An *i** based approach for conceptual modeling of business process technology

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Abstract. Recently, the use of technologies in organizations is a key feature to automate business process. On the other hand, the conceptual modeling of information systems is about describing the semantics of software applications at a high level of abstraction. However, at present, the modeling of business technologies has not been given at conceptual modeling level. Therefore, in this paper we present an approach to represent technology at conceptual modeling level in order to know the impact that represents to current business processes. We validate and formalize the approach through a real example in the domain of inventory management. In order to model business technologies, the i* modeling language was enriched with business technology modules that has been used to model technology that enables business processes execution. This approach allows system analysts to take right decisions on selecting technology to implement in software applications in early phases of software development.

Keywords: Business technology, business process modeling, iStar modeling language, technology modeling.

1 Introduction

The technology is a key factor in the organizations for the implementation of efficient business processes, and it is seen as a tool to organize things in a different way, coordinate processes and carry out tasks more easily [1]. At present, the technology is considered as a system that provides mechanisms for transmitting, processing and storing information within an organizational context, in order to facilitate and accelerate the realization of business processes and the work of organizational actors. On the other hand, the concept of conceptual modeling in information system area is used for detailing the general knowledge that an information system requires. Within this knowledge highlights the description of business processes, which represent the expected functionality of the information system-to-be [4].

The technology and the information system play an important role in business process management due to some tasks realized by organization are supported through software systems. The organization can achieve its organizational goals in an effective and efficient manner as long as actors, information systems, and other resources work properly. The business processes are important elements to facilitate these work [5], in such a way, through the adequate conceptual modeling of them is an important aspect to the effective and efficient information systems design.

The use of technology is a significant aspect to the implementation of efficient business. In this sense, the technology could improve the performance of business process because it represents essential tasks for exchanging information between actors and process. However, the design and analysis of technology in modeling of business processes at conceptual level is a current problem that applies to general design solutions as a software implementation of the technological infrastructure.

In this paper, we propose an approach for modeling the technology involved in business processes of organizations. Our proposal uses i* as base of modeling [6], which allow us to identify functionalities and quality aspect offered by a specific technology. The graphical and formal modeling of these technologies are also shown in this paper.

2 Objectives of the research

As first objective of this research, we present a new business technology modeling approach that considers the technology as a modeling concept. We enrich *i** models with the definition of a technology model that contains information about specific technology elements and its relationships. The enrichment consist in the definition of technology at conceptual modeling level considering five aspects *(i)*: description of physical elements of the technology and its relationships; *(ii)*: identification of functionalities that the technology offers to business process; *(iii)*: definition of quality attributes that functionalities offer; *(iv)*: identification of technology resources needed for technology proper operation; and *(v)*: identification of relationships between elements. As second objective of this research, we present a formalization of business technology models.

Thus, the modeling of business technology allows software analysts to clarify the advantages of selecting specific technology at conceptual modeling level.

3 Scientific contributions

Our scientific contributions are linked to the achievement of the first and the second objective of our research work. Therefore, in this section we present our proposed approach based on i* language, which describes the process to model business technologies at conceptual modeling level. Moreover, we present the formalization of this process.

The business technology models allow us to represent the functions, quality aspects and resources that technology offers to a business processes, as well as quality aspects and resources that technology require to its proper operation. The technology models are created using the i* framework [6] and based on the module definition [2]. A previous definition of our approach is showed in [3].

The objective of modeling business technology at conceptual modeling level is to know the benefits that offer specific technology to improve a business process in early phases of software development. With the modeling of technology is possible to determine the advantages that has technology on the realization of business process, in order to select the best technological alternative to implement into a business process. We define the approach into a six phases, which are defined below. We ilustrate the approach with an example in the domain of inventory management.

The general formal definition of the business technology model (Fig.1) is described as follows: Given a set of components $C = \{c_{i1}, c_{i2}, ..., c_{im}\}$, a set of functionalities $F = \{f_{i1}, f_{i2}, ..., f_{in}\}$, set of quality attributes $Q = \{q_{i1}, q_{i2}, ..., q_{io}\}$ and $AC = \{ac_{i1}, ac_{i2}, ..., ac_{io}\}$, and a set of technology resources $R = \{r_{i1}, r_{i2}, ..., r_{ip}\}$, we define a technology model as a *n-tuple*(Equation1):

$$M_{tech}(t_i) = (C, F, Q, R, AC, Comp_{tech}(ti), Funct_{tech}(ti), QA_funct(ti), D_{in}, D_{out}, AC_{comp}, Res_{com}(ti)) \quad (1)$$

Where: C= Set of technology components, F= Set of technology functionalities, Q= Set of quality attributes of functions, AC= Set of quality attributes of technology, R= Set of technology resources, D_{in}= Set of D_{in} dependences, D_{out}= Set of D_{out} dependences, $Comp_{tech}$= Technology components function, $Funct_{tech}$= Technology functions function, QA_{funct}= Quality attributes of functions function, AC_{comp}= Quality attributes of technology function, and Res_{comp}= Technology resources function.

3.1 Definition of technology components

In this phase we should identify the components of technology that are part of a software system. The components are represented as $i*$ actors in business technology model, and they are related directly with the software system actor using the *is-part-of* relationship.

The formal definition of the components of technology is described as follows: Given a set of technologies $TS = \{t_{i1}, t_{i2}, ..., t_{in}\}$, components are identified and associated with specific technology as shown in equation2.

$$Comp_{tech}(ti) : TS \rightarrow P(C) \quad (2)$$

Where: $Comp_{tech}(ti) = t_i$ is a specific technology, TS = Set of technologies, P(C)= C is a power set of components, T(c) = c is a component that belong to technology, and $C = \{c_{i1}, c_{i2}, ..., c_{im}\}$. As a result of this phase, the set of components obtained for the example is: $C = \{RFIDReader, RFIDtag\}$, which are part of RFID system.

3.2 Definition of technology functionalities

In this phase the functionalities of technology should be defined as $i*$ tasks. The functionalities represent functions that offer a specific technology through a software system and they can used to improve some tasks of business process.

The formal definition of the functionalities of technology is described as follows: Given a set of technologies $TS = \{t_{i1}, t_{i2}, ..., t_{in}\}$, functionalities are defined and associated with specific technology as shown in equation3.

$$Funct_{tech}(tn) : TS \rightarrow P(F) \tag{3}$$

Where: $Funct_{tech}(ti) = ti$ is an specific technology, TS = Set of technologies, P(F)= is a power set of functionalities, f = functionalities of technology, and $F = \{f_{i1}, f_{i2}, ..., f_{in}\}$. As a result of this phase, the set of functionalities of RFID technology obtained is: $F = \{F1, F2, F3, F4\}$. F1=Identify objects, F2=Obtain object information, F3=Register object information, F4=Edit object information. The functionalities are associated to RFID technology.

3.3 Definition of functionalities quality attributes

In this phase the quality attributes for each of the functionalities defined are created. The quality attributes represent the non-functional requirements of functionalities and they are represented using an $i*$ softgoal.

The formal definition of quality attributes of functions is described as follows: Given a set of technologies $TS = \{t_{i1}, t_{i2}, ..., t_{in}\}$, and a set of functionalities $F = \{f_{i1}, f_{i2}, ..., f_{in}\}$, the quality attributes are defined and they are associated with functions, as shown in equation4.

$$QA_{funct}(f_{in}) : F_{ij} \rightarrow P(Q) \tag{4}$$

Where: $QA_{funct}(f_i) = f_i$ is a function of technology, F_{ij}= Set of functionalities of specific technology, P(Q) = Power set of quality attributes, Q = Quality attribute of functions, and $Q = \{q_{i1}, q_{i2}, ..., q_{io}\}$. As a result of this phase, the set of quality attributes of functionalities is: $Q = \{F1.1, F1.2, F2.1, F2.2, F2.3, F3.1, F3.2, F4.1\}$. F1.1= Object identified unobtrusively, F1.2=Object identified easily, F2.1= Information obtained accurately, F2.2= Information obtained easily, F2.3= Information obtained quickly, F3.1= Information registered accurately, F3.2= Information registered quickly, F4.1= Edit object information accurately. The quality attributes are associated with functionalities.

3.4 Definition of technology resources needed for proper operation

In this phase the resources needed for proper operation of technology are defined. The resources represent a physical object required by technology and are represented as an $i*$ resources.

The formal definition of resources needed for proper operation of technology is described as follows: Given a set of components $C = \{c_{i1}, c_{i2}, ..., c_{im}\}$, the resources for proper operation of technology are defined and they are associated to technology components, as shown in equation5.

$$Res_{comp}(c_{im}) : C_{ij} \rightarrow P(R) \tag{5}$$

Where: $Res_{comp}(c_{im}) = c_{im}$ is a specific component of technology, C=Set of components, P(R)= Power set of resources, r= Resource of component of technology, and $R = \{r_{i1}, r_{i2}, ..., r_{ip}\}$. As a result of this phase, the set of resources of

technology is: $R = \{RFIDtaggedobject\}$, the resources are associated to RFID components. The technology needs the business process to provide the needed resources for its proper operation.

3.5 Definition of quality attributes needed for proper operation of technology

In this phase the quality attributes needed for proper operation of technology are defined. The quality attributes represent a non-functional requirement required by technology and are represented as an $i*$ softgoal.

The formal definition of quality attributes needed for proper operation of technology is described as follows: Given a set of components $C = \{c_{i1}, c_{i2}, ..., c_{im}\}$, the quality attributes for proper operation of technology are defined and they are associated to technology components, as shown in equation6.

$$AC_{comp}(c_{im}) : C_{ij} \rightarrow P(AC) \tag{6}$$

Where: $AC_{comp}(c_{im}) = c_{im}$ is a specific component of technology, C= Set of components, P(AC) = Power set of quality attributes of technology, ac= Quality attribute of technology, and $AC = \{ac_{i1}, ac_{i2}, ..., ac_{io}\}$. As a result of this phase, the set of resources of technology is: AC={*RFID tag handled adequately*, *RFID tag located adequately*}. The quality attributes are associated with RFID components.

3.6 Definition of relationships between elements

In this last phase, the relationships between elements of technology model are defined. We define two kinds of dependence relationship, D_{in} and D_{out}. In D_{in} relationship the business process depends on technology to provide functionality and in D_{out} the technology depends on the business process to its proper operation.

The formal definition of relationship between elements is described as follows: Given a set of components $C = \{c_{i1}, c_{i2}, ..., c_{im}\}$, and a set of elements x, y $\in$ $F = \{f_{i1}, f_{i2}, ..., f_{in}\}$ or $Q = \{q_{i1}, q_{i2}, ..., q_{io}\}$ or $AC = \{ac_{i1}, ac_{i2}, ..., ac_{io}\}$ or $R = \{r_{i1}, r_{i2}, ..., r_{ip}\}$, the dependence relationships are defined.

The relationship dependences are: CT(x)= x is a component of technology, FT(y)= y is an element of technology model, IN(x, y)= x is related to y, and OUT (x, y) = x is related to y.As a result of this phase, the sets of relationships between elements are:Din= {(RFID system, F1- Identify objects), (RFID system, F1.1), (RFID system, F1.2), (RFID system, F2), (RFID system, F2.1), (RFID system, F2.2), (RFID system, F2.3), (RFID system, F3), (RFID system, F3.1), (RFID system, F3.2), (RFID system, F4), (RFID system, F4.1)}. For setDout= RFID technology, R1), (RFID technology, R2), (RFID technology, R3- RFID tag located adequately).

4 Conclusions

In this paper we have shown an approach for conceptual modeling of business process technology. Our approach is based on the $i*$ modeling language and on the concept of module which allows us to create technology modules. Our

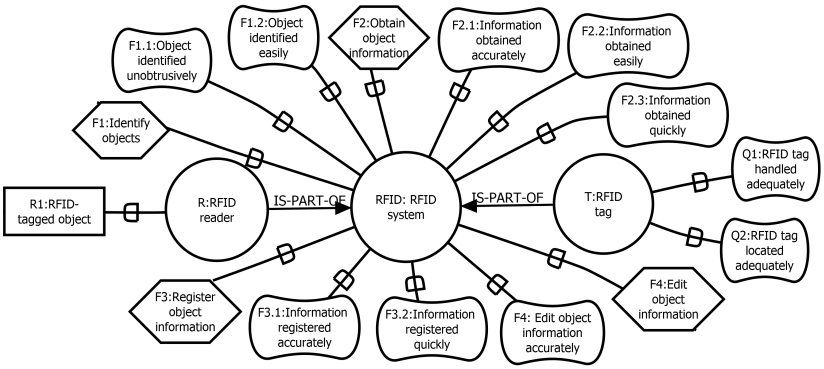

Fig. 1. RFID Technology Model

approach is based on well defined phases to create business technology models. This business technology models represent the benefits or advantages that specific technology can offer for the business process at conceptual modeling level. We showed an example in the domain of inventory management in order to explain the proposed approach, as a final result we obtained a business technology model for specific technology.

5 Ongoing and future work

Other relevant aspects of our current work are: to create a process to integrate business process and business technology; and to define a process analysis in order to know the impact that has specific technology on realization of business processes.

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