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

Luis Santillan[1], Alicia Martinez[1], Hugo Estrada[1,2], Ricardo Quintero[3], and Joaquin Perez[1]

[1] National Center of Research and Technological Development - CENIDET, Mexico
{lsantillan, amartinez, hestrada, jperez}@cenidet.edu.mx
[2] Fund Information and Documentation for the industry - INFOTEC, Mexico
{hugo.estrada}@infotec.com.mx
[3] Technology Institute of Culiacan - ITC, Mexico
{rquintero}@itculiacan.edu.mx

Abstract. Currently, the use of technologies in organizations is a key feature in automating business processes. 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 a conceptual modeling level. Therefore, in this paper an approach to represent technology at a conceptual modeling level in order to know the impact that current business processes make is presented. We validate 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 have been used to model technology that enables business process execution. This approach allows system analysts to model the technology that is implemented in business processes in early phases of software development.

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

1 Introduction

Technology is a key factor in 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]. In this paper, 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 the information systems area is used for detailing the general knowledge that an information system requires. Within this knowledge the description of business processes is highlighted, which represents the expected functionality of the information system-to-be [4].

The technology and the information system play important roles in business process management due to some tasks realized by organization which are

supported by technologies and software systems. The business processes are important elements to facilitate this work [5], in such a way, that the adequate conceptual modeling of them is an important aspect to the effective and efficient design of information systems.

Currently, the use of technology is a significant aspect of the implementation of efficient business. The design and analysis of technology in modeling of business processes at the conceptual level is a current problem due to the high dependence between business processes and technology. This problem generates implementation errors because no one knows if the implemented technology meets the needs of the business process. However, if technology is modeled in early phases of software development we can have more effective implementation, therefore good decisions about selecting and implementing technologies in business processes can be made.

In this paper, an approach for modeling the technology involved in business processes of organizations is proposed. Our proposal uses *i** as a base of modeling [6], which allows functionalities and quality aspects offered by a specific technology to be identified. The graphical and formal modelings of these technologies are also shown in this paper.

2 Objectives of the research

As the first objective of this research, a new business technology modeling approach that considers the technology as a modeling concept is presented. We enrich *i** models with the definition of a technology model that contains information about specific technology elements and their relationships. The enrichment consists on the definition of technology at the conceptual modeling level considering five aspects *(i)*: description of physical elements of the technology and their relationships; *(ii)*: identification of functionalities that the technology offers to the 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 the second objective of this research, a formalization of business technology models is presented. Thus, the modeling of business technology allows software analysts to clarify the advantages of technology to business processes at the 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, the formalization of this process is presented.

The business technology models allow us to represent the functions, quality aspects and resources that technology offers to business processes, as well as quality aspects and resources that technology requires for its own 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 shown in [3].

The objective of modeling business technology at the 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 it is possible to determine the advantages that technology has on the realization of business processes, in order to select the best technological alternative to implement into business processes. The approach is divided into six phases, which are defined below. The approach is illustrated 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 $F = \{f_{i1}, f_{i2}, ..., f_{in}\}$, a 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 $R = \{r_{i1}, r_{i2}, ..., r_{ip}\}$, a technology model is defined as a *n-tuple*(Equation 1):

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

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 the components of technology that are part of a software system are identified. The components are represented as i^* actors in the 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 equation 2.

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

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 belongs 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 processes.

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 equation 3.

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

Where: $Funct_{tech}(ti) = ti$ is an specific technology, TS = Set of technologies, P(F)= 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 equation 4.

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

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 with technology components, as shown in equation 5.

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

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={RFID tagged object}, the resources are associated to RFID components. The technology needs the business process to provide the needed resources for its own 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 equation 6.

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

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*}.

3.6 Definition of relationships between elements

In this last phase, the relationships between elements of technology model are defined. Two kinds of relationships are defined, 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 of its own 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.

It is important to explain how the technology module is related to i^* business processes. The business process realizes a lot of tasks, and technology offers functionalities, then the tasks of business process and the functionalities of technology are compared showing that the tasks of business process can be realized by a specific function of technology. So, a relation is established between business process and technology indicating that technology will realize some tasks of business processes. This relationship is according to the kind of dependence (IN or OUT). If the relationship is IN it is indicated that it is a function or quality attribute that technology offers to business process, and if it is OUT this indicates that it is a function, quality attribute or resource that technology needs for its own operation. The technology model can be reused.

4 Conclusions

In this paper an approach for conceptual modeling of business process technology has been shown. Our approach is based on the i^* modeling language and on the concept of module which allows us to create technology modules in early

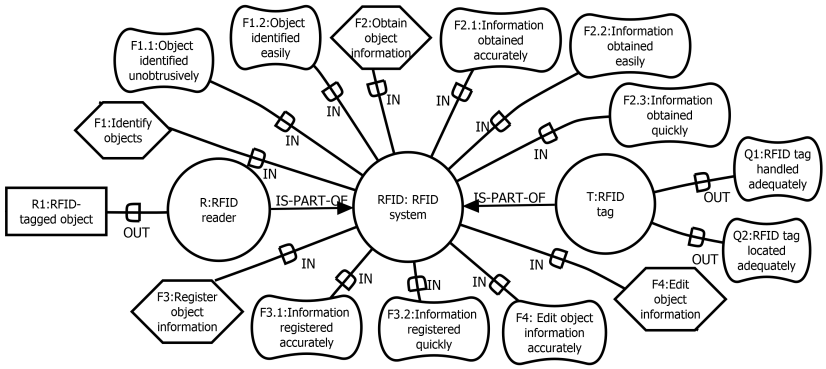

Fig. 1. RFID Technology Model

phases of software development. Our 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 the conceptual modeling level. An example is shown in the domain of inventory management in order to explain the proposed approach, as a final result a business technology model for specific technology was obtained.

5 Ongoing and future work

Other relevant aspects of our current work are: to create a process to integrate business processes 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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