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Abstract—The requirements elicitation process, whose main objective is to give birth to the requirements, not only is a technical process to build a particular system but also an important process of social connotations involving different people (stakeholders), a circumstance which causes certain problems arise when carrying out this process of requirement conceptualization. We propose a process of Requirements Conceptualization that are structured in two phases: (a) Problem-Oriented Analysis: aimed at understanding the problem given by the user in the domain in which this takes place, and (b) Product-Oriented Analysis: its aim is to obtain the functionalities that the user intends to obtain from the software product to be developed, taking into account the relationship of these features with the reality expressed by the user in his speech. The techniques for each activity in both phases are introduced.

Keywords - Requirements Conceptualization; Process; Phases; Activities; Techniques.

I. INTRODUCTION

The requirements elicitation process, whose main objective is to give birth to the requirements, not only is a technical process to build a particular system but also an important process of social connotations [1] that involves different people (stakeholders). It is usual that the process of requirements elicitation causes problems when it is being carried out [2]. Similarly, with regard to the stakeholders it is clear that the term is used in reference to any person or group that is affected by the system directly or indirectly, between them can be cited to end users who interact with the system and as well as others who may be affected by the implementation of it (maintenance professionals providing other related systems, experts in the domain of the system, business managers, others).

Now, in light of all the constraints that make mention by Sommerville, proper of requirements elicitation process is that there is a need to explore and analyze those features that are inherent to this process and, as such, contribute to characterize the process. Characterized the task of requirement elicitation, it follows that the axis of it focuses on establishing communication between the User and the Requirements Engineer. When developing their work in elicitation, this must capture and model a reality that frames a problem, whose solution must be approached through a software product. Since this is really an intangible element, usually too complex, it is also difficult to capture.

These problems, taken from the elicitation process, make it difficult for the requirements engineer to develop the stakeholder universe of discourse, as well as the construction of adequate conceptual models [3][4], i.e. these problems, which begin to manifest themselves in the process from requirements elicitation and communication between the user and the engineer, probably will be propagated in the activity of construction of conceptual models. These drawbacks inexorably converge towards obtaining low-quality software.

In this context, the problem is focused (Section 2), we propose a process of requirements conceptualization (Section 3), the techniques proposed for the activities in each phase are a presented (Section 4), and conclusions and future research work is outlined (section 7).

II. PROBLEM DESCRIPTION

The open problem identified in this section, is the need to structure and categorize the information body coming from the elicitation process. The purpose is facilitating the understanding of the problem expressed by the user [5][6], in other words, to conceptualize the requirements. Inadequate treatment of the complexity contained in the user’s discourse has been highlighted by several authors [7][8][9][10]. These authors mention the difficulties in building conceptual models based on the information contained in the elicitation process and reflected in the user’s speech. Also worth noting that these difficulties give the analysis process to a degree of immaturity which makes it difficult to perform effectively in this activity, while difficult to adopt this approach in organizations [11]. Accordingly and pursuant to the foregoing, the open problem addressed in this paper, is a “perception gap” [5][7] in the transition of a process (requirements elicitation) to another process (Conceptual Modeling). Because of this, is clearly a need to conceptualize the requirements stated by the user in his speech before going to the construction of conceptual models in order to reduce complexity and promote understanding referred to the problem described by the user, contributing to the achievement of better quality of Conceptual Models.

III. PROPOSAL OF PROCESS OF REQUIREMENTS CONCEPTUALIZATION

The solution proposed in this work involves the insertion of an activity of Requirements Conceptualization, which aims to act as a bridge or “link” between the activities of requirements...
elicitation and the activities conceptual modeling, thereby facilitating the understanding of the problem expressed by the user and therefore obtain higher quality Conceptual models [2][3][5][10][12].

The process of conceptualizing the proposed requirements is done through the so-called Requirements Conceptualization Process which is developed in two phases: (a) Problem-Oriented Analysis, whose goal is to understand the problem posed by the user in the domain in which this takes place, and (b) Product-Oriented Analysis, whose goal is to obtain the functionality that the user intends to obtain from the software product to be developed, taking into account the relationship of these features with the reality expressed by the user in his speech. Figure 3 represents the process of Requirements Conceptualization with focus on interdependence between the phases, tasks and products.

Problem-Oriented Analysis phase is divided into three tasks: (a) "User Discourse/Speech Segmentation", (b) "Cognitive Analysis of Text Segments", and (c) "Construction of Problem Space based on User Scenarios". The "Discourse of Natural Language User" (which from now on in this paper we will call user speech) is the input for the task "User Discourse/Speech Segmentation" that results in the "Text Segments". These segments are the input to task, "Cognitive Analysis of the Text Segments" generating the respective "Knowledge Types". The "Text Segments" and "Knowledge Types" are the inputs for the task "Construction of Problem Space based on User Scenarios" that will result in "Problem Space based on User Scenarios".

Product-Oriented Analysis phase is divided into three tasks: (a) "Construction of Users Scenarios", (b) "Refinement of User Scenarios", and (c) "Construction of the Unified Map of User Scenarios". The "Text Segments & Knowledge Types Association" and the "Problem Space based on User Scenarios" constitute the inputs for the task "Construction of User Scenarios". These scenarios along with the "User Speech" respectively are the input to task "Refinement of Scenarios User" that generates the respective "Refined User Scenarios". These, and "Text Segments" are the inputs of the task "Construction of the Unified Map User Scenarios", that result in the "Unified Map User Scenarios". The techniques and representations of the tasks in the problem-oriented analysis phase are summarized in Figure 4.

IV. TECHNIQUES FOR PHASE OF PROBLEM-ORIENTED ANALYSIS

This section presents techniques for the phase Problem-Oriented Analysis, which are: Technique for User’s Discourse Segmentation (TS - DU) used to the implementation of task of User’s discourse segmentation (SDU) (section IV.A), Cognitive Techniques to Identificate different types of Knowledge as: factual knowledge, Procedural knowledge, Contextual knowledge and Association knowledge (TCI - CFPKA) for the implementation of task Cognitive Analysis of Text Segments (ACST) (section IV.B) and the Technique for Building the Problem Space Diagram of User’s scenarios (TCD - EPEU) for the implementation of task Building the Problem Space of User’s scenarios (CEPEU) (section IV.C).

A. Technique for User’s Discourse Segmentation (TS - DU)

By means of this technique is implemented the first task that requirement engineer (RE) has to carry in the early stage of the phase Problem-Oriented Analysis, called Technique for User’s Discourse Segmentation (TS - DU). For application of
TS – DU the RE uses as input the User’s Discourse in plain text to segment it sentence by sentence [13], integrating these sentences in Text Segments (ST) are related with real situations described by user. Finally the ST associated to user’s scenarios (EU) are obtained. ST and EU are the output of this technique which is summarized in table 1.

**TABLE I. TECHNIQUE FOR USER’S DISCOURSE SEGMENTATION (TS – DU)**

<table>
<thead>
<tr>
<th>Technique:</th>
<th>User’s Discourse Segmentation (TS – DU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input:</td>
<td>User’s Discourse</td>
</tr>
<tr>
<td>Output:</td>
<td>Text Segments (ST) associated to user’s scenarios (EU)</td>
</tr>
</tbody>
</table>

**Step 1.** User’s discourse segmentation (DU) sentence by sentence
(In this first step is performed a preliminary analysis of DU looking segmenting in short sentences. This initial segmentation allows a simpler treatment of DU to meet the step 2 of this process. Short sentences are the output obtained for this step).

**Step 2.** Integration of sentences in Text Segments (ST)
(In this second step integrates the sentences obtained in step 1 into segments of text (ST) describing a situation of reality. These ST are formed by sets of short sentences, and are the output for this step).

**Step 3.** Association of Text Segments (ST) to User’s Escenarios (EU)
(In this third step, each segment of text obtained is associated with a user scenario obtained in step 2. Therefore, as a result of this process are obtained Text Segments (ST) associated with User Scenarios (EU), which are the output of this technique)

B. **Cognitive Technique to Identify Factual, Procedural, Contextual and Association Knowledge (TCI - CFPCA)**

This technique implements the second task the RE should develop during the problem-oriented analysis called Cognitive Analysis of Text Segments (ACST). The input of the technique are the Text Segments (ST) associated with User Spaces (EU) [14] that were obtained from the application of the technique for User’s Discourse Segmentation (TS – DU) these segments are processed With The notion of Identifying Different types of knowledge (TC), Which are present in the "mental model" of the user based on personal experiences that occur in uncertain contexts [15][16]. The technique begins by Identifying Contextual Knowledge in the text segments (ST), and then continues with the identification of Factual Knowledge, Procedural Knowledge, and Knowledge Association. Finally, the RE Integrates Different types of information These with text segments, seeking to establish which kind of knowledge corresponds to segment text. Knowledge identified in each text segment (ST) are the output provided by this technique, which is summarized in Table 2.

**TABLE II. COGNITIVE TECHNIQUE TO IDENTIFY Factual KNOWLEDGE, PROCEDURAL KNOWLEDGE, CONTEXTUAL KNOWLEDGE AND ASSOCIATION KNOWLEDGE (TCI - CFPCA)**

| Technique: | Cognitive Identification of Factual Knowledge, Procedural Knowledge, Contextual Knowledge and Association Knowledge (TCI - CFPCA) |

| Input: | Text Segments (ST) associated to User Spaces (EU) |
| Output: | Types of Knowledge (TC) identified in Text Segment (ST) TC |

**Step 1.** Identification of Types of Knowledge (TC) in Text Segments (ST)
(This step identifies the different types of knowledge: Contextual, Factual, Procedural and Association in the text segments (ST)).

1.1. **Contextual Knowledge**
Identification in Text Segments (ST)

1.2. **Factual Knowledge**
Identification in Text Segments (ST)

1.3. **Procedural Knowledge**
Identification in Text Segments (ST)

1.4. **Association Knowledge**
Identification in Text Segments (ST)

**Step 2.** Integration among Text Segments and Types of Knowledge
(In this second step is necessary to integrate text segments (ST) with the types of knowledge identified in the respective ST, for which, drawing up a table indicating the various TC contained in each of the ST. Table connecting ST with respective identified TC is the output of this technique)

C. **Technique for Building the Problem Space Diagram of User’s scenarios**

By means of this technique is implemented the third task to carry out by RE in the phase Problem-Oriented Analysis, called Technique for Building the Problem Space Diagram of User’s scenarios (CEPEU). For the implementation of the TCD - EPEU, RE uses as input the ST associated to EU obtained from the application of the technique TS – DU, and the TC identified in each of the ST obtained from the application of the technique TCI - CFPCA. To begin application of the TCD - EPEU, the RE proceeds to make use of the TC identified in each ST (leaving the association CT for Oriented Analysis Phase of the Product) to obtain the different elements that make up the EPEU, which are: Actors, Relationships, Attributes, Actions and Interactions. The RE then proceeds to identify the Contextual Framework Base (MCB) in which actors will unfold in the built EPEU (first diagram for this purpose). Finally, RE develops the remaining EPEU diagrams reflecting different realities provided by the respective ST. The EPEU diagrams are the output of this technique which is summarized in Table 3.

**TABLE III. TECHNIQUE FOR BUILDING THE PROBLEM SPACE DIAGRAM OF USER’S SCENARIOS (TCD – EPEU)**

| Technique: | Building Problem Space Diagram of User’s Scenarios (TCD – EPEU) |
| Input:     | ST associated to EU and ST-TC Table |
| Output:    | EPEU Diagram |

**Step 1.** Use of TC for identifying EPEU elements
(In this first step RE makes use of the respective TC for identifying the elements of EPEU diagrams for each of the associated ST. The completion of this step is accomplished through the following three substeps)

1.1. **Use of Factual TC**
V. TECHNIQUES FOR PRODUCT-ORIENTED ANALYSIS

This section presents techniques for Product Oriented-Analysis, which are: Technique for Construction of User’s Scenarios Diagram (TCD-EU) to implement the task of User’s Scenario Development (CEU) (section V.A), Technique for Refining User’s Scenarios Diagram (TRD-EU) to implement the task of User’s Scenarios Diagram refinement (REU) (section V.B) and Technique for Construction of Unified User’s Scenario Map Diagram (TCD-MUEU) for the implementation of the construction task Unified User’s Scenarios Map (CMUEU) (section V.C).

A. Technique for Construction of User’s Scenario Diagram (TCD-EU)

By means of this technique, RE implements the first task to be carried out in Product-Oriented Analysis phase called Construction of User’s Scenario (CEU). For the implementation of the TCD-EU, RE uses as input those ST associated to TC obtained from the application of the technique TS-DU, and each of the EPEU diagrams obtained from the application of the technique TCD-EPEU. To begin to apply the TCD-EU, RE proceeds to make use of the ST with the association CT that allows to get the functionalities of the problem defined by the user, as well as identification those EPEU actors that are necessary for the system to perform these functions. RE develops the blocks for Space Product of User Scenarios (EPrEU) for these EPEU [5] with these functionalities and EPEU diagrams in which the associated functionalities are identified. Finally, the RE performs a process of association for the purpose of obtaining the linkages among elements of the blocks of EPrEU and EPEU, thus obtaining a single diagram for each EU constituted from both blocks. The diagrams corresponding to EU is the output product provided by this technique, which is summarized in Table IV.

<table>
<thead>
<tr>
<th>TABLE IV.</th>
<th>TECHNIQUE FOR CONSTRUCTION OF USER’S SCENARIO DIAGRAM (TCD-EU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique:</td>
<td>Construction of User’s Scenario Diagram (TCD-EU)</td>
</tr>
<tr>
<td>Input:</td>
<td>ST with association TC (from Table ST-TC) and EPEU Diagram</td>
</tr>
<tr>
<td>Output:</td>
<td>EU Diagram</td>
</tr>
</tbody>
</table>

Step 1. Using Association TC
(In this first step, the ER uses the association CT for the construction of the EU. The completion of this step is performed by means of the following two substeps)

1.1. Funcionalities Identification
1.2. Actors Identification needed to carry out those functionalities

Step 2. Construction of EPrEU diagram for each EPEU
(In this second step, the ER uses obtained functionalities and EPEU diagrams which were identified associated functionalities, to build the Space Product of User’s Scenario Diagram (EPrEU) for these EPEU. Therefore, the EPrEU diagrams with the respective functionalities are the output of this step)

Step 3. Linking elements of EPEU and EPrEU blocks for each EU
(In this third step, the ER proceeds to establish the “linkage” among the functionalities that make each of the EPrEU diagrams and actors of the corresponding EPEU, to perform these functions)

B. Technique for Refinement User’s Scenarios Diagram (TRD-EU)

Through this technique, RE implements the second task to carry out the Oriented Analysis Product phase called Refining User Scenarios (REU). The TRD-EU is applied jointly by the RE and User. The input products are the original User Speech (DU) and the UE obtained in the previous technique. As an output result are obtained Refined User Scenarios (EUR). The application substep TRD-EU includes joint review (User and ER) of the original DU, which is carried out based on an analysis of consistency (to identify inconsistencies), which are classified into incompleteness and contradictions. These inconsistencies are solved to have a refined DU. From a refined DU, User and RE develop the validation and debugging of ST and CT for the purpose of purging inconsistencies in elements of the DU. Then, User and RE validates EU diagrams to obtain the EUR diagrams. Finally, User and ER develop final review of the EUR, if both granted pursuant to the obtained EUR the
application of the technique finishes, if not, return to step 1 to
begin to apply again. The diagrams corresponding to the EUR
are the output product that provides this technique, which is
summarized in Table V.

| TABLE V. | TECHNIQUE FOR REFINEMENT OF USER´S SCENARIOS
| Technique: | Diagram (TRD-EU) |
| Input: | User Speech (DU) and the UE Diagram |
| Output: | Refined User Scenarios (EUR) |

Step 1. Consistency Analysis of DU
(In this first step, User and RE develop consistency analysis of DU
based on the identification of incompleteness and inconsistencies
to obtain a refined DU. This step is performed by means of the
following three substeps)
1.1. Validation and Debuging of DU
1.2. Validation and Debuging of DU contradictions
1.3. Validation and Debuging of DU
Step 2. Validation and Debuging of ST and TC
(In this second step, user and RE develop validation and subsequent
debugging of the ST and TC, since the inconsistencies
identified in the DU in the substeps 1.1 and 1.2, are propagated to
the ST and CT. Therefore, the refined ST and TC (STR and TCR)
is the output product of this step).
Step 3. Validation and Debuging of EU
(In this third step, using DU, STR and TCR, User and RE
develop a validation and subsequent debugging the EU. In this
way, it may be a case of having to add actors, change attributes,
include interactions among actors; obtaining refined EU diagrams
EUR). Therefore, these EUR diagrams are the output product of
this step).
Step 4. Final Revision of EUR
(In this fourth step, User and RE develop a final review of the
EUR diagrams contrasting with EU diagrams that served as input
to this technique jointly with the original DU. In case User and
RE agree with the obtained EUR, these are the output product of
this technique and the application of the technique finish, otherwise
it returns to Step 1 and begin to apply the technique again)

Through this technique, the third and final task to carry out is
implemented of the Product Oriented Analysis phase, called
Construction of User’s Scenarios Unified Map Diagram (CMUEU).
For the development of the TCD-MUEU, RE uses
as input products each of ST associated to EU and EUR
obtained by the application of the previous technique. As
output result is obtained the User’s Scenarios Unified Map
Diagram (MUEU). The MUEU diagram represents a space-
time sequence about how the user understands the problem
to be solved and the reality that fits the problem. The application
of TCD substep - MUEU includes a transitional analysis of
User Scenarios (EU) through which it may be identified the
triggers of User Scenarios (EU), which allow to identify the
corresponding precedence relations among EU. From these
triggers the RE s able to establish appropriate links among EU
that lead to MUEU diagram. MUEU diagram is to the output
product provided by this technique.

| TABLE VI. | TECHNIQUE OF CONSTRUCTION OF USER´S SCENARIOS
| Technique: | UNIFIED MAP DIAGRAM (TCD-MUEU) |
| Input: | Text Segments Associated to EU and EUR Diagrams |
| Output: | MUEU Diagram |

Step 1. Transition Analysis of EU
(The RE identifies EU triggers present in ST associated to EU and
reflected in the EUR. These triggers produce changes in EU occur
in the body of the EU leading precedence relations among EU.
The completion of this step is carried out through the following
three substeps according to EU triggers types identified by RE)
1.1. Context Change Identification
1.2. Actors State Change Identification
1.3. New Actors Identification
Step 2. Construction of MUEU Diagram
(The RE proceeds to build MUEU diagram using EU which
identifies Base Context Framework (Trigger type I). With triggers
type II and III identified in step 1, build the chain of EU which
will then lead to MUEU. MUEU Diagram with their respective
EUR properly linked are the output product of this technique, and
output of the process of requirements conceptualization)

VI. A CONCEPT PROOF OF THE PROPOSED PROCESS

This section presents the example of an Aircraft’s Fuel
Supply System as concept proof of the phase “Problem-
Oriented Analysis”. For each task is described inputs and
outputs and the used techniques. There are described: the Task
User Discourse / Speech Segmentation (Figure 5) the Task
Cognitive Analysis of Text Segments (Figures 6. a, b, c) and
the Task Construction of Problem Space based on User
Scenarios (Figure 7. a, b, c), the Task Refinement of Users Scenarios
(Figure 8), the Task Refinement of User Scenarios (Figure 9), and the Task Construction of Unified-Map of User
Scenarios (Figure 10).

The results of cognitive techniques that have been applied
to identify factual knowledge, procedural knowledge, and
contextual knowledge and association knowledge with the Text
Segments are shown in Figures 6.a, 6.b and 6.c. The results of
having applied the technique of construction of diagram of
problem-space based on user scenarios from templates of
factual knowledge, procedural knowledge, contextual
knowledge and association knowledge obtained are shown in
Figures 7.a, 7.b and 7.c. In the Task Construction of Users
Scenarios, shown in Figure 8, the requirement engineer
proceeds to the building the User Scenario with the building of
the blocks corresponding to the Product Space for those
scenarios in which the functionalities associated to the space
problem are identified. In order to perform this task, the
requirement engineer has as input products two elements: the
Problem Space of the Users Scenarios and the Text Segments
with Knowledge Types of Association. The result output are
the Users Scenarios which are represented by the diagrams that
have two blocks corresponding to the Problem Space y al
Product Space; which are linked by the arrows between the
element and the functionality.
Thus, this representation shows the “existing linkage” between the required functionalities for the software product and the elements of the problem space that are necessary to process the functionality. In this case, the Text Segment [3] is the only one identified as knowledge of association. This knowledge of association allows defining two functionalities which include all the product space (Registry of the procurement authorizations accepted by the Tower of Control in one given day and Total quantity of mechanical maintenances performed in all the aircrafts in one given day).
In the task Refinement of Users Scenarios, shown in Figure 9, the user and the requirement engineer interact together in order to acquire scenarios free of errors and inconsistent. These “debugged” scenarios are called Refined Users Scenarios.

In order to perform this task, the requirement engineer has as input products two elements: the Users Scenarios and the
original User’s Discourse / Speech, getting as output the RUS complying the user’s requirements. For this study case, it is reviewed the User’s Discourse / Speech and the Users Scenarios in the paragraph of Text Segment [3]: “that a registry is updated with all the procurement authorizations accepted by each Tower of Control in a given day”. that defines the functionality “Registry of the procurement authorizations accepted by the Tower of Control in one given day”. A problem is detected in the User Scenario and it is necessary to add in each Tower of Control act the attribute Procurement Authorization with the value Accepted, because these type of authorizations are the only one interested to be registered by this functionality. As a result, the User Scenario that is refined is the third one. In the task Construction of Unified-Map of User Scenarios, shown in Figure 10, the requirement engineer works on the construction of the Unified-Map of User Scenarios, which allows documenting the “temporal order” in which the scenarios are performed. For this task, the requirement engineer has as input products the Text Segments and the Refined Users Scenarios, getting as a result the UMUS.

The used technique is “Analysis of Transitions of Users Scenarios”, which allows identifying in the Text Segments the elements called “scenario dispatchers” from which the transition is performed. The dispatcher can have three types: 1) context changes in the user discourse, 2) state change in the actors of the scenario (modifying the attribute values) and 3) adding actors to the scenario. In this case, the analysis of Text Segment [1] indicates that the US-1 is performed by a dispatcher type 1), because it is related to a contextual basis frame; the analysis of Text Segment [2] indicates that the US – 2 is performed by a dispatcher type 3), because the aircraft actor is added; and finally the analysis of Text Segment [3] indicates that the US-3 is performed by a dispatcher type 2), because a change in the state actor aircraft is done when the location attribute is set from Hangar N°1) to tank supply location. As a result.

![Figure 10. Task: Construction of Unified-Map of User Scenarios.](image)

### VII. CONCLUSIONS

The main contribution of this paper is to present a methodical process called Requirements Conceptualization, which is divided into two phases, called the Problem Oriented Analysis and Product-Oriented Analysis, and whose main objective is to structure and characterize the mass of information from elicitation activity within the discourse (speech) of the user. This paper presents two proofs of concept for a specific case about two phases of this process. The first phase has as input the text associated to the User’s Speech and as an output the Diagram of Problem-Space Based on User Scenarios. To carry out the tasks it has been adapted some techniques and developed another ones; they are: Protocol Analysis, Cognitive Techniques for Identification of Factual Knowledge, Procedural Knowledge, Contextual Knowledge and Association Knowledge, and Technique of Construction of Diagram of Problem-Space Based on User Scenarios. The structuration of the Phase of Problem Oriented Analysis into the tasks: User Discourse / Speech Segmentation, Cognitive Analysis of Text Segments and Construction of Problem Space based on User Scenarios; allows the requirement engineer to carry out a systematic analysis of user's speech to reach gradually an integrated representation of the fundamental elements of it. The next research steps are: [a] develop and execute an experiment to validate empirically the process of requirements conceptualization introduced and [b] to focus on implementing of high quality conceptual models.

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