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Challenge of validation in requirements engineering

Sourour Maalem[a,*], *Nacereddine Zarour*[b]

[a] *LIRE Laboratory, Mathematics and Computer Sciences Department, Ens-C Higher Normal School-Constantine, Constantine, Algeria*

[b] *LIRE Laboratory, Computer Sciences Department, Constantine 2 University, Constantine, Algeria*

HIGHLIGHTS

- Framing the issue of validation in Requirements Engineering.
- Classification and taxonomy of existing techniques in requirements validation.
- A validation techniques is intended for a particular area.
- The combination of validation techniques is essential.
- Several iterations are necessary because of the multidisciplinary projects.

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ABSTRACT

This paper will review the evolution of validation techniques and their current status in Requirements Engineering (RE). We start by answering the following questions: What validate? Why the benefits of having the requirements validation activities during the RE process? Who are the stakeholders involved in the requirements validation process? Where applied the validation in the RE process? and How the techniques and the approaches of requirements validation?

1. Introduction

To error is human, and there is no reason to think that it does not occur during the development of the system. Problems can result from a misunderstanding between analyst and the customer an ambiguity in the documentation, etc. Errors that occur at this stage and are not corrected are often the most persistent and costly. It is therefore important to set in motion steps that will minimize errors, detect and correct them as soon as possible. Error prevention is a matter of good practice in software engineering. However, it is wise to assume that errors will occur and establish procedures to prevent. Thus,

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* *Corresponding author.*
E-mail addresses: soumaalem@yahoo.fr (S. Maalem), nasro.zarour@univ-constantine2.dz (N. Zarour).

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the requirements engineering process (such as sub-processes of the larger systems engineering and software engineering processes) must be validated. Validation has the purpose of ensuring that the correct functionality of the solution-system has been defined:

- If the problem domain behaves as described (in the requirements document);
- If the requirements are properly recorded;
- If the new system behaves as described (in the requirements document);
- If the inventive step (design interactions) is correct when the requirements are met.

The objective of validation is to ensure that all manufacturing steps result in a product that meets the requirements of stable and reproducible way. While the objective of requirements validation is to certify that the requirements on the set of specifications conform to the description of the system to implement and verify that the set of specifications is essentially: complete, consistent, consistent with standards standard, requirements do not conflict, does not contain technical errors, the needs are not ambiguous, etc. During our study in requirements validation, a problem set are appeared, we have classes in: Problems associated with validation in the software life cycle: the nature of information, what? How? When? Who? How (by what means technical)? Where? Duration the position of the validation activity compared to the software life cycle, etc. Problems related to validation during the requirements engineering process: is what an activity or phase? Which is the result of the validation, how can we validate requirements? What types of validation processes is best suitable for a project? How to ensure that the solution meets the needs of stakeholders and company? What is the best technique to use in validating? How to agree all stakeholders? The different validation modes (formal, semi-formal, informal) level verification model where requirements, validation of non-functional requirements and functional control of changing requirements, insufficient in negotiation techniques for validation, the lack of activity of Validation in RE in some ways, the lack of validation methods, lack of expert analysts, lack of business experts with a high level of analytical and communication and experienced users, etc.

The paper is organized as follows: After the introduction we will present the what, validation in RE and some quality criteria that must be based evaluation of requirements to Section 2. Then we describe the Why requirements validation in Section 3, before giving in Section 4 Who should be involved in the process. In Section 5, we will see, speak as validation against the RE process; Spent Section 6 for the techniques that can be used during requirements validation process. Finally we come to a conclusion and some prospects.

2. What is requirements validation?

Many areas merge between the definitions of validation and verification. Thus, it is necessary to agree on their explanations.

According to Artem Katasonov [1] Validation of the requirements is the process to determine whether the requirements as defined, do not contradict the expectations of the various stakeholders of the system and do not contradict each other; this is the control of the quality requirements. Requirements validation is concerned with the process of review of the requirements document to ensure that it defines the right software (the software that users expect). According Kotonya and al. in [2] "requirements validation is concerned to check the requirements document for consistency, completeness and correctness", and in [3] states that the requirements should be checked to: validate, understand, consistent, traceability, completeness, realism and verifiability.

Because the terms verification and validation are often confused, Terry Bahill [4] defined requirements verification as a process to prove that each requirement has been satisfied. Verification can be done by logic, inspection, modeling, simulation, analysis, examination, testing or demonstration. Requirements Validation to ensure that (1) all of the requirements are: correct, complete and consistent, (2), a model can be created that meets the requirements, and (3) real-world solution to be built and tested to prove that it meets the requirements (see Fig. 1).

The requirements validation process is not so clear. According to the EIA632 standard, the requirements validation process ensures that the requirements are necessary and sufficient for the appropriate design phase to meet the exit criteria for the lifecycle software phase and lifecycle phases of the company in which efforts occur for the engineering phase or reengineering.

3. Why requirements validation?

There are processes models in RE, which do not take the validation as sub-phase during the RE overall process [5,6]. To ensure a better support of requirements, requirements must be good quality; the guarantee of that quality is assured through the stages of validation and verification. These activities take place throughout the life cycle, when approving the interim filings for reserved phases. Most of the existing methods or practices are only to identify and gather the requirements. Compared to customer needs, validation activities fit naturally in the harsh process [7]. Jose and al in [8] show that only a few approaches provide techniques for requirements validation. Most of them only set guidelines on how developers and customers will need to review the specification of requirements to find inconsistencies and errors and to complete. A comparative study between web development methodologies and supported the activities of the RE process, they mention that only 4/10 of the methods considered by this validation and mention technique without any approach or methodology.

Lulu He and all [9] realizes that the requirements validation is often not sufficiently covered not only in the practical world but even in the academic world. As said Siew et all [10] consider that most books present it as a list of "best practices" and this validation requirements as much as a heterogeneous process based on the application of a variety of independent techniques. In their towers Nuseibeh B and

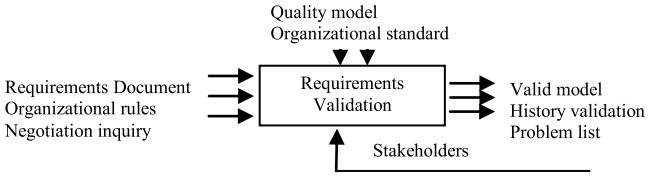

Fig. 1 – Requirements validation process (what).

all in [11] confront the problem of validating requirements with the problem of validation of scientific knowledge. Yet the requirements documents may be procedures for validation and verification. Davis [12] explains that the requirements can be validated to ensure that the analyst to understand the requirements and it is also important to check that a document meets the standards (standards) of business, and that it is understandable, consistent and complete. Similarly Bryne [13] and Rosenberg [14] said, it's normal to explicitly provide one or more points in the process where the latter requirements are validated. The purpose is to identify or collect any problems before resources are committed to meet the requirements. In [15] Yves.C says that requirements must be validated by the various stakeholders. This validation is done at several levels. Future users often to validate as of writing, the client typically validate the entire document. And ends with the conclusion that the monitoring requirements validation is not an easy task. He defined validation as a process of obtaining, on the part of all stakeholders, a formal agreement on the specified requirements.

4. Who validate requirements?

Stakeholders are the actors of the RE process, they are the individuals involved in its implementation. They are identified by their role and not individually.

Requirements engineering reveals actors who are interested in the problem or its solution:

- Customers, users, domain experts
- Software Engineers, Requirements Engineers
- Project Managers.

The role of a party during the RE process is represented by Gerald Kotonya and Sommerville [2] in a model. The latter brings up the RE process with stakeholder responsable, it starts *Understand the business problem* by performing (Requirements engineers, domain experts and end users) and the activity *Establish requirements* outline accomplished by (Requirements Engineers, end users), followed by the activity carried out by *Select prototyping system* (software Engineers, project Managers) suite activity *devlop prototype* execute by (Engineers needs, software Engineers) and end the Evaluate activity *prototype completed* by (the end user, domain experts, Requirements Engineers, software Engineers).

The largest number of works in RE, does not explain the exact role of the Stakeholders in requirements validation. Sharp in [16], argue that the literature does not even distinguish between the roles of individuals or groups and in [17] we proposed a methodology for collaborative requirements validation in distributed platforms. Where we have determined in detail the roles and skills of stakeholders, the results of each activity in the validation process, and the means for its implementation. Selection of participants is based on certain criteria that differ across phases. We clung especially to have different points of view and to call for complementary multiple skills. We suggest selecting participants outside the development team. They will be more objective because less involved in the project. It is then necessary to assign a role to each. It is obvious that a participant may possibly take several roles. The roles and competences are summarized in Table 1.

5. When validate requirements?

The RE process can be seen as a set of activities containing a structure in each activity. These activities include words such as who will be responsible for each activity inputs for an activity and outputs generated by this activity, etc. According to Leite et al. [18] "The whole of the requirements engineering process is a subprocess of fabric, and it is very difficult to make a clear distinction between them".

In [19], Pohl presented the RE process in three dimensions; representation, agreement and specification. The needs are discovered and described in accordance with a system of representation in the Dimension representation. The needs are traded based on their priority, costs and risks of their achievement during the Dimension consensus and end the specification Dimension where needs must conform to standards. Only after two years he joust validation and presents a process with 4 Elicitation activities, negotiation, specification and validation.

Loucopoulos, Karakostas [20] uses the appointment activities (not phase) of the RE process: Elicitation, Specification, and Validation. They present as a retroactive loop that passes from one activity to another in all ways, from the user to the problem domain.

Kotonya, Sommerville [2] keep the same appointment activities with more details. Feasibility study, Elicitation and requirements analysis, negotiation, documentation, validation and adds Management which is the change management process system requirements.

Larry Boldt, [21] presents the RE process in a hierarchical, fractioning task of creating the requirements of development and management. The development is divided into Elicitation, Analysis, Specification and Verification. Larry does not use the word in its RI validation process model.

Gerald Kotonya Ian Sommerville [22] presents a business model Coarse-Grain in quell; the RE process activities and continuous activity where:

Table 1 – Roles and competences of stakeholders in requirements validation.

Stakeholder	Intervention	Roles	Competences and expertise
Analyst	Complete process	He is a moderated, direct the discussion. He prepares the meetings and ensures the sequence of steps. He ensures for the conduct of business objectives and maintain attaches not to neglect human factors. He presides over the decision.	Analysis of IS, animation and communication, order, decision, negotiation
Customer	Validation	Identify needs read the requirements to verify the correspondence with needs.	Communication
Managers project	Inspection	Use of specifications to plan supply and the development process of the system	Problem domain management cost, delay, technical communication
Domain experts, domain problems and solutions communication	Validation	Identify Functional requirements	Domain problems and solutions communication
End user	Validation	Spread Functional and non functional requirements, organization, context, constraint	Domain problems and solutions knowledge of computers (operating systems, software, hardware)
System engineers and developer	Verification	Use requirements to understand the system under development	Communication HMI
System test engineers	Verification	Use the requirements to develop validation tests for the system	Test enable communication
System maintenance engineers	Maintain de la validation	Use requirements to help understand the system	Communication
Designers (including realized earlier versions)	Verification	Detailer et completer les requirements	Communication solution domain

The activities are: the elicitation, the analysis and negotiation and ongoing activities that are documentation, validation, approval. Ian Sommerville follows [23] improves the process presented a general consensus of the activities of traditional requirements engineering process to measure that consists of five main areas of process analysis, elicitation, negotiation, documentation, validation and management. Where the documentation and management are presented as a nucleus and turn them the remains of activities.

Like all phases of the RE process or activity, and produces a result which justifies its presence in all RE process models. It is necessary to provide an evaluation at each level activity. We thus providing a more general approach than that found in the literature that deals validation as an activity and not as a phase, which presents the validation as an ongoing, incremental, collaborative, which takes place throughout RE process, see Fig. 2.

The result of the validation in each step has an increment of the solution which it constructed as one moves in the process. Each increment will make the results of its phase carried out by the stakeholder concern and often generates a heterogeneous product, which continuously requires another pass.

6. How to validate requirement?

Most existing methods and practices aims to identify and gather the requirements. Due to delays and other considerations, the validation is done informally, either on an *ad hoc* basis or simply *peer review* [24]. Different organizations are possible, from simple personal interpretation to the highly organized and formalized review (*walkthrouths*).

There are different types of requirements validation techniques available in the literature, some of which are summarized in Table 2, with respect to their objectives, in particular that detects and ensures that?

7. Summary of approach

Although the literature mentions several approaches to validation requirements, all can be classified according to the level of formality of the specification with what starts the specification validation process (formal, Semi-Formal, Informal) Terminated has a solution (automatic, Semi-Automatic or Manual) generalized into two levels of evaluation: an internal level, this activity is provided by the RI team, externally are appealing to customers, Mixed or that involves the work of master guided by the prime contractor. Applied on examples of systems that can be Critique (Embedded, Real-time, etc.), management Ordinary (see Table 3).

It is interesting to understand the current state of practice of requirements validation. In a rapidly growing market and continuous change. The latter having topical work involving several technical requirements validation justifying none

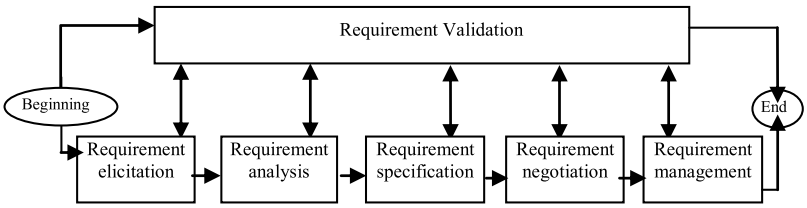

Fig. 2 – When validate in requirements engineering.

Table 2 – Summary of requirements validation techniques.

Techniques	Objective of the technique	What is detected?	Stakeholder
Pre revision	Saves the cost and time for revision	- Faults spelling - Not Standards compliance - Typographical errors - Requirements missing	Involves people from different backgrounds
Revision of requirements	Minimizing changes and changes in the software	Identify inconsistencies, conflicts, omissions, etc.	Involves customers and developers
Inspection of requirements or Fagan inspection [25]	Make understandable product	Defects in artifacts	Used by people who study the state of the art
Inspection based test-cases Gorschek [26], Nina [27]	Ensure that the requirements are good enough for the product and business planning is also	Eliminate defects before the project begins and during the project	The project manager and the tester
Reading techniques Gilb [24], O. Laitenberger [28], Laitenberger [25], O. Laitenberger [24], T. Thelin [27].	Show how to read and what to look in Artifact	The mistakes, Typographical errors	The project manager, analyst
Prototyping	Understand the requirements of the system	The critical situations and panes, the blockages, etc.	End user, analyst
Based-model	Maintain traceability	The formulation, structuring, etc.	Designer, tester, developer
Based viewpoint Leite et al. [29]	Cover all requirements met, the different views	Conflict, consensus	Customer, developer, project manager, Tester
Based-test Wendland et al. [30]	Examine each requirement and derive a series of tests. It can define one or more tests that can be run when the system will be developed	Mainly involve the appropriate definition and data integrity, consistency, non-ambiguity and testability requirements.	Developers tester

Table 3 – Synthesis of validation approach in RE.

Levels	Approaches					
	Math and logic	Natural language	UML	Empiric	Expert system	Formal method
Level of specification formalism Formal/semi-formal/informal	Formal	Informal	Semi-formal	Informal	Informal	Formal
Automatically level Automatic/semi-automatic/manuela	Automatic	Automatic	Semi-Automatic	Manuel	Automatic	Automatic
Level of evaluation Interne verification/external validation/mixed	Interne	Interne	Mixed	Interne	Mixed	Interne
Type de system Critique/ordinary	Critique	Ordinary	Ordinary	Ordinary	Ordinary	Critique

Table 4 – Synthesis of current work of requirements validation.

Approaches	What	Why	Who	When	How
Shahid Nazir Bhatti [31] [2015]	Functional and non functional requirement	Efficiency usability, functionality, portability, maintainability	Elicitor	Elicitation	Prioritization - Inspection -
Luca Sabatucci [32] [2015]	Requirement specification	Correct understand	Non-technical users\ analyst	Specification	Scenarios -Test -
S. Zafar Nasir [33] [2015]	Requirement model	Maintenance	Enterprise manager	Validation	ERP data - model -
Alberto Rodrigues da Silva [34] [2014]	Formal specification	Consistency, completeness, unambiguousness	Domain experts	Specification	Natural Language Processing (NLP) - reading techniques -

is perfect or sufficient. The detection of the methodical approach becomes more topical in hollowing work, comparing with older approaches that fail her approach and the clarity of the validation process for (who does what why when and how) The Table 4, shows the results of a synthesis of recent research in requirements validation analyzed to detect, what validate, validate why, when validating and how to validate.

8. Conclusion

The literature tends to consider the validation of requirements, as a heterogeneous process based on the application of a variety of independent techniques; without being able to specify: What, Why, Who, When and How to validate the requirements. Requirements validation techniques play a pivotal role, to detect possible defects in the requirements. They are summed up in: the review, inspection, reading techniques, prototyping, validation model-based, validation test-bases and validation perspective -based. These techniques can help in the implementation of projects within the timeline, budget, and according to the desired functionality. The prospects for this sought after area varies between: transformation model, automatic generation of prototype, natural language processing to maintain the validation in the requirements management process that requires frequent review of all documents.

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