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Toward a Method for Eliciting Software Requirements Using Constraint Natural Language

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Abstract: Requirement elicitation is considered as one of the most important activities in software development. Most of the faults found during testing and operation result from poor understanding or misinterpretation of requirements. Although there are many techniques focusing on the requirements elicitation, there are only a few focusing on the formalization of object-oriented features and the methodology for identifying and refining objects. We propose a methodology for eliciting requirements using constraint natural language based on object-oriented paradigms.

Keywords: requirements engineering, requirements elicitation

1. INTRODUCTION

Requirement elicitation is considered as one of the most important activities in software development. Most of the faults found during testing and operation result from poor understanding or misinterpretation of requirements. Until now, there are only a few effective methods and tools to guarantee a complete, consistent, and unambiguous requirement model [Lu00]. In the traditional approach to software analysis, system analyst interviews end-users to capture requirement.

We propose a methodology where user takes an active role in the requirements elicitation using constraint natural language, which is called object-based formal specification (OBFS).

2. THE THREE DIMENSIONS of REQUIREMENTS ENGINEERING

The requirements engineering is the first phase of software engineering process, in which user requirements are collected, understood, and specified. Requirements engineering is recognized as a critical task, since many software failures originate from inconsistent, incomplete or simply incorrect requirements specifications. A correct, consistent and complete way to collect, understand, specify and verify user requirements is important and necessary. The result of the requirements engineering phase is documented in the requirements specification. The requirements specification reflects the mutual understanding of the problem to be solved between the analyst and the client. The requirements specification serves as a starting point for the next phase, the design phase. To achieve well-defined document containing the user requirements that satisfies these prerequisites, we can distinguish three processes in requirements engineering [Loucopoulos-95]. These processes involve iteration and feedback (Figure 1).

- Requirements Elicitation

Requirements elicitation is about understanding the problem. In general, the requirements analyst is not an expert in the domain being modeled. Through interaction with domain specialists, he has to build himself a sufficiently rich model of that domain. The fact that different disciplines are involved in this process complicates matters. In many cases, the analyst is not a mere outside observer of the domain modeled, simply eliciting facts from domain specialists.

- Requirements Specification

Once the problem is understood, it has to be described in the requirements specification document. This document describes the product to be delivered, not the process of how it is developed.
• Requirements Validation and Verification

Once the problem is described, the different parties involved have to agree upon its nature. We have to ascertain that the correct requirements are stated (validation) and that these requirements are stated correctly (verification).

3. The Problems of Requirements Elicitation

Problems of requirements elicitation can be grouped into three categories [Christel-91]:

1. Problems of scope, in which the requirements may address too little or too much information.
   - The boundary of the system is ill-defined
   - Unnecessary design information may be given

2. Problems of understanding, within groups as well as between groups such as users and developers.
   - Users have incomplete understanding of their needs
   - Users have poor understanding of computer capabilities and limitations
   - Analysts have poor knowledge of problem domain
   - User and analyst speak different languages
   - Ease of omitting “obvious” information
   - Conflicting views of different users
   - Requirements are often vague and untestable, e.g., “user friendly” and “robust”

3. Problems of volatility, i.e., the changing nature of requirements.
   - Requirements evolve over time

4. OBFS as a Constraint Natural Language

We propose an approach where end-users take an active role in the analysis by eliciting requirements using OBFS. We use OBFS to guide end-users in describing their problem based on object-oriented paradigm. OBFS is composed of Description Statements (DS), Collaborative Statements (CS), Attributive Statements (AS), Behavioral Statements (BS), and Inheritance Statements (IS). OBFS use English natural language based on the constraint syntax rules.

4.1. Description Statements (DS)

DS is used to guide the writing of an overview of the system that one wants to build. DS is composed from four elements: Requirement ID, Requirement Name, Language, and Description. DS should specify what is to be done, but not how it is to be done. It should be a statement of needs, not a proposal for a solution.

4.2. Collaborative Statements (CS)

CS is used to identify objects, and associations between the objects. CS consists of a set of forms and contains Subject-Verb-Object (S-V-O) as well as the English natural language based on CS syntax rules (E). We use $S_{cs}$-$V_{cs}$-$O_{cs}$ notation for describing S-V-O natural language, which is based on CS syntax rules. The collaboration between $S_{cs}$ and $O_{cs}$ must be described in the CS.

The CS syntax rules are listed as follows. Predicates are extracted from synonym data dictionary (thesaurus) [Chapman-92].

\[
\begin{align*}
\langle \text{ActionSentence}\text{(AcS)} & \rangle := S_{ac}\langle \text{AcSPredicate}\rangle O_{ac} \\
\langle \text{AcSPredicate} & \rangle := \text{drive|work for|maintain|manage|own|execute|serve|use} \\
\langle \text{LocationSentence}\text{(LeS)} & \rangle := S_{ac}\langle \text{LeSPredicate}\rangle O_{ac} \\
\langle \text{LeSPredicate} & \rangle := \text{next|togo|to} \\
\langle \text{CommunicationSentence}\text{(CommS)} & \rangle := S_{ac}\langle \text{CommSPredicate}\rangle O_{ac} \\
\langle \text{CommSPredicate} & \rangle := \text{talk to|communicate with|refer to} 
\end{align*}
\]

The objects and its associations can be identified by using the following formulas:

\[
\begin{align*}
\forall CS \in E \left[ S_{cs} \Rightarrow OBJ \right] \ \text{and} \ \forall CS \in E \left[ O_{cs} \Rightarrow OBJ \right] \ \cdot \cdot \cdot (1) \\
\forall CS \in E \left[ V_{cs} \Rightarrow \text{ASS} \right] \ \cdot \cdot \cdot (2) \\
\neg \left( OBJ \right)_{red} \Rightarrow OBJ \ \text{and} \ \neg \left( \text{ASS} \right)_{red} \Rightarrow \text{ASS} \ \cdot \cdot \cdot (3) \\
X_{ac}=\text{tentative} \ X, Y_{ac}=\text{redundant} \ Y, OBJ=\text{object}, \ ASS=\text{association}
\end{align*}
\]

4.3. Attributive Statements (AS)

AS are used to identify the attributes of objects. Attributes are properties of individual objects. Attributes usually correspond to nouns followed by possessive phrases, and sometimes are characterized by adjectives or adverbs. AS must contain properties of each object identified at the previous step. AS consists of a set of forms and contains $S_{as}$-$V_{as}$-$O_{as}$ as well as the English natural language based on AS syntax rules (E).

The AS syntax rules are listed as follows.

\[
\begin{align*}
\langle \text{OwnershipSentence}\text{(OwS)} & \rangle := S_{as}\langle \text{OwSPredicate}\rangle O_{as} \\
\langle \text{OwSPredicate} & \rangle := \text{has (properties)|consists of|contain of}
\end{align*}
\]

The object attributes can be identified by using the following formulas.

\[
\begin{align*}
\forall AS \in E \left[ O_{as} \Rightarrow ATT \right] \ \text{and} \ \forall AS \in E \left[ S_{as} \Rightarrow OBJ \right] \ \cdot \cdot \cdot (4) \\
\neg \left( ATT \right)_{red} \Rightarrow ATT \ \cdot \cdot \cdot (5) \\
X_{as}=\text{tentative} \ X, Y_{as}=\text{redundant} \ Y, OBJ=\text{object}, \ ATT=\text{attribute}
\end{align*}
\]
4.4. Behavioral Statements (BS)

BS is used to identify object behaviors. Behavior is how an object acts and reacts, in terms of state changes and message passing. A behavioral statement must contain behaviors of each object identified at the previous step. BS consists of a set of forms and contains $S_{b}$-$V_{bs}$-$O_{bs}$ as well as the English natural language based on BS syntax rules $(E)$. The BS syntax rules are listed as follows.

$$(\text{CapabilitySentence(CpS})) := S_{a}(\text{CpSPredicate})O_{a} \]
$$(\text{CpSPredicate}) := \text{has (a capability to)}\mid \text{has (a capacity for)}\mid \text{can (capabilities)\mid able to (capabilities)}$

$$(\text{CpSPredicate}) := \text{has not (a capability to)}\mid \text{has not (a capacity for)}\mid \text{can not (capabilities)\mid not able to (capabilities)}$

The object behaviors can be identified by using the following formulas.

$$\forall BS \in E \left[ O_{b} \Rightarrow BEH \right] \text{ and } \forall BS \in E \left[ S_{bs} \Rightarrow OBJ \right] \cdots (6)$$
$$= \left[ BEH \right]_{\text{false}} \Rightarrow BEH \cdots (7)$$
$$X_{\text{false}} \Rightarrow OBJ \Rightarrow \text{BEH}\Rightarrow \text{behavior}$$

4.5. Inheritance Statements (IS)

IS is used to organize classes by using inheritance, to share common object attributes and behaviors. IS provide sentences that describe is-a-kind-of relationship. IS consists of a set of forms and contains $S_{a}$-$V_{is}$-$O_{is}$ as well as the English natural language based on IS syntax rules $(E)$. The IS syntax rules are listed as follows.

$$(\text{InheritanceSentenceA(IhSA)}) := S_{a}(\text{IhSPredicate})O_{a} \]
$$(\text{IhSPredicate}) := \text{is a kind of } \mid \text{is specialization of } \mid \text{is generalization of } \mid \text{is a-kind-of } \mid \text{is specialization of } \mid \text{is generalization of }$$

The object and its class hierarchy organization can be refined by using the following formulas.

$$\forall IS \in E \left[ O_{a} \Rightarrow SCL \right] \text{ and } \forall IS \in E \left[ S_{a} \Rightarrow OBJ \right] \cdots (8)$$
$$\forall IS \in E \left[ S_{is} \Rightarrow SCL \right] \text{ and } \forall IS \in E \left[ O_{is} \Rightarrow OBJ \right] \cdots (9)$$
$$\left( SCL \right)_{\text{false}} \Rightarrow SCL \cdots (10)$$
$$X_{\text{false}} \Rightarrow Obj \Rightarrow SCL \Rightarrow \text{superclass}$$

5. Concluding Remarks

It is argued that requirements elicitation is an ill-defined task. Although there are many techniques focusing on the requirements elicitation, there are only a few focusing on the formalization of object-oriented features and the methodology for identifying and refining objects. We presented a methodology for eliciting requirements using constraint natural language based on object-oriented paradigms.

6. REFERENCES


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