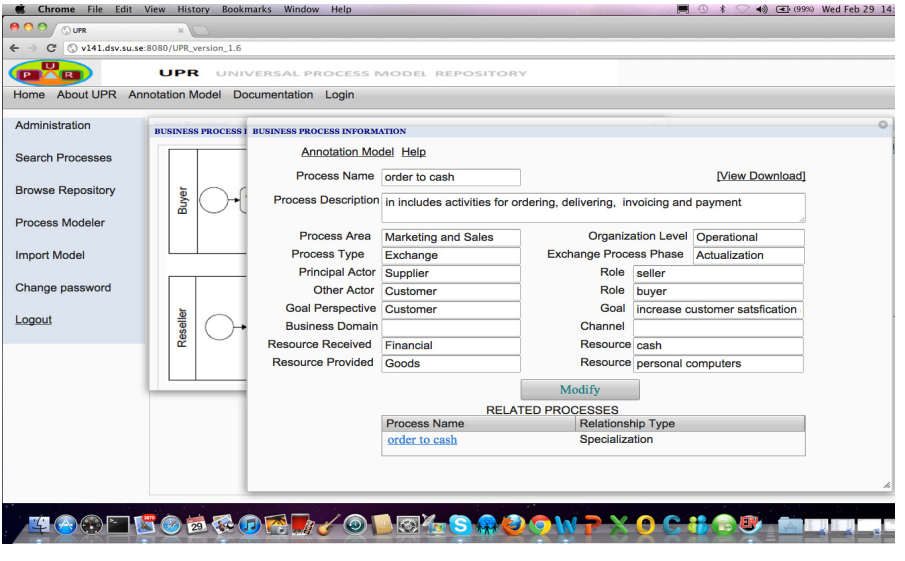


Fig. 3. Annotation of an order to cash process model (for delivery of goods)

- The goal of this process is to "Increase customer satisfaction and retention" and "Goal Perspective" is "Customer"
- This is a generic order to cash process, not restricted to any domain; therefore it is not annotated with business context information.

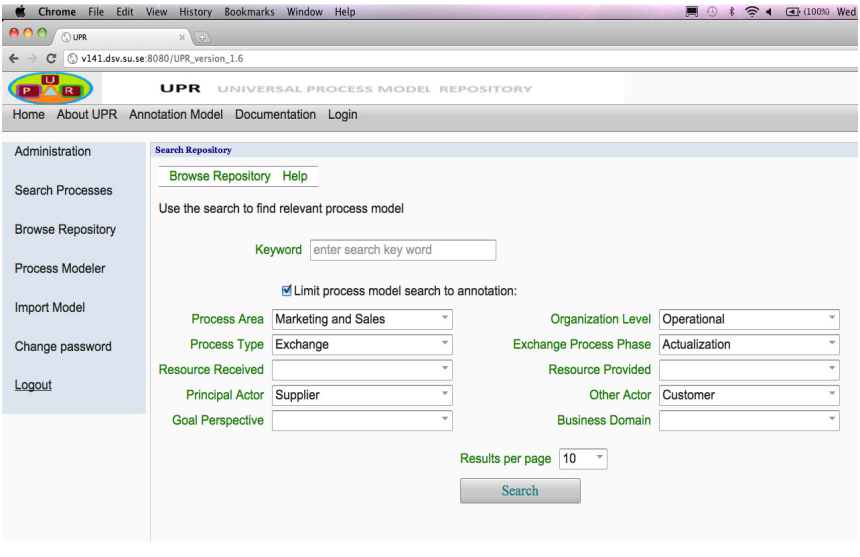
The analyst will produce the annotation as shown in Figure 3 above.

Task 2: Searching a Process Model

In this task we describe how a repository user uses the CPSAM based annotation to search for an order-to-cash process model (for delivery of service) in the repository.

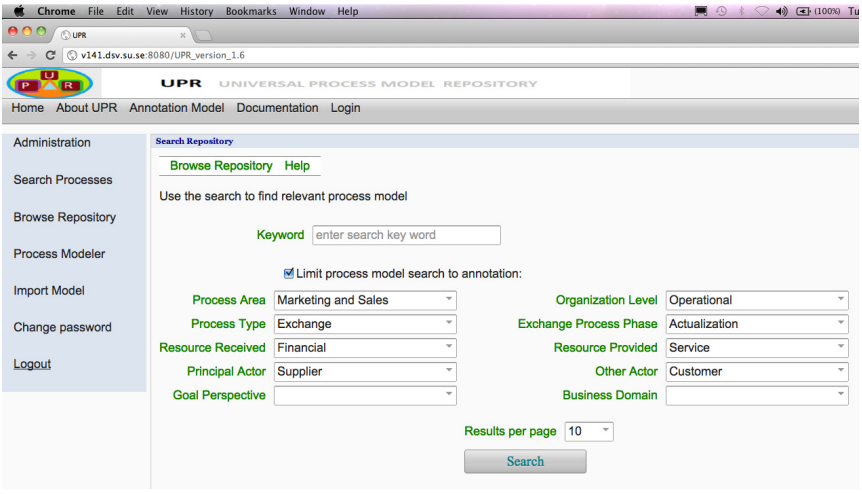
Using annotation-based search, the user looking for an order-to-cash process model for consultancy service delivery, can limit the search to annotation elements. Starting with *process area, organization level, process type, and process phase, principal actor and other actor* to form query 1 shown in Figure 4 (a), the query retrieves the three process models in Figure 2, from the studied repository. Therefore, a user can take a strategy of stepwise narrowing the query by using more annotation elements. Since the user is looking for an order to cash process model for service delivery, this means the *resource provided* in exchange is 'Service' and the *resource received* is 'Financial'. In this way, we decrease the search space to form query 2 in Figure 4 (b), and the process model in Figure 2 (c) is retrieved as relevant.

A query may result in any number of process models that are considered as relevant. Therefore, the user may identify the relevant process model that meets his or her business need from the retrieved models. Otherwise, the user may decide to narrow or expand the query for further search.



(a) Query 1

Fig. 4. Semantic-based Process Model Search



(b) Query 2

Fig. 4. (*Continued*)

3 Evaluation Framework and Experimental Settings

Our evaluation framework follows the Method Evaluation Model (MEM)[18], a method for evaluating IS design methods. The MEM is based on two areas of theory: the Technology Acceptance Model (TAM) [19], from the IS success literature and Methodological Pragmatism [20] from the philosophy of science. The MEM is chosen because it incorporates both aspects of evaluation i.e. performance, and user perception. Figure 5 shows the MEM indicating the primary constructs and causal relationships between them. The construct of the MEM in the context of CPSAM can be defined as follows.

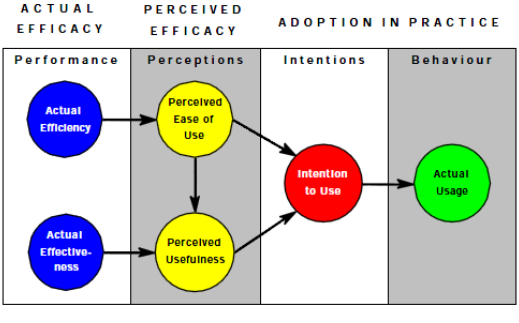


Fig. 5. The Method Evaluation Model (MEM) [18]

Actual efficacy is the degree to which the use of CPSAM based annotation achieves its objectives, which in this case are searching process models, navigating process model repository and understanding process models. *Actual efficiency* can be measured by investigating the extent to which the use of the CPSAM based annotation reduces the time or effort required to search and navigate the repository to find a relevant process model, as well as the effort or time required to comprehend a process model. *Actual effectiveness* can be measured by investigating the extent to which the use of CPSAM based annotation improves the quality (i.e. accuracy) of the search, navigation and comprehension of process models.

Perceived ease of use is the degree to which a person believes that using the CPSAM based annotation in searching, navigating and comprehending process models is free of effort.

Perceived usefulness is the degree to which a person believes that the use of the CPSAM based annotation will be effective (i.e. accurate) in searching, navigating and comprehending process models in the repository.

Intention to use is the extent to which a person intends to use the CPSAM based annotation for searching, navigating and comprehending a process model.

3.1 Experimental Settings

The purpose of this study is to test whether the annotations based on CPSAM meets its objectives—to facilitate searching of process models, to support navigation of the repository and enhance understandability of process models. In this research we have carried out a two-stage evaluation test: In the first stage, we used a controlled experiment to test the performance (actual efficacy). For that purpose, we formulated the following hypotheses for measuring the performance of the annotation model on searching, navigation and understandability of process models.

H1: The annotation positively affects searching of process models in the repository
H2: The annotation positively affects navigation of the process model repository
H3: The annotation positively affects process model understandability

In the second stage, we have used a survey (using a questionnaire) to test the user's perception on the effect of annotation. In the following subsections, a detailed description of the experimental design is presented.

Experimental Materials and Tasks. The main instrumentation for the experiment was a repository prototype demonstrated in section 2. For the experiment, the repository was populated with more than 100 business process models adopted from existing repositories, i.e. MIT, IBM and SAP. The process models were redesigned using BPMN, a standard process modeling notation, and stored in the repository. In addition to that the following materials were prepared for the experiment

- A document describing the CPSAM annotation model
- A document describing the prototype of the repository

- A post-task survey questionnaire to measure the user perception of the effect of the annotation. The survey consisted of eight closed questions assessed over a scale of 1 to 5 (Strongly Disagree, Disagree, Not Sure, Agree, and Strongly Agree)
- A document describing a set of questions for each experimental task. The document included five questions for searching, five questions for navigation, and four questions for understanding i.e. one question for each process design perspective (functional, behavioral, organizational and informational).

The questions related to the understanding task were accompanied with six process models (P1 to P6), where half of the accompanied processes were annotated and the others were not. During the experiment the participants were divided into two groups. The first group of the participants was given P1, P3 and P5 as annotated process models, whereas the second group was given P2, P4 and P6 as annotated process models.

The experiment consisted of four main tasks, which are as follows:

- *Searching Task.* In this task participants were asked to find process models that are relevant to a given question. For each question, participants were required to perform both the keyword-based and the annotation-based search. From questions, participants were supposed to identify some keywords and annotations that they would use for searching.
- *Navigation Task.* In this task participants were asked to navigate the repository and locate process models that are relevant to a given question. For each question, participants were required to perform both the alphabetical-based and the annotation-based navigation. From questions, participants were supposed to identify some alphabets of the keyword and annotations that would guide them in navigating the repository.
- *Understandability Task.* In this task participants were required to study process models and answer related questions. As discussed above, half of the process models were annotated and other half were un-annotated.
- *Post Task Survey.* Upon completing the experiment participants were asked to perform a post task survey.

Participants Selection and Experimental Treatment. The participants involved in the experiment were a mix of Masters students in Engineering and Management of Information Systems (EMIS) and PhD students in Information Systems at KTH. By the time the experiment was done, all students had completed a course on Enterprise Systems and Modeling, in which they learnt basic concepts about business process modeling. The benefit of using student participants is that they form a homogeneous group with respect to their academic background and industrial experience. Furthermore, the experimental tasks did not require high levels of industrial experience, which justifies our selection of the participants.

At the beginning of the experiment, the participants were given a short list of written instructions describing the experiment. Experiment mentors demonstrated how the prototype could be used to search and navigate the repository. Furthermore, a case of understanding process models annotation was demonstrated.

For the experiment, 20 randomly selected participants were given the materials (described in section 3.2). Responses from 15 participants were received and all the collected data is considered for analyses. Due to the length of the experiment each participant was asked to perform two tasks and a post task survey. For the analyses (in section 4) of each task (searching, navigation and understandability) results from 10 participants are included.

3.2 The Studied Variables

In order to test the influence of the annotations (based on the CPSAM) on searching, navigation and process model understandability, we distinguish two types of variables: performance based (objective) and perception based (subjective) measures.

3.2.1 Performance Based Variables

Variable 1. *Search Correctness (SC)*: The degree of accuracy with which a user finds a relevant process model by searching the repository. It is measured in terms of F-measure—the harmonic mean of *precision* and *recall*. *Precision* is the fraction of retrieved process models that are relevant, whereas *recall* is the fraction of relevant process models retrieved. F-measure is a standard measure for evaluating information retrieval results [21].

The steps taken for measuring *SC* are to let different participants find process model(s) from the repository that are relevant to given question and then we compute *SC* as follows:

1. Let $RR(q, i)$ be the total number of relevant processes retrieved on question q by subject i, $IR(q, i)$ be the number of irrelevant processes retrieved on question q by subject i, and $RN(q, i)$ be the number of relevant processes in the repository that have not been retrieved. The precision $PR(q, i)$ and recall $RC(q, i)$ on question q by subject i is, $PR(q, i) = RR(q, i) / [RR(q, i) + IR(q, i)]$ and $RC(q, i) = RR(q, i) / [RR(q, i) + RN(q, i)]$
2. The Search Correctness on question q by subject i, measured by F-measure, $F(q, i) = 2 * PR(q, i) * RC(q, i) / [PR(q, i) + RC(q, i)]$
3. The average *SC* by subject i, $F(i) = (\bullet F(q, i))/n$ for $q = 1$ to $q = n$, where n is the number of process retrieval questions.

By comparing the results of *SC* for the keyword based and annotation based search, we can determine whether the annotation positively affect the searching or not.

Variable 2. *Navigation Efficiency (NE)*: Is the proportion of the steps (efforts) that are useful to find the relevant process models in the repository. It is measured by the minimum path length (*MPL*) divided by the total user path length (*TUPL*) [22, 23] used to locate the process model. The path length is the number of steps (button clicks) performed in order to find relevant process models by navigating the repository. The total user path length is the total number of steps a user used to locate relevant process model by navigating the repository. The minimum path length is the least number of steps needed to locate relevant process model.

The steps taken for measuring *NE* are to let participants locate a process model relevant to a given question by navigating the repository and then we compute *NE* as follows:

1. Let *MPL(q)* be the least number of steps needed to locate a process model for question *q* by navigating the repository and *TUPL(q, i)* be the total number of steps subject *i* used to locate relevant processes for question *q*.
2. The Navigation Efficiency for locating a process for question *q* by subject *i* is, *NE(q, i) = MPL(q) / TUPL (q, i).*
3. The average *NE* by subject *i*, *NE(i) = (•NE(q, i))/n* for *q* = 1 *to q* = n, where n is the number of process retrieval questions.

By comparing the results of *NE* for alphabetic-based and annotation based navigation, we can determine whether the annotation positively affect the navigation or not.

Variable 3. *Understandability (UL)*: It is the degree of correctness to which a user understands a process model. It is measured as the fraction of correct answers given by the subject to the different questions about the process [24].

The steps taken for measuring *UL* are to let subjects study a process model and respond to questions related to the process model. We then compute *UL* as follows:

1. Let *CA(p, i)* be the number of correct answers on process *p* by subject *i* and *EA(p)* be the number of expected correct answers on process *p*. The understandability on process *p* by subject *i* is given by *UL (p, i) = CA(p, i)/ EA(p).*
2. The average understandability by subject *i*, is *UL(i) = (•UL(p, i))/n* for *p*=1 to *p*=n, where n is the number of process models.

By comparing the results of *UL* for annotated and unannotated process models, we can determine whether the annotation positively affect the understandability or not.

3.2.2 Perception Based Variables

Variable 4. *Perceived Usefulness (PU)***:** Is the degree to which a person believes that the annotations (based on CPSAM) improve searching, navigation and understanding of process models.

Variable 5. *Perceived Ease of Use (PEOU)*: Is the degree to which a person believes that the use of the CPSAM based annotation is free of effort.

Variable 6. *Intention to Use (IU)*: Is the extent to which a person intends to use the CPSAM based annotation for searching, navigating and comprehending a process.

In order to investigate users' perception of the model we asked the participants to assess several statements on a scale of 1 to 5 (Strongly Disagree, Disagree, Not Sure, Agree and Strongly Agree). The statements (as shown in **Table 1**) are PU1, PU2, and PU3 for *Perceived Usefulness*, PEOU1and PEOU2 for *Perceived Ease of Use*, and IU1, IU2 and IU3 for *Intention to Use*.

Table 1. Item for measuring perception based variables

Items	Statements
PU1	I think the annotations have improved the process of locating and searching of process models in the repository
PU2	I found navigating the process model repository based on CPSAM elements to have improved my work
PU3	I found the annotations to be helpful for understanding process models
PEOU1	It was easy for me to locate/search the process models
PEOU2	It was easy for me to navigate the repository
IU1	If I have to search a process in the repository in the future I will use annotation based search
IU2	If I have to navigate the repository in the future I will use annotation based approach
IU3	If I am involved in building the repository for process models I would recommend the CPSAM model

4 Results and Discussion

In this section, the data collected from the study are analyzed and discussed in order to evaluate the CPSAM. The Wilcoxon matched pairs test is chosen for data analysis, as demonstrated by Zobel [25], Wilcoxon's signed rank test is a reliable way to evaluate statistical differences between two retrieval systems. The following are the results and discussion for each studied variable.

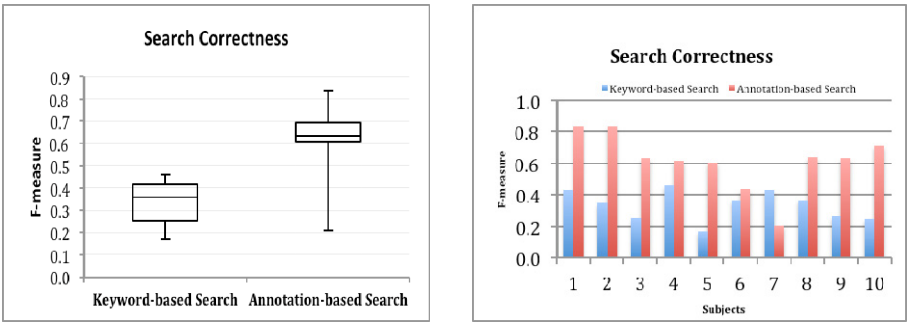
Effects of Annotation on Searching of Process Models. Figure 6 depicts boxplots (a) and graph (b) of F-measure for keyword based search and annotation based search.

Table 2. Search Correctness

Subjects	F-KBS	F-ABS	Differences	Diff. Rank	Signed Rank
1	0.430000000	0.833333333	-0.403333333	7	-7
2	0.351052632	0.833333333	-0.482280702	10	-10
3	0.251052632	0.633333333	-0.382280702	6	-6
4	0.460769231	0.617142857	-0.156373626	2	-2
5	0.167719298	0.604617605	-0.436898306	8	-8
6	0.367719298	0.440000000	-0.072280702	1	-1
7	0.434385965	0.206349206	0.228036759	3	3
8	0.367719298	0.638961039	-0.271241741	4	-4
9	0.266666667	0.633333333	-0.366666667	5	-5
10	0.246000000	0.713333333	-0.467333333	9	-9

The plot and the results in Table 2 shows that Search Correctness for annotation-based search (ABS) is better than keyword-based search (KBS) given that the median value for F-measure is higher for ABS than for KBS. This indicates that annotation positively affects the searching of process models in the repository.

Using the data in Table 2 and the Wilcoxon signed-ranks test and 0.01 significance level, we test the claim that there is no difference between keyword-based search (KBS) and annotation-based search (ABS). The sum of the absolute values of the negative ranks, T-= 52 and the sum of the positive ranks, T+=3. Because n=10, we have $n \leq 30$, so we use a test statistic of T=3. Therefore, Critical Value(0.01(2),10)=3.0 and Critical Value(0.01(1),10)=5.0 Since T+ is less than or equal to the critical value we reject the null hypothesis. Thus hypothesis H1 is accepted.



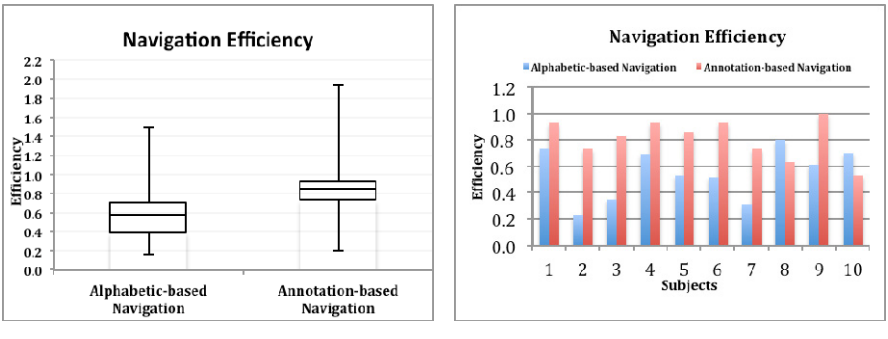
(a) (b)

Fig. 6. Search Correctness

Effects of Annotation on Navigating the Process Models Repository. Figure 7 depicts the boxplots (a) and graph (b) of navigation efficiency for alphabetic-based navigation (ALN) and annotation-based navigation (ANN).

Table 3. Navigation Efficiency

Subjects	NE-ALB	NE-ANB	Differences	Diff. Rank	Signed Rank
1	0.733333333	0.933333333	-0.200000000	3	-3
2	0.230000000	0.733333333	-0.503333333	10	-10
3	0.351904762	0.833333333	-0.481428571	9	-9
4	0.695238095	0.933333333	-0.238095238	4	-4
5	0.533333333	0.866666667	-0.333333333	5	-5
6	0.516666667	0.933333333	-0.416666667	7	-7
7	0.306666667	0.733333333	-0.426666667	8	-8
8	0.800000000	0.633333333	0.166666667	1.5	1.5
9	0.616666667	1.000000000	-0.383333333	6	-6
10	0.700000000	0.533333333	0.166666667	1.5	1.5



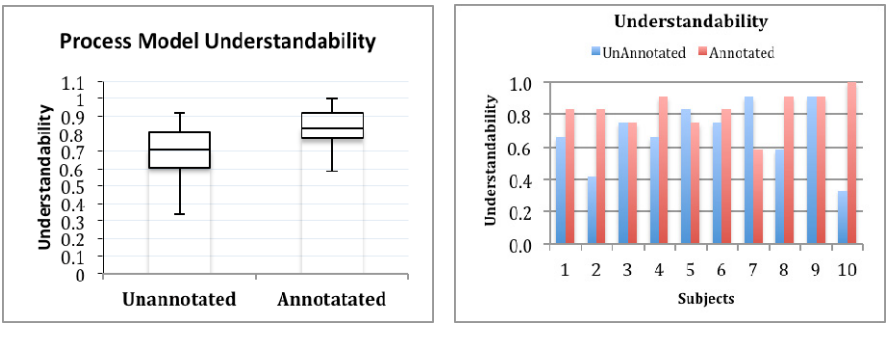
(a) (b)

Fig. 7. Navigation Efficiency

The plot and the results in **Table 3** shows that Navigation Efficiency (*NE*) for annotation-based navigation (ANN) is better than alphabetic-based navigation (ALN) given that the median value of *NE* is higher for ANN than for ALN. This indicates that annotation positively affects the navigation performance in the repository.

Using the data in **Table 3** and the Wilcoxon signed-ranks test and 0.05 significance level, we test the claim that there is no difference between alphabetic-based navigation (ALN) and annotation-based navigation (ANN). The sum (T-) of the absolute values of the negative ranks is 52 and the sum (T+) of the positive ranks is 3. Because n=10, we have n≤30, so we use a test statistic of T=3. Therefore, Critical Value(0.05(2),10)=8.0 and Critical Value(0.05(1),10)=10. Since T+ is less than or equal to the critical value we reject the null hypothesis and accept hypothesis H2.

Effects of Annotation on Process Model Understandability. Figure 8 depicts the boxplots (a) and graph (b) of understandability (UL) of un-annotated and annotated process models. The boxplots and the graph shows that understandability of annotated process models is higher than understandability of un-annotated process models, given that median of understandability for annotated models is higher than the median of understandability of un-annotated model. This indicates that annotation positively affects process model understandability.



(a) (b)

Fig. 8. Process Model Understandability

Using the collected data and the Wilcoxon signed-ranks test and 0.05 significance level, we test the claim that there is no difference between understandability of un-annotated models and annotated model. The sum of the absolute values of the negative ranks, T-= 29 and positive ranks, T+=7. Because n=8 (we omit two values with difference = 0), we have n≤30, so we use a test statistic of T=7. Therefore, Critical Value(0.05(2),8)=3.0 and Critical Value(0.05(1),8)=5.0. Since neither T+ nor T- is less than or equal to the critical value we fail to reject the null hypothesis.

User Perception on the Annotation. Figure 9 shows the summary of statistics for user perception of the annotation model.

Perceived Usefulness (PU). The graph shows that more than 80% of participants at least agree (i.e. agree and strongly agree) with PU2 and PU3, whereas, more than

60% at least agree on PU1. Therefore, it can be argued that most users perceived the annotation to be useful.

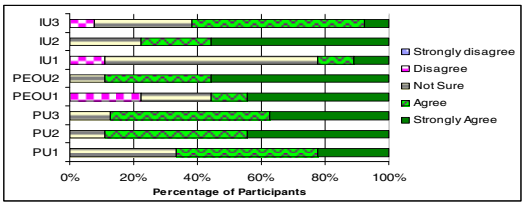


Fig. 9. User Perception of the Annotation Model

Perceived Ease of Use (PEOU). The graph shows that more than 50% at least agree on PEOU1, whereas more than 80% of participants at least agree with PEOU2. Therefore, it can be argued that most users perceived the annotation to be easy to use.

Intention to Use (IU). The graph shows that less than 30% of participants at least agree with IU1 (i.e. more than 60% of participants are not sure about IU1), whereas more than 60% at least agree with IU2 and IU3. This implies that most users are not sure about their intention to use annotation-based search. We hypothesize that the reasons to this are, a) that annotation based search requires some time and effort to think about different annotation elements before searching, b) people are used to keyword based search is their searching routine.

5 Conclusion

In this paper, we have evaluated the effect of context-based process semantic annotation through a controlled experiment to test whether annotation can facilitate searching, navigating and understanding process models stored in a repository. For the evaluation we have used the Method Evaluation Model (MEM), a widely accepted model for measuring the performance and user perception of artifacts. In order to perform the experiment we have implemented a repository prototype that implements the annotation model and populated it with more than 100 process models.

The results provide evidence that the annotation model positively affects searching and navigating a process model repository. Furthermore, the results indicate that the annotation model positively affects the understandability of process models. However, the effect of the model on understandability is not significant. One of the reasons could be that most process models used for the experiment were not complex. Therefore, we hypothesize that CPSAM based annotation could improve the understandability for very large and complex process models.

The results from the post task survey suggest that most users perceived the annotation as easy to use and useful for searching, navigation and understanding of process models. Also, the results showed that users have positive intention to use the annotation model for navigation and understanding. However, most users are not sure about their intention to use the annotation model for searching. Possible reasons may

include: a) annotation based search requires some time and effort to think about different annotation elements before searching, b) people are used to keyword based search in their searching routine.

One of the limitations of the study is that a small number of participants were used for the experiment. Future research aims at a large scale evaluation of the annotation model and to improve the annotation model based on the evaluation results.

References

1. Rodrigues Nt., J.A., de Souza, J.M., Zimbrão, G., Xexéo, G., Neves, E., Pinheiro, W.A.: A P2P Approach for Business Process Modelling and Reuse. In: Eder, J., Dustdar, S. (eds.) BPM Workshops 2006. LNCS, vol. 4103, pp. 297–307. Springer, Heidelberg (2006)
2. Markovic, I., Pereira, A.C.: Towards a Formal Framework for Reuse in Business Process Modeling. In: ter Hofstede, A.H.M., Benatallah, B., Paik, H.-Y. (eds.) BPM Workshops 2007. LNCS, vol. 4928, pp. 484–495. Springer, Heidelberg (2008)
3. http://process.mit.edu/Default.asp (last accessed March 10, 2012)
4. http://repository.phios.com/SCOR/ (last accessed March 10, 2012)
5. http://help.sap.com/saphelp_sm40/helpdata/EN/5e/c8145e3a9d9340913099159d80fc87/frameset.html (last accessed March 10, 2012)
6. http://publib.boulder.ibm.com/infocenter/wchelp/v5r6m1/index jsp?topic=/com.ibm.commerce.business_process.doc/concepts/processPrice_order.html (last accessed March 10, 2012)
7. La Rosa, M., Reijers, H.A., van der Aalst, W.M.P., Dijkman, R.M., Mendling, J., Dumas, M., García-Bañuelos, L.: APROMORE: An advanced process model repository. Expert Systems with Applications 38, 7029–7040 (2011)
8. Shahzad, K., Elias, M., Johannesson, P.: Requirements for a Business Process Model Repository: A Stakeholders' Perspective. In: Abramowicz, W., Tolksdorf, R. (eds.) BIS 2010. LNBIP, vol. 47, pp. 158–170. Springer, Heidelberg (2010)
9. Elias, M., Johannesson, P.: A survey of process model reuse repositories. In: Dua, S., Gangopadhyay, A., Thulasiraman, P., Straccia, U., Shepherd, M., Stein, B. (eds.) ICISTM 2012. Communications in Computer and Information Science, vol. 285, pp. 64–76. Springer, Heidelberg (2012)
10. Elias, M., Shahzad, K., Johannesson, P.: A Business Process Metadata Model for a Process Model Repository. In: Bider, I., Halpin, T., Krogstie, J., Nurcan, S., Proper, E., Schmidt, R., Ukor, R. (eds.) BPMDS 2010 and EMMSAD 2010. Lecture Notes in Business Information Processing, vol. 50, pp. 287–300. Springer, Heidelberg (2010)
11. Porter, M.: Competitive Advantage. Free Press, New York (1985)
12. http://jtc1sc32.org/doc/N0651-0700/32N0659.pdf (last accessed March 10, 2012)
13. McCarthy, W.E.: The REA Accounting Model: A Generalized Framework for Accounting Systems in a Shared Data Environment. The Accounting Review 57, 554–578 (1982)
14. Dunn, C., Cherrington, J.O., Hollander, A.: Enterprise Information Systems: A Pattern-Based Approach. McGraw-Hill/Irwin (2005)
15. Anthony, R.N., Dearden, J., Bedford, N.M.: Management Control Systems, Irwin Homewood, IL (1995)
16. Anthony, R.N.: Planning and Control Systems: A Framework for Analysis. Harvard Business School, Cambridge (1995)

17. Persson, A., Stirna, J.: Why Enterprise Modelling? An Explorative Study into Current Practice. In: Dittrich, K.R., Geppert, A., Norrie, M. (eds.) CAiSE 2001. LNCS, vol. 2068, pp. 465–468. Springer, Heidelberg (2001)
18. Moody, D.L.: The Method Evaluation Model: A Theoretical Model for Validating Information Systems Design Methods. In: European Conference on Information Systems, Naples, Italy (2003)
19. Davis, F.D., Bagozzi, R.P., Warshaw, P.R.: User acceptance of computer technology: a comparison of two theoretical models. Manage. Sci. 35, 982–1003 (1989)
20. Rescher, N.: Methodological Pragmatism: Systems-Theoretic Approach to the Theory of Knowledge. Blackwell Publishers, Oxford (1997)
21. Kandefer, M., Shapiro, S.: An F-Measure for Context-based Information Retrieval. In: International Symposium on Logical Formalization of Commonsense Reasoning, Toronto, CA, pp. 79–84 (2009)
22. Huang, A.H.: Effects of multimedia on document browsing and navigation: an exploratory empirical investigation. Information & Management 41, 189–198 (2003)
23. Mondary, T., Bouffier, A., Nazarenko, A.: Between browsing and search, a new model for navigating through large documents. HAL - CCSD (2007)
24. Melcher, J., Mendling, J., Reijers, H.A., Seese, D.: On Measuring the Understandability of Process Models. In: Rinderle-Ma, S., Sadiq, S., Leymann, F. (eds.) BPM 2009. LNBIP, vol. 43, pp. 465–476. Springer, Heidelberg (2010)
25. Zobel, J.: How reliable are the results of large-scale information retrieval experiments? In: Proceedings of the 21st Annual International ACM SIGIR Conference on Research and Development in Information Retrieval, pp. 307–314. ACM, Melbourne (1998)