Prof. D.M.Thakore, Ravi P.Patki / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 5, September- October 2012, pp.1624-1630

Generation of Software Artifacts and Models at Analysis Phase

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ABSTRACT

The main objective of Object Oriented Analysis (OOA) is to capture a Complete, Unambiguous and Consistent picture of the requirement of system and what system must do to satisfy the user requirement and needs. This is accomplished by constructing several models of system such as use case model, class model. To take out the basic building blocks such as actor, use cases, candidate classes, their attributes and relationships to construct OOA models from the unstructured textual requirement specification document expressed in English like natural language is not an easy task. There are plenty Nouns (Real Time Entities or Classes), Nouns which represent the values (Class Attributes), verbs or verbs phrases (Events), in the system requirement document. Also the size of unstructured source requirement document, writing style, vocabulary and ambiguity present in Natural Language (NL) works as barriers to find out the analysis model artifacts.

Thus analyzing requirements and generating the software artifacts to build analysis model are huge and complex task which need automated support. In the last two decades, major tools that can automatically analyze the Natural Language requirement specification and generate the analysis models are developed. However, none of the tool generates more than one model at analysis phase. Most of the attempts are concentrating on generation of incomplete class model. Also none of these tools cannot be used in real time software development as they provide with quite less coverage and accuracy (60% to 75%) in generating software artifacts. The key reason of lesser accuracy that has been identified by various researchers is ambiguous and informal nature of natural languages.

To conquer some of these issues in automating the analysis phase this paper proposes a techniques that aims at to automatic generation of software artifacts at analysis phase. Initially this technique converts the NL requirements in to some formal, controlled middle representation of software requirement such as Semantic Business Vocabulary and Rules (SBVR) Language (Standard introduced by OMG) to increase in accuracy of generated artifacts and models. Then it focuses on identifying the software artifacts such as actors, use cases, classes, attributes, methods, relationships, multiplicity and many more to generate analysis phase models such as use case and class diagram. Finally this technique generates XML Metadata Interchange (XMI) Files to visualize generated models in UML modeling tool having XMI import feature.

Keywords- Class Diagram, POS Tagging, OOA, UML, Use case, XMI.

I. INTRODUCTION

Software development process invariably begins with some human being needs, wants and desire to explore or solve any business problem. In such early phases of software development natural language are used to describe the exact business problem need to be solved. But the natural language are often complex, vague and ambiguous, sentences are vague when they contain generalization. Some time they are missing important information such as subject or object needed by the verb for completeness or contains pronouns. All these difficulty arise when any one discuss the business problem in using natural language. On other hand software requires more precision, correctness and cleanness that are not found in natural language. Analysis is process of transforming a problem defining from fuzzy set of facts and myths in to coherent statement of system's requirements. The main objective of Object Oriented Analysis (OOA) is to capture a entire, definite and consistent picture of the requirement of system and what system must do to satisfy the user requirement and needs. This is accomplished by constructing several models of system. In this process user's needs and wants are transformed in to set off problem statement and requirements specification document called as Software Requirement Specification (SRS) in natural language (NL). After that this natural language (Such as English) SRS are translated to the formal specifications such as UML models. This translation consists of generation of structural model of the system such as identifying the actors and related use cases, identify classes, their attributes, methods, and relationships among them [1].

However requirement (SRS) explained in NL can often uncertain, imperfect, and incoherent. In addition the explanation and understanding of anything described in natural language has potential of being influenced by geological, mental and sociological factors. It is usually job of requirement

business analyst to detect and fix potential ambiguities, inconsistencies and incompleteness in such natural language SRS. But due to business analyst can overlook defects in SRS document in Natural language which can lead to multiple interpretations and difficulties in recovering implicit requirements if analysts do not have enough domain knowledge. Also fault occurred in this stage of software development process can be quite expensive to fix on in later stages of development. Thus evaluating requirements and generating the software artifacts to build analysis model are massive and difficult task which need some automated support.

In automated software development process the software requirements described in natural language are transformed in to some formal specification means that the business models or computation independent models are transformed in to some platform independent module which are very near to the any of the platform specific models or development environment. In last few years there are so many attempts has been made to transform the natural language business models in to platform independent models. It includes CM Builder, LIDA, GOOAL, LOLITA (NL-OOPS), NL-OOML, Event Extractor, Li, SUGER, and many more. But these tools are not used in real time software development process due there lesser accuracy and coverage in generating the formal models of system. Such tools produce 65 to 70 percentages of accuracy and coverage. The main reason behind failure of these tools is ambiguous and casual nature of natural languages. Also business model described in natural language are very complex to computational process due to inherent semantic inconsistencies in a natural language. Also majority natural language words have multiple senses and single senses can be replicated by multiple words. A better solution to this problem is to convert the natural language business model in to some formal representation which is very simple for computation or machine process and also easy to understand by human being as natural language. Semantic Business Vocabulary and rule (SBVR) specification is the standard developed by Object Management Group fulfills this need. This specification defines the vocabulary and rules for documenting the semantics of business vocabularies, business information, and business rules. This specification is applicable to the domain of business vocabularies and business rules of all kinds of business activities of all kinds of organizations.

Thus to analyze, extract and transform the hidden facts in natural language to some formal model has so many challenges and obstacles. To overcome some of these obstacles in software analysis there should be some mean or a technique which aims at to generate software artifacts to build the formal models such as UML diagrams. Initially such technique should convert the NL business requirements in to some formal intermediate representation to increase in accuracy of generated artifacts and models. Then it focuses on identifying the various software artifacts to generate analysis phase models. Finally this technique provide output in the format understood by model visualizing tool

This paper proposes such approach to analyze, extract, transform and generate software artifacts from natural language business model to build the formal semantic models of the system. Proposed approach first convert the natural language requirement documents in to intermediate SBVR format for better accuracy. Then by doing some semantic and syntactic analysis on such SBVR intermediate result it focuses on identifying the software artifacts such as actors, use cases, classes, attributes, methods, relationships, multiplicity and many more to generate analysis models such as use case and class diagram. Finally this technique produces XML Metadata Interchange (XMI) Files to envision generated models in UML modeling tool having XMI importation characteristic.

II. BASIC CONCEPTS

In this section, a brief introduction about the basic concepts of the OOA, UML Use Case and Class Model, SBVR is provided

2.1 Object Oriented Analysis (OOA):

Analysis is concerned with devising a precise, concise, understandable model of the real world business. Object oriented analysis consist of identifying, extracting the needs of business and what system must do to satisfy the business requirements. The goal of object oriented analysis first is to understand the system's responsibilities by understanding how the user (Actor) use or will use the system. Next, the artifacts or elements (classes) that make up the system must be identified and their responsibilities and relationships among them. OOA concentrate on the describing what system does? Rather than the how it does it? This is accomplished by constructing the several models of the system from fuzzy set of system description such as use case model and class model. Use case model represent the user's view of the system or user's needs. Another activity in the OOA is to identify the classes and subparts such as attributes, methods and relationships among them in the system.

2.2 UML Use Case Model:

"Use case model is nothing but a sequence of transition in a system whose task is to yield to result of measureable value to an individual actor of the system"

A use case model is graph or diagram of actors, a set of use cases and communication relationships between actor and use cases. Use case

model defines the outside (Actor) and inside (Use Case) of system's behavior.

A use case is a special flow of events through the system. An actor is a user playing a role with respect to the system. Actor is a key to findings the correct use cases. Actor carries out the use cases. In use case model single actor can perform many use cases or a use case may have many actors performing it. A use case must help actor to perform a task that has some identifiable value.

2.3 UML Class Model:

The UML class model is the main static analysis model. This model shows the static structure of the system to be analyzed. A class model is nothing but the collection of the static modeling artifacts such as classes and their relationships, and multiplicity among them connected as graph to each other and to their contents. The key element of class model is he classes and relationships among them. The class can have sub artifacts as attributes, and methods. Such model represents the mapping of objects in the real world to actual objects to be used in computer program.

2.4 SBVR

SBVR is a short form of "Semantic Business Vocabulary and Rules" which has been introduced by Object Management Group (OMG) to reduce the gap between Business analyst and IT persons. This is an contemporary an better way of capturing the business requirements in natural language like structure which is very easy to understand for human beings and also very simple to machine process due to its higher order of logic foundation. One can generate a business model of the system using the SBVR with the same communicative influence of standard natural language. In SBVR all specific expressions and definition of facts and concepts used by an organization in course of business are considered as vocabulary. Also in SBVR a formal presentation under the business influence are considered as rules which are used to express the operation of particular business entity under certain conditions.

III. BACKGROUND AND COMPARATIVE ANALYSIS

Many approaches and techniques have been proposed up till now to automate the process of various model generations from natural language requirement specification. However theses approaches are not used in real world system development due to their limitations in coverage and accuracy generation. Also majority of models concentrates on the class model only and require the high order of human interaction to complete the generated models

CM-Builder aims at supporting the analysis stage of development in an Object-Oriented framework. CM-Builder uses robust Natural Language Processing techniques to analyze software requirements texts written in English and build an integrated discourse model of the processed text, represented in a Semantic Network. This Semantic Network is then used to automatically construct an initial UML Class Model. The initial model can be directly input to a graphical CASE tool for further refinements by a human analyst.

CM- Builder analyzes the requirements text and build initial class diagram only. This model can be visualized in graphical case tool by converting it into standard data interchange format where human analyst can make further refinements to generate final class model. Also CM-builder makes the extensive use of NLP techniques.

A Natural Language Object Oriented Production System (NL- OOPS) [3] generates object oriented analysis model from SemNet obtained by parsing NL SRS document. It considers noun as objects and identifies the relationships among objects using links. This approach lacks in accuracy in selecting the objects for large systems and cannot differentiate between class nouns and attribute nouns.

Linguistic assistant for Domain Analysis (LIDA), provide linguistic assistance in the model development process. It presents a methodology to conceptual modeling through linguistic analysis. Then gives overview of LIDA's functionality and present its technical design and the functionality of its components. Finally, it presents an example of how LIDA is used in a conceptual modeling task.

This tool identifies model elements through assisted text analysis and validates by refining the text descriptions of the developing model. LIDA needs extensive user interaction while generating models because it identifies only a list of candidate nouns, verbs and adjectives, which need to be categorized into classes, attributes or operations based on user's domain knowledge.

"GOOAL" (Graphic Object Oriented Analysis Laboratory) [5] receives a natural language (NL) description of problem and produces the object models taking decisions sentence by sentence. The user realizes the consequences of the analysis of every sentence in real time. Unique features of this tool are the underlying methodology and the production of dynamic object models. GOOAL produces the class diagram by considering the validation threshold of 50% and its coverage accuracy (Precision matrices) is very minimum that is 78%

NL-OOML [6] presents an approach to extract the elements of the required system by subjecting its problem statement to object oriented analysis. This approach starts with assigning the parts of speech tags to each word in the given input

document. The text thus tagged is restructured into a normalized subject-verb -object form. Further, to resolve the ambiguity posed by the pronouns, the pronoun resolutions are performed before normalizing the text. Finally the elements of the object-oriented system namely the classes, the attributes, methods and relationships between the classes, the use-cases and actors are identified by mapping the 'parts of speech- tagged' words of the natural language text onto the Object Oriented Modeling Language elements using mapping rules. But approximately 12.4 % of additional classes and 7.4 % of additional methods are identified in all the samples taken each of around 500 words. These additionally identified candidates are those that will usually be removed by human by intuition. Since the system lacks this knowledge, they were also listed as classes. Coverage accuracy is 82%

An evaluation methodology proposed by Hirschman and Thompson [9] is used for the performance evaluation of all above existing tools. According to this methodology the most enduring metrics of performance that have been applied to information extraction are termed as recall (Coverage of tool) and precision (Coverage Accuracy of tool).These metrics may be viewed as judging effectiveness from the application user's perspective. In the case of in information extraction, a correct output is a relevant fact.

Recall = no of Relevant-returned facts / actual relevant facts

Precision = no of relevant-returned facts / total no. of returned facts

Following TABLE I show the comparison of results of available tools that can perform automated or semi-automated analysis of the Natural Language requirement specifications.

Recall value was not available for some of the tools.

Table I - A Comparison of Performance Evaluation of Existing Available Tools

Tools	Recall Value	Precision Value
CM-Builder (Harmain, 2003)	73.00%	66.00%
GOOAL (Perez-Gonzalez, 2002)	---	78.00%
NL-OOML (Anandha, 2006)	----	82.00%
LIDA (Overmyer, 2001)	71.32%	63.17%
Extract (only Event Extraction) (2009)	92.00%	85.00%

As the existing system uses natural languages as direct input to tool so that their recall and precision values are very less. Such results are there due to problems associated with Natural Languages such as

- Ambiguous and informal nature
- Inherent semantic inconsistencies
- Complex to machine process.
- Informal sentence structure

Moreover, the various functionalities supported by existing tools are also compared as shown in TABLE II

Table II – Functionality Support Comparison of Existing Available System

Tool Functionality → / ↓	NL-OOPS	CM-Builder	LIDA	GOOAL	NL-OOML	Extract
Use-Case Model	NO	NO	NO	NO	NO	NO
Classes	YES	YES	YES	YES	YES	YES
Attributes	YES	YES	YES	YES	YES	YES
Methods	YES	YES	YES	YES	YES	YES
Associations	YES	YES	YES	In Semi NL	NO	NO
Multiplicity	NO	YES	YES	NO	NO	NO
Aggregation	NO	YES	NO	NO	NO	NO
Generalization	YES	NO	NO	NO	NO	NO
Instances	YES	NO	NO	NO	NO	NO
XMI Support	NO	YES	NO	NO	NO	NO
Normalize Requirement	NO	YES	NO	NO	NO	NO
User Interaction	High	Medium	High	High	High	Low

Table II shows that there are very few tools those can extract information such as multiplicity, aggregations, generalizations, instances from Natural language requirement. None of the tool generates the OCL representation of output model and thus they are inadequate to capture the nonfunctional requirements.

As every event itself is a single interaction i.e. atomic unit of interaction (Below Use-case) that captures functional requirements in terms of an interaction from a scenario. Proposed system supports the functionality to capture the events from requirement statement and generates Event Meta Model/Template to capture the event from natural language requirement

Thus, the results of this initial performance evaluation show that there is still potential for automation and provide motivation for approach proposed here.

IV. SBVR

The Semantics of Business Vocabulary and Business Rules (SBVR)[9] is an adopted standard of the Object Management Group (OMG) proposed to be the root for proper and detailed natural language declarative explanation of a complex thing, such as a business. SBVR is planned to formalize complex compliance rules, such as operational rules for an enterprise, security policy, standard compliance, or regulatory compliance rules. Such formal vocabularies and rules can be interpreted and used by computer systems. SBVR is an integral part of the OMG's Model Driven Architecture (MDA). SBVR defines the vocabulary and rules for documenting the semantics of business vocabularies, business facts, and business rules

SBVR include a vocabulary for conceptual modeling and captures expressions based on this vocabulary as formal logic structures. The SBVR vocabulary allows one to formally specify representations of concepts, definitions, instances, and rules of any information domain in natural language. These features make SBVR well suited for describing business domains and requirements for business processes and information systems to employ business models.

4.1 Elements of SBVR

Business vocabulary and business rules are the major key component of OMG's SBVR specification.

4.1.1 Business Vocabulary

A business vocabulary include all the specialized terms, names, and fact type forms of concepts that a given business domain or community uses in their talking and writing in the course of doing business. SBVR includes two specialized vocabularies:

Vocabulary for Describing Business Vocabularies, this element of specification deals with all types of terms and meanings. Vocabulary for Describing Business Rules, this element of specification deals with the meaning of business rules, and builds on the previous one.

These two have been separated so that the Vocabulary for Describing Business Vocabularies could be used independently.

4.1.2 Business Rule

Business Rules are rules that are under business jurisdiction. Means that a business can, fit, enact, revise, and discontinue the business rules that govern and guide it. Thus, 'business rule' means sense of 'guide for conduct or action' in business. Business rules serve as criteria for making decisions. The SBVR's interpretation of 'rule' therefore encompasses the sense of 'criteria' as given by authoritative glossary. An additional in the SBVR's treatment of 'rule' is consistency with formal logics. The best treatment for the SBVR's understanding of rules would involve obligation and necessity claims. Consequently, in SBVR, a Rule is "an element of guidance that introduces an obligation or a necessity."

The two fundamental categories of Rule are:

• Structural Rule: These are rules about how the business chooses to organize (i.e., 'structure') the things it deals with. Structural Rules supplement definitions

• Operative Rule: These are rules that govern the conduct of business activity.

In contrast to Structural Rules, Operative Rules are ones that can be directly violated by people involved in the dealings of the business

In SBVR, rules are always constructed by applying necessity or obligation to fact types. SBVR realizes a the basic principal of the Business Rules Approach at the business level, which is states that "Business rules build on fact types, and fact types build on concepts as expressed by terms." This blueprint allows SBVR's support for concepts to be optionally used on its own for building business vocabularies.

V. PROPOSED SYSTEM METHODOLOGY

This section describes the used methodology to identify the artifacts which are used to generate the models at analysis phase from natural language. This methodology consist of automatic conversion of natural language software requirement specification conversion to controlled intermediate SBVR format and secondly to identification of software artifacts and model generation, finally visualization of generated models. Used methodology works in different phases organized in pipelined fashion as follows.

1. Preprocess Analysis
   This phase stars with the by reading the given English input and tokenizing the whole input in to individual tokens. To do so java tokenizer class is used. After tokenizing each token is stored in separate array list. While tokenizing the English input sentence splitter is used to identify the boundary of each sentence.
2. Tagging
   This processed text is further given as input to Part Of Speech (POS) tagger to identify the basic POS tags. To do so Standard POS tagger is used which identifies the 44 basic POS tags.
3. Morphological Analysis
   To remove the suffixes attached to noun phrases and verb phrases this type of analysis is performed on the tagged output from

pervious phase. In this type of analysis WordNet is used to convert the plural into singular form also suffixes attached to verb phrases such as "ed" are also removed.

4. Pronoun Resolution
   In this phase JavaRAP is used to replace all possible pronouns with correct noun form up to third person.
5. Parse Tree Generation
   Stanford Parser is used to generate parse tree from pos tagged output for each requirements. This phase is very useful to find out artifacts such as actors, use cases to model the use case diagram.
6. Role Labeling and Element/Concept Identification
   In this phase role labels are identified from preprocessed text such as performer, co actors, events, objects and receiver in the sentences. Also in this phase SBVR concept identification is done according to some identification constraints such as all proper nouns are identified to individual concepts, all common nouns are identified as noun concepts or object type, all action verbs are identified as verb concepts, all auxiliary verbs are identified as fact types, possessed nouns are identified as characteristics or attributes, indistinct articles, plural nouns and cardinal numbers are identified as quantification. Output of this phase is stored in an array list.
7. Rule Generation
   To generate the SBVR rule we have to first produce fact types, in the form of sentences which represents some relationships between the concepts identified in the previous phase. For that purpose use the template such as noun-verb-noun to establish the relationship between two concepts. Thus a fact type is created by combining the noun concepts and verb concepts from pervious phase array list. Generated fact type is used to create the SBVR rule by applying various logical formulation such as use of logical expression AND, OR and NOT etc, Quantification token conversion rules, possibility and obligation formulation rules are used.
8. Applying Notations
   In this phase SBVR notations are applied to generate rules such as noun concepts are underlined, verb concepts are italicized, keywords are bolded, individual concepts or attributes are double underlined.
9. Artifacts Extraction
   In this phase produced SBVR vocabulary and rules are further processed to extract the basic building blocks or artifacts of models such as use case and class diagram etc. all SBVR noun concepts and object type are tends to be actor for use case model and classes for class model. All verb concepts associated to noun concepts are tend to be use cases of that actor for use case model and methods for the class model. Association between actor and use cases are identified with the help of parse tree generated as well as from the SBVR unary fact types in the form of template noun-verb or binary fact types created in phase 7. All SBVR characteristics associated with the noun concepts and object type are mapped to the data items in class model. SBVR Quantifications identified with respective noun concepts are mapped to the multiplicity between two classes.
10. XMI Generation and Model Visualization
    Finally in this phase the output of above phases are generated in the form of XML meta data interchange (XMI) file format. Such file is further given as input to UML modeling tool having XMI import feature to visualize the generated models.

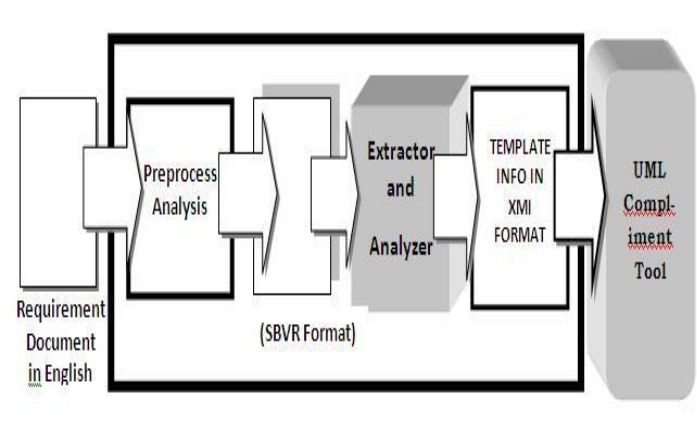

Figure 1 Process Architecture of System

VI. SYSTEM WORKFLOW

Take the input from user, a document which is written in English like natural language. Then we do the preprocessing of this natural language specification document using different natural language processing tools and technologies to do tagging, morphological analysis, pronoun resolution and parse tree generation. After doing so this preprocessed text is converted into controlled intermediate format such as SBVR Concepts and Rules which are then mapped to software artifacts to build the models at analysis level. These models are finally visualized using the UML compliment tool having XMI import features. Following fig2 shows the sequenced steps to be followed to generate the analysis level models of software specification.

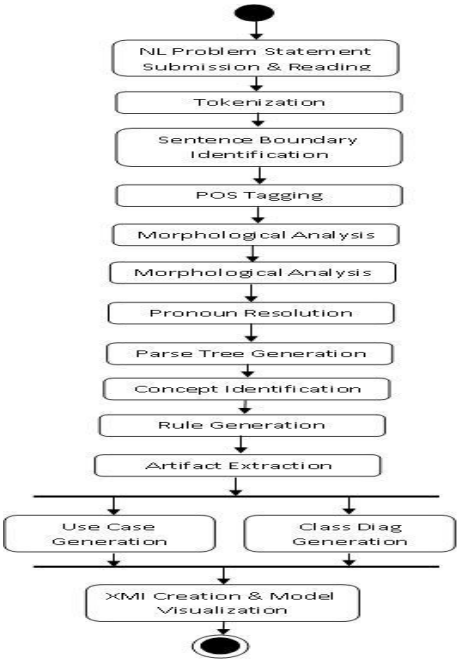

Figure 2 Workflow of System

VII. UTILITY

- Proposed system may be used across all domain over unlimited requirement size expressed in Natural Language to generate analysis phase software elements and models.
- Proposed system would be very useful in understanding functional requirements because it gives list of events that represents the behavior of system
- Non functional requirements are basically constraints in Natural Language Requirement Specification and proposed system will be useful to find out such non-functional requirement in the form of OCL Specification.
- Proposed system may be used to for summarization and for extraction of important software elements in Objects Oriented Analysis Process.
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VIII. CONCLUSION

This approach describes a computerized way to take out the software element at analysis phase. It uses Natural Language Processing techniques to consider business level software requirements and builds an incorporated analysis level model.

This approach can be used for the identification of software elements such as event list, use cases, classes, their attributes, and the static relationships among them with increase in accuracy due to use of intermediate format SBVR. The outcome achieved have shown the utility of this approach

- Across all domain over unlimited requirement size expressed in Natural Language to generate analysis phase software elements and models.
- in understanding functional requirements because it gives list of events that represents the behavior of system
- For summarization and for extraction of important software elements in Objects Oriented Analysis Process.

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