Creative Strategic Scenarios for Preparation to Requirements Evolution

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***Abstract*—The focus of this research is Creative Strategic Scenarios as predictive models of software evolution for socio-technical systems in organizations. This research seeks to combine theories of Strategic Planning and Creativity to generate strategic scenarios that could predict Organizational Changes. The work will integrate scenarios and the i* goal modelling mechanism to analyse the impacts of organizational change through strategic scenarios.**

***Index Terms*—Requirements Engineering, Software Evolution, Strategic Planning, Scenario Planning, Creativity.**

I. Introduction

An organization can be viewed as a set of individual efforts with the purpose of achieving collective purposes and it is connected to an external environment. This social organization is supported by organizational information systems, which in turn are supported by software systems. To keep their competitiveness, organizations evolve and organizational evolution is motivated by internal and external factors. As an example of internal factor, changes to personnel turnover or retirement, this will require changes in the organization, driving changes to the software as well. As an example of external factor, the organization is inserted into a constantly changing marketplace, and its changes may lead to organizational changes. In this context, strategic planning comes to support this dynamism and to achieve the company's goals. To contribute to this purpose, strategic scenarios can be the input of these activities. Furthermore, these strategic decisions need to be creative to anticipate and to pre-emptively prepare the organization and its software systems for organizational changes.

Organizations should keep evolving to maintain their competitiveness in the marketplace. They have to respond quickly to changes of the market, of their clients' needs or of organization goals [1]. The organization sustainability depends on anticipating and reacting to sequences of voluntary and emerging change [2]. In this setting, Software Evolution is currently done under time pressure and some changes can be anticipated in order to better adapt *Software Systems that support Organizational Information Systems (SSsOIS)* [3]. We will focus on the Lehman's Laws of Software Evolution that relates the *Continuing Change* of E-systems to their *Increasing Complexity, Continuing Growth* and *Declining Quality,* mostly laws' numbers I, II, VI, VII and VIII [4][5], as well as on the lack of accurate Predictive Models in Software Evolution [6].

To help the anticipation of organizational changes related to the evolution of SSsOIS, strategic planning can be seen as a creative process in which organizational futurologists work together to create ideas for new strategic scenarios that are eventually expressed as i* models [7]. Therefore, as strategic planning can be framed as a creative problem solving, strategic practitioners can recruit relevant theories, models, techniques and tools from creative problem solving to understand and support requirements processes more effectively [8] [9].

This Doctoral Research is centred on the hypothesis of contributions from visions of organizational evolution and strategic planning with an emphasis on creativity to generate Creative Strategic Scenarios (CSS) as predictive models for software evolution to support organizational information systems. This Doctoral Research addresses *SSsOIS* and software represented by *"Conceptual Models that support Requirements Engineering (CMsRE)"*.

II. Problem Statement

Handling Changes is considered one of the major challenges the community is facing [10]. Namely, even when the organization and the SSsOIS are aligned, requirements are going to evolve due to organizational changes demanded by the dynamicity of the organizational environment. Because of this, over time, software systems present inconsistencies and lack of compliance with new environmental requirements in which they were deployed.

III. Aim and Objectives

The main aim of this Doctoral Research is to study how to adapt SSsOIS to organizational changes pre-emptively.

From this, the objectives are:

1) Study how to predict organizational changes;
2) Study how to identify impacts of organizational changes in CMsRE;
3) Study how to identify points of change on CMsRE.

IV. Assumptions

To achieve the objectives of this Doctoral Research, some assumptions were adopted:

1) If organizational changes could be anticipated, a CMsRE could be adapted pre-emptively;
2) Strategic decision have impacts of broad spectrum in the organization;
3) Writing conceptual models having different purposes in the same language helps identify impacts between them.

V. Research Questions

This Doctoral Research is driven by the following Research Questions:

1) How to anticipate organizational changes?
2) How to identify impacts of organizational changes in CMsRE pre-emptively?
3) How to adapt a CMsRE to organizational changes pre-emptively?

VI. Research Hypotheses

The general Hypothesis of this Doctoral Research is:

"The use of CSS provides basis for predicting changes at SSsOIS".

Auxiliary hypotheses are exposed below:

1) The following areas can contribute to the construction of CSS;
   a) Strategic Planning
   b) Organizational Evolution;
   c) Organizational Change;
   d) Organizational Futurology;
2) Creativity theories can assist the construction of CSS;
3) A Conceptual Model CSS is compatible with a CMsRE.
4) It is possible to write both a CSS and a CMsRE at the same modelling language.

VII. Strategy to Be Investigated

This Doctoral Research comes to a preliminary strategy to be investigated in order to address the problem stated and to achieve the goals exposed. It presented as follows:

1) Construction of Creative Strategic Scenarios to support the anticipation of Organizational Changes:
   a) Basis:
      i) Organizational Evolution;
      ii) Organizational Change;
      iii) Organizational Futurology;
      iv) Creativity;
   b) Representation Languages for modelling CSS and CMsRE:
      i) Language that is understood by organizational futurists;
      ii) Language Extended Lexicon (LEL) [11];
      iii) Scenarios [12] [13];
      iv) i* [14];
2) Impact Analysis between CSS and CMsRE to identify the impacts of organizational changes anticipated;
3) Identification of points of changes in CMsRE in order to adapt them to organizational changes pre-emptively.

VIII. Research Proposal

This Doctoral Proposal is presented as an activity model using SADT (*Structured Analysis and Design Techniques*). This technique uses a hierarchical decomposition of activities with a top-down approach, wherein each new diagram, the activities of the previous level are decomposed into three to six others. Moreover, the boxes represent activities, the left incoming arrows are inputs of these activities, the right outgoing arrows are outputs, the bottom incoming arrows are the means, components or tools used and the upper incoming arrows are the controls that influence the execution of the activity [15]. Fig. *1* depicts Level 0 of this Doctoral Proposal which is: *Prepare Requirements for Software Evolution based on Alternatives Futures oriented by Strategic Planning and Strategic Thinking theories using Creativity*.

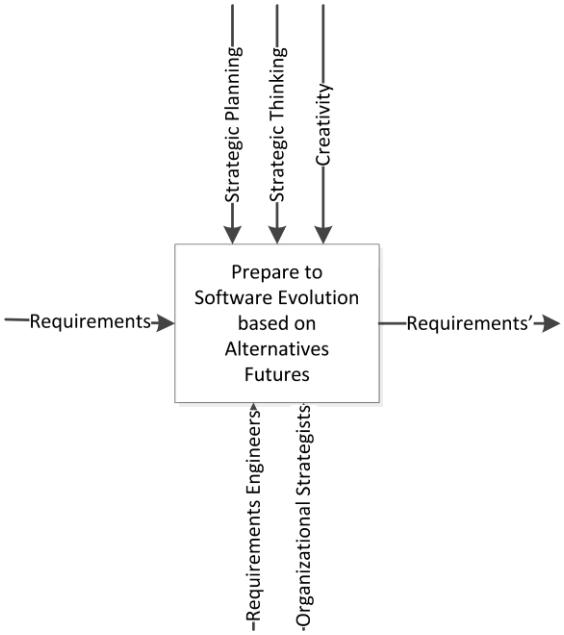

Fig. 1. Level 0 – Proposal

Then, this objective is decomposed in three activities that represent this Research Questions, as showed at Fig. 2.

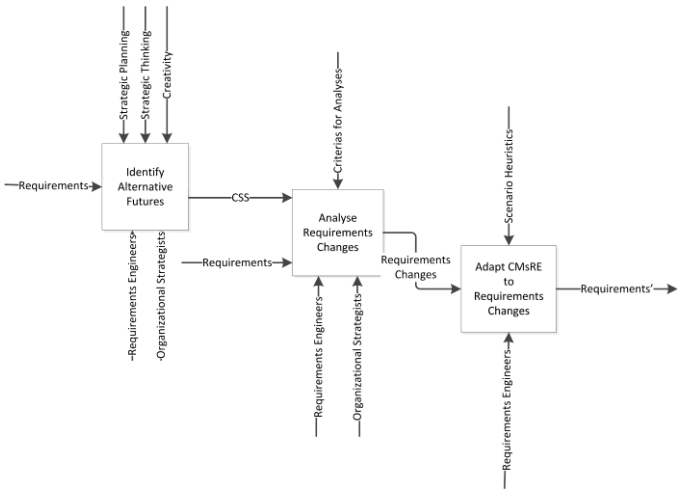

Fig. 2. Level 1 - Prepare to Software Evoltion based on Alternative Futures

In order to *Identify Alternative Futures*, we apply Scenario Planning as a tool to construct scenarios of possible futures. *Strategic Planning* and *Strategic Thinking* theories will guide this construction as well as Creativity Framework. The output of these activities will be validated CSS of possible futures aligned to the Organizational Aspects.

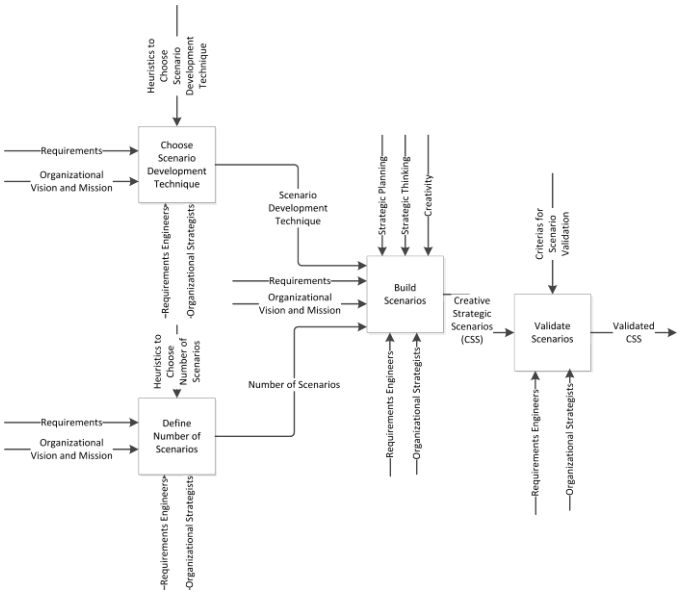

Fig. 3. Level 2 – Identify Alternative Futures

Based on the CSS, next activities aims to identify how the requirements should behave in these alternative futures. Requirements and CSS will be analysed in order to point the Requirements Changes, its risks, impacts and prioritization. The definition of requirements changes will be the output of these activities.

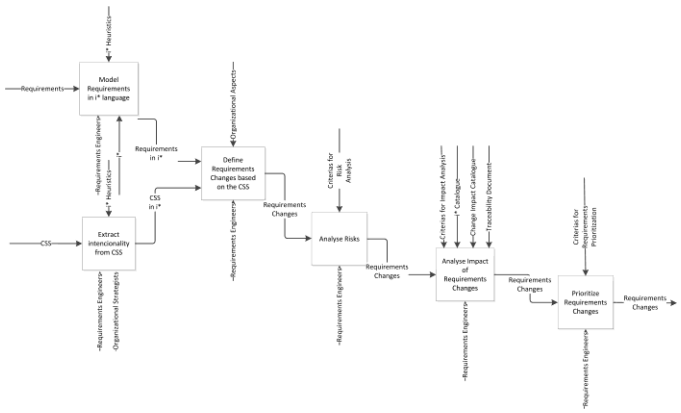

Fig. 4. Level 2 – Analyze Requirements Changes

Next step is to pre-emptively adapt the CMsRE to the Requirements Changes. In this phase, the CMsRE, here represented by scenarios, will be evolved aligned to the Requirements Changes.

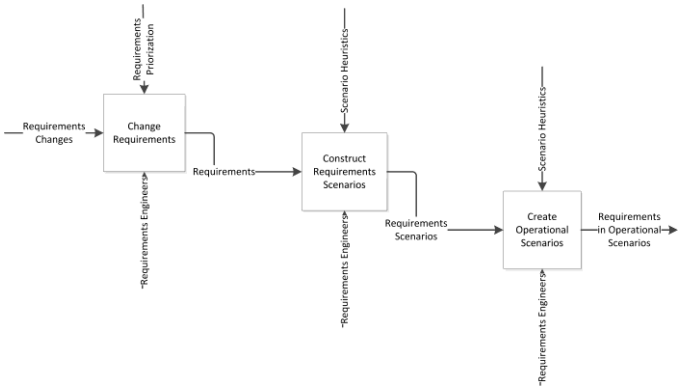

Fig. 5. Level 2 – Adapt CMsRE to Requirements Changes

Fig. 6 summarizes de relationship between the concepts approached by this Doctoral Research and the objective of their relationships.

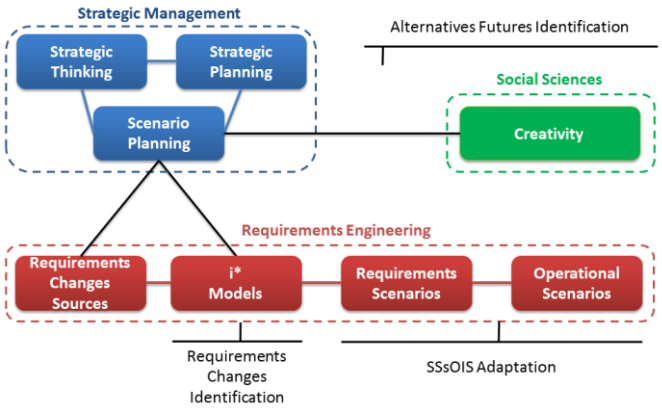

Fig. 6. Concepts approached in this Research

IX. State of the Art

The works listed below are the foundation of this research and are briefly examined as follows:

Macedo's Doctoral Thesis worked with Continuous Organizational Change and how to strategically deal with it using Knowledge Management support [16]. It proposes an architecture for corporate memory with emphasis on strategic issues, hence the name Strategic Corporate Memory - SCM, which takes into account the competitive situation of the global market. The architecture of SCM reflects their Organizational Baseline, which is the repository of knowledge that aims to meet this range of information needs, based on the business conceptual model. The modelling (abstraction) of the business model is conducted taking as inspiration the different approaches to strategic analysis, notably the visions of "positioning" and "emphasizing efficiency", therefore, using an integrated view of these proposals and enriched with an analysis of the processes and functions under a total quality orientation and metaphors about the images of the organization. This work substantially contributes to this Doctoral Research concerning to the Organizational Aspects, as Strategic Planning and Continuous Change, and relating them to the modelling of Software Systems.

Breitman and Leite developed an extensive research on Scenario Evolution, from elicitation to coding [17] [18] [19] [20]. They work on the Evolution of Scenarios due to the Learning Process intrinsic to Requirements Engineering, presented in [21] and in [22]. In their work, they address the lack of a specific methodological support to the use of scenarios. From this problem, they aim to understand what is required for the effective use of scenarios in system development, and propose an organization that supports an engineering approach to scenario evolution. The organization is based on domain knowledge embodied in the scenario evolution model and takes into consideration other software management issues, such as configuration management and traceability. Their research presents aspects co-related to this with respect to the use of scenarios. Therefore, it provides methodological support for the use of scenarios which is very important for this work.

Colette Rolland has been publishing insightful papers in the area of Requirements to Software Evolution for more than 20 years [23]. In the year of 2006, Rolland, Salinesi and Etien came up with an Alignment and co-evolution Method (ACEM) [1]. They investigated the alignment between IT systems and the business they support; and also how system evolves due to contextual forces. For the former, Rolland takes the position that intentional modelling can help resolving some of these issues. For the later, they propose a generic typology of gaps to facilitate a precise definition of change requirements, by means of modelling change as a set of gaps between the requirements specification of the current and the future system. Their work provides solid foundation for the co-evolution approach with regard to the interdependence between the organization and the IT system. Their contributions will guide how to apply intentional modelling to represent the organizational factors to IT systems.

Ernst, Mylopoulos and Borgida examined the issue of Software Evolution from a Requirements Engineering perspective [24] [3]. In Ernst's Ph.D. dissertation, they followed the Requirements Problem approach, wherein software development can be characterized as finding a specification that satisfies user requirements, subject to domain constraints. To enable this, they proposed a shift from treating requirements as artefacts to treating requirements as design knowledge, embedded in knowledge bases. They introduced a Requirements Engineering Knowledge Base (REKB) and the main result of their work on the REKB is a tool and approach which can guide software developers and software maintainers in design and decision-making in the context of software evolution. Their works provides guidelines to relate Requirements Engineering with Software Evolution. Besides that, their results can also be either extended or compared to those achieved by this work.

Pumareja and Wieringa studied the relationship between socio-technical systems and Software Evolution [25] [26]. In her Ph.D. dissertation, they analysed the evolution of requirements in groupware systems (applications that support the cooperative process of individuals working as a group). Through empirical investigation by means of case studies, their most important contribution is a set of requirements evolution patterns. Pumareja's work is helpful to this research with respect to the domain studied, the research method employed and the results attained. First, they explored socio-technical systems that can bring about profound organizational change based on studies that point to emergent organizational properties; this can direct theoretically this research in the subject of organizational aspects related to Software Evolution. Second, they applied a conceptual framework of Software Evolution to study real cases in this context; this method can guide the studies to be made in this work. Finally, their results can be used either for extension as for comparison to those achieved by this work.

Bryl and Giorgini researched the growing involvement of humans and organizations in system structure and operation [27] [28]. They argue that an interdisciplinary notion of a Socio-Technical System (STS) is the one that captures aspects as the organizational environment in which software operates, the software system itself, the related hardware components and human users. They address the problem of understanding the requirements of the STS software component and the way in which the structure of human and organizational activities is influenced by introducing technology. Then, they present a framework, which aims at supporting the design of STS, specifically the design of a network of inter-actor dependencies intended to fulfil a set of initial goals. The focus on the relationship between socio and technological aspects in the design of socio-technical systems is the one applied in this Doctoral Research. However, they propose Requirements Engineering specifically to socio-technical systems and this Doctoral Research proposes Requirements Engineering to evolve socio-technical systems. Their results are very valuable and relevant for this Doctoral Research.

X. Research Method

The Research Method applied in this Doctoral Research is guided by the Research Framework, proposed by Wieringa, Maiden, Mead and Rolland, illustrated in Figure 1 [29]. It is called Engineering Cycle and its activities will be followed in the development of this Doctoral Research.

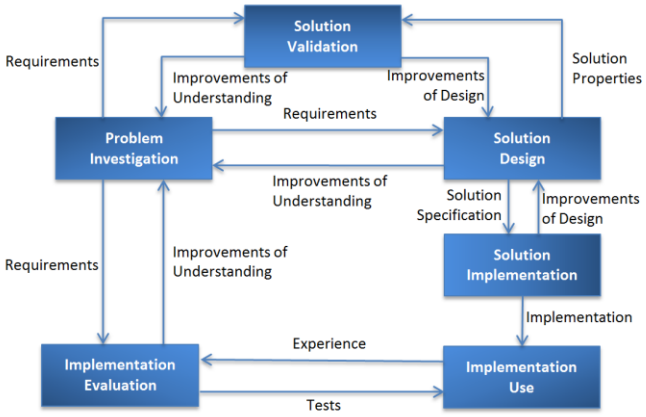

Fig. 7. Activities in the engineering cycle, plus the use activity. Boxes represent activities, arrows represent impacts. There is no preferred sequential relationship among the activities [29]

1) **Problem Investigation (PI):** Investigation of the current situation.
   a) Exploratory Research about Strategic Planning (SP)
      i) Literature Review
      ii) Study Cases
      iii) Analysis of results
   b) Exploratory Research about Creative Problem Solving (CRE)
      i) Literature Review
      ii) Experiments
      iii) Analysis of results
2) **Solution Design (SD):** Propose an improvement to the current situation.
3) **Solution Validation (SV):** Investigation of proposed solution properties.
4) **Solution Selection (SS):** Selecting the improvements over the recommended ones.
5) **Solution Implementation (SI):** Realizing the selected solution, for example, introducing a new RE technique in an organization.
6) **Implementation Evaluation (IE):** Investigation of the new situation.
   a) Comparison with other researches.

XI. Contributions

In summary, the intended contributions of this Doctoral Research are *Heuristics to prepare Requirements for Evolution based on alternative futures*:

1) **Anticipation of possible evolutions:** A study of how *Strategic Management* and *Creativity* can support the identification of alternative futures;
   a) Expected Result: *Creative Strategic Scenarios (CSS)*;
2) **Analysis of risks and impacts of Requirements Changes:** Heuristics to identify Requirements Changes, analyse its risks and impacts and prioritize them;
   a) Expected Result: *Change Impact Catalogue* for *i* Models Evolution:* Identification of costs of each kind of changes in evolution of i* models, based on YU (2000).
3) **Adaptation of CMsRE to Requirements Changes pre-emptively:** Heuristics to pre-emptively evolve CMsRE, (here represented by scenarios);
   a) Expected Result: *Change Impact Catalogue* for *Scenarios Evolution:* Identification of costs of each kind of changes of evolution of scenarios, based on Breitman and Leite.

XII. Progress of the Research

Currently, we are investigating the state of the art and designing a strategy for prediction of organizational changes. This solution aims to prepare the software for requirements changes related to the organizational changes once predicted.

Regarding references of accepted publications we have written, the preliminary aspects of this Doctoral Research were published in the following events:

- **Requirements Engineering at Brazil (ER@BR 2013):** An event co-located with the 21st IEEE International Requirements Engineering Conference (RE'13), it focused on the Brazilian Requirements Engineering Community. All submissions were peer-reviewed and accepted works were published in the CEUR Workshop Proceedings Series. This Doctoral Research was selected as a full paper to be presented in the event. The work was "Requirements Engineering with a Perspective of Software Evolution - Anticipating requirements based on organizational change" [30].

- **First Latin-American School on Software Engineering: Basics and State-of-the-Art (ELA-ES):** Also co-located with the Latin-American Colloquium on Model-Driven Software Engineering (ESMod), this event happened one week before RE'13, at the same local PUC-Rio. It was four-days of lectures on both basic and state-of-the-art themes of software engineering. The accepted submissions were face-to-face presented to trendsetters in the area and to invited lecturers. This Doctoral Research received insightful feedbacks from senior researchers of Software Engineering Community. The work was "Predicting Requirements Based on Organizational Changes" [31].

ACKNOWLEDGMENT

We would like to thank CAPES for their financial support.

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