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Person responsible for CD-ROM Proceedings:
Łukasz Piątek
(+48 17) 866 1105
E-mail: *LPiatek@wsiz.rzeszow.pl*

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Dear Conference Participants,

This compact disk contains the papers selected for presentation at the International Conference on **Human System Interaction** (**HSI'2008**), held in Kraków, Poland, May 25-27, 2008. The conference was organized by the **U**niversity of **I**nformation **T**echnology and **M**anagement (**UITM**, located in Rzeszów, Poland). There were roughly 240 online submissions for HSI'2008, excluding for five keynote papers. Papers went through a rigorous review process: each paper was reviewed by at least three highly competent reviewers; only 200 papers have been accepted for presentation. Owing to the cooperation with the Industrial Electronics Society within IEEE, all papers contained on this CD will also be available in the **IEEE Xplore®** digital library.

The scientific scope of the conference is extremely broad, and covers (except for keynote lectures, not contained on the CD from reasons independent of us):

Special sessions, organized by the leading scientists and practitioners in the field, to stimulate a new wave of knowledge beyond the main stream of human system interaction, in:

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- *Data Mining and Modern Heuristics in Human Systems Interaction* (***S2***),
- *Cognitive Communication in Intelligent Space Environment* (***S3***),
- *Intelligent Techniques in Manufacturing* (***S4***),
- *Human System Interaction in Education* (***S5***),
- *Next Generation Computer Supported Collaborative Media Environments* (***S6***),
- *Electronic Systems Aiding the Blind in Independent Mobility and Navigation* (***S7***),
- *Stochastic Modeling and Control in Biology, Economy and Engineering* (***S8***), *and*

Regular sessions, contributing to the following problems:

- *Hardware/Software Co-Design* (***R1***),
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  E-mail: *JKolbusz@wsiz.rzeszow.pl*
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Towards the Definition of a Multi-Agent Simulation Environment for Education and Training in Global Requirements Elicitation

Miguel Romero†, Aurora Vizcaíno‡, and Mario Piattini‡, *Member, IEEE*
† University of Bío-Bío, Chile
mromero@pehuen.chillan.ubiobio.cl
‡University of Castilla-La Mancha, Ciudad Real, Spain
{aurora.vizcaino, mario.piattini}@uclm.es

***Abstract* — Challenges resulting from global software development are moving both industry and universities to find new strategies through which to teach and train software engineers. One of the principal challenges is that of communication which is impeded both by the geographical distribution of the stakeholders and their cultural differences. In this work we propose a tool which, by means of the simulation of the requirements elicitation process, will support the education and training of said requirements elicitation.**

***Keywords* — Global Software Development, Elicitation Requirements, Teaching, Training.**

I. Introduction

In the Requirements engineering process, three principal processes take place: Elicitation, Modelling and Review. The purpose of the elicitation process is that of "extracting the domain knowledge from the experts, identifying features that are in scope and out of scope for the system, and documenting the features into a highly structured and logical model" [1] p. 27.

It is the most critical process in software development, because the final product quality depends on requirements quality [2]. In reference [3] it has been demonstrated that 85 % of the faults in software come from the requirements elicitation activities.

It is therefore fundamental to have professionals trained in this process, who are capable of accomplishing top-quality requirements elicitation.

Unfortunately, this objective is not achieved in universities, principally because the manner of teaching is centered on theory and the students rarely get involved in real projects [4]. In addition, the current trends of software development and their effect upon requirements elicitation are not generally considered.

Global Software Development (GSD) [5]–[7] is one of those trends. In GSD the stakeholders are distributed throughout several countries. The geographic and temporal distance between stakeholders increases the difficulty in developing the RE process [8]–[10]. Communication is particularly less effective because the different time zones complicate synchronous communication and distance makes face to face meetings difficult [8]. Other difficulties for communication are cultural differences [5], [11], and lack of awareness [8] which may cause misunderstandings. A complete list of critical factors is show in [12].

These difficulties make a review of the contents, techniques and tools used in the teaching of the requirements elicitation process necessary.

In this work we outline a simulation environment that permits the training of engineers in the Global requirements elicitation process to be supported. To do this we have carried out a bibliographical review which identifies the competencies, both generic and specific, that a global requirements engineer needs. From this list we have selected some of the competencies that must be promoted for GSD.

In the following section we shall briefly describe the current education proposal for GSD. In Section III the competencies that we have obtained from the bibliographical review are shown. In Section IV we describe the virtual environment that we propose, and both the generic and specific competencies that will be supported. Section V shows the technology for implementation, Section VI describes related works and in Section VII we present our conclusions.

II. GSD and its Education

Various strategies have been used to confront the challenge of teaching competencies necessary for GSD. The strategies found in the bibliography are the following: Curricular changes [4], [13]–[16], a stronger interaction between industry and the academic world [17], a project for software development between universities in different countries [18]–[19], and postgraduate specialization [20].

One of these proposals is found in [4], in which the authors propose the following changes through which to carry out courses which are more practical and are orientated towards GSD:

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- Change the traditional course into a lab in conjunction with local industry. The focus here must be to expose students to real software projects with real stakeholders.
- Bring in the global perspective via collaborative software engineering education involving multiple universities which are geographically dispersed across multiple time zones.
- incorporate the findings regarding globalization of software development into the theoretical aspects of process and product

However, there are certain problems in putting these strategies into practice, such as the difficulty in finding companies who are willing to invest time and resources in a joint education project with universities, or the lack of experience of students which may be a very high risk factor for real projects.

This is one of the motivations for our work, since a simulator for the training of engineers may be an initial step in the implementation of combined projects with industry and universities as the experience acquired in the simulator would diminish the risk of using personnel who are not qualified in real projects.

III. Competencies for the Requirements Elicitation Process in GSD.

In order to develop a tool that supports education in requirements elicitation in GSD we have carried out a bibliographical review in search of the generic and specific competencies that a professional must have if s/he is to work in requirements elicitation.

To obtain the list of competencies we have defined two criteria of inclusion:

1. Competency is related to certain requirements elicitation activities
2. Competency is influenced by certain critical or success factors for GSD.

A. Generic competencies

The list of generic competencies selected from literature is shown below, using the same classification as in [21]:

1) Instrumental Competencies

1. Capacity for analysis and synthesis [21].
2. Knowledge of a second language [21].
3. English Language skills [10].
4. Information management skills (ability to retrieve and analyze information from different sources) [21].
5. Oral and written communication in subject's native language [21].
6. Elementary computing skills [21].
7. Computer mediated communication [10], [22].
8. Communication protocols [10], [23].
9. Individual accountability [19].

2) Interpersonal Competencies

1. Critical and self-critical abilities [21].
2. Teamwork ability [19].
3. Interpersonal skills [21].
4. Virtual team skills [15], [22].
5. Ability to work in an interdisciplinary team [15].
6. Ability to communicate with experts in other fields [21].
7. Appreciation of diversity and multiculturality [21].
8. Ability to work in an international context [21].
9. Communication skills (timely responses, speed) [24], [19], [10].
10. Knowledge of culture [10].
11. Swift reaction to project changes [18].
12. Living with ambiguity/uncertainty in Remote Teams [22].
13. Ability to maintain global awareness [24].

3) Systemic Competencies

1. Research Skills [21].
2. Capacity to learn [21].
3. Ability to learn quickly about a domain or technology in order to begin project planning [18].
4. Capacity to adapt to new situations [21].
5. Understanding of cultures and customs of other countries [10].
6. Concern for quality [21].
7. Will to succeed [21].
8. Swift reaction to project changes [18].

B. Specific Competencies

A complete list of the specific competencies for software engineers can be found in [25]. The following is an extract of the specific competencies for the requirements elicitation process:

1. Comprehension of the definition of requirements (e.g. product, project, constraints, system boundary, external, internal, etc.).
2. Comprehension of the layers/levels of requirements (e.g. needs, goals, user requirements, system requirements, software requirements, etc.).
3. Comprehension of requirements characteristics (e.g. testable, non-ambiguous, consistent, correct, traceable, priority, etc.).
4. Knowledge of Requirements management (e.g. consistency management, release planning, reuse, etc.).Knowledge of Interaction between requirements and architecture.
5. Comprehension of Elicitation Sources (e.g. stakeholders, domain experts, operational and organization environments, etc.).
6. Application of Elicitation Techniques (e.g. interviews, questionnaires/surveys, prototypes, use cases, observation, participatory techniques, etc.).
7. Knowledge of Requirements documentation basics (e.g. types, audience, structure, quality, attributes, standards, etc.).
8. Comprehension of Software requirements specification.
9. Knowledge of analyzing quality (non-functional) requirements (e.g. safety, security, usability, performance, root cause analysis, etc.).
10. Knowledge of managing changing requirements.
11. Comprehension of requirements process.
12. Comprehension of reviews and inspection of

requirements.

13. Knowledge of prototyping to validate requirements (Summative prototyping).
14. Comprehension of acceptance test design.
15. Comprehension of validating product quality attributes.

To support the teaching of requirements elicitation in GSD, in the following section we propose a virtual environment which will allow students to develop some of the competencies mentioned in this section. The competencies that it will be possible to develop with the tool also are described.

IV. The Virtual Environment Proposed

Simulation is a technique which has been used in teaching for many years. It is successfully used, for example, in medicine [26] and aviation. The main advantage is that it allows students to train themselves without the risk of a real environment and at a lower cost.

We propose a simulator of the requirements elicitation process in the global context in which the student (taking on the role of a requirements engineer) interacts with various stakeholders which will be virtual humans and/or real humans. The simulator will allow the professor to create new modules, indicating the description of the scene, the virtual agents to be used, personality and culture.

The interaction will be natural through the main tools of electronic communication used for requirements elicitation: instant messaging and Chat, E-Mail, Telephone and Video Conferencing (simulated in the case of virtual humans).

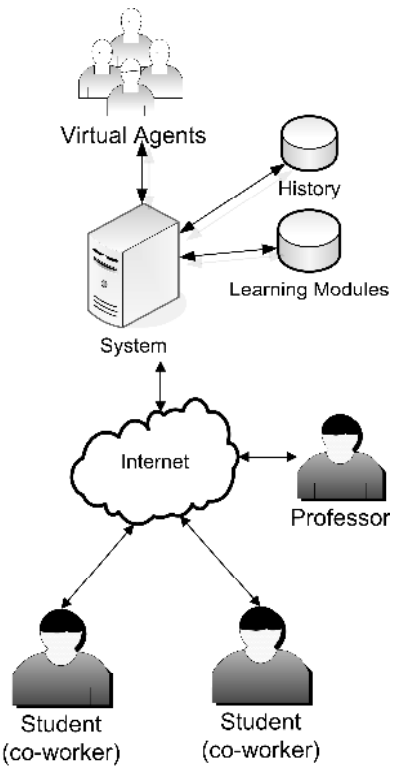

Fig 1. Abstract Model of a simulation environment.

Fig. 1 shows a diagram of the elements which are a part of the system and the actors that interact with it.

Initially, the students must enter their data with the aim of tracking the learning process. Then the system must present the different lessons or units that it has developed, showing the students' results. In addition, the system must permit a review of the history of talks with each of the stakeholders. Another capability of the system will be to show the lessons that it has not developed, allowing the student to select any of them. When students perform a lesson selection, the system must submit the context of the problem in which the elicitation is developed and show the participating stakeholders and their roles.

Through interviews with the various stakeholders (who will be of different nationalities) the students should prepare a list of requirements, both functional and non-functional, which should be sent to the system for its validation at the end of the simulation with the purpose of measuring the quality of the work done by the student. The system should provide an interface in which to keep a list of the student's requirements.

The students may carry out the requirements elicitation either individually or as members of a requirements elicitation team. This team may be composed either of virtual agents or of humans.

The simulator will validate the student's work by means of a questionnaire in which it will present various requirements (both functional and not functional) and the student must indicate whether or not these correspond with what the users need. The requirements document will be checked to detect faults such as: ambiguous requirements, non-existent requirements, unspecified requirements, etc. Besides this evaluation, the system will also record the questions that the student has formulated in an inadequate way in consideration of the cultural differences and protocol of communication (manner of greeting and taking one's leave, degree of formality informality, etc.).

In short, the simulator will teach competencies by means of the following characteristics:

1. Interaction with agents of different nationalities.
2. Interviews with the stakeholders.
3. Diverse scenarios.
4. The elaboration of the requirements document.
5. The validation of the requirements document.

A. Generic competencies that the tool will attempt to develop

The following list comprises the generic competencies that the simulator will develop. The characteristics of the simulator which foments competency are in brackets:

1) Instrumental Competencies

- Computer mediated communication. (1, 2)
- Communication protocols (1, 2)

2) Interpersonal Competencies

- Virtual team skills. (1, 4)
- Ability to work in an international context (1, 2, 3).
- Appreciation of diversity and multiculturality (1, 2, 3).

- Knowledge of culture (3, 5).
- Living with ambiguity/uncertainty in Remote Teams.(1, 2, 3)

3) Systemic Competencies

- Ability to learn quickly about a domain or technology in order to begin project planning (2, 4).
- Capacity to adapt to new situations (3).
- Understanding of cultures and customs of other countries (1, 2, 3, 4).

We have chosen this list of competencies.because they are not generally considered in the training of engineers in universities or are taught poorly with little or no practical exercises.

B. *Specific Competencies that the tool will attempt to develop*

The following list comprises the specific competencies that will be supported by the tool:

- Comprehension of GSD Critical Factors (1, 2, 4)
- Comprehension of Elicitation Sources (e.g. stakeholders, domain experts, operational and organization environments, etc.). (2, 3)
- Comprehension of Software requirements specification (4, 5).
- Knowledge of analyzing quality (non-functional) requirements (e.g. safety, security, usability, performance, root cause analysis, etc.) (4, 5).
- Knowledge of managing changing requirements (4, 5).
- Elicitation of real requirements based on stakeholders' needs using an Interview Technique and computer mediated communications (2, 3, 4, and 5).
- Representation of functional and non-functional requirements for different types of systems (3, 4, 5).
- Comprehension of reviews and inspection of requirements (5).

V. TECHNOLOGY FOR IMPLEMENTATION

In this section we shall describe the principal technologies that will support the implementation of the virtual environment.

A. *Educational Virtual Environments*

Educational Virtual Environments (EVEs) are frequently used for simulation. These environments use Virtual Reality (VR) to create virtual worlds. In EVEs it is possible to [27]:

- Provide a low-cost alternative to creating full-scale physical training scenarios.
- Offer the opportunity of creating a wide variety of scenarios including those rarely (or never previously) encountered in the real world.
- Simulate training scenarios that can be run repeatedly.
- Include a monitoring of progress during training sessions to evaluate learners' skills.

Although we do not propose a virtual reality system, our proposal attempts to take advantage of the possibilities that we have mentioned for these environments.

B. *Virtual Agents*

The Artificial agents paradigm constitutes a natural metaphor for systems with purposeful interacting agents, and this abstraction is close to the human way of thinking about his/her own activities [28]. This foundation has led to an increasing interest in social aspects such as motivation, leadership, culture or trust [29]. We propose the use of artificial agents to model the EVE because:

- Agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal states (Autonomy).
- Agents interact with other agents (and possibly humans) via some kind of agent communication language. This feature will be highly important in the simulation of human interactions in distributed teams (Social Ability).
- Agents perceive their environment and respond in a timely fashion (reactivity).
- Agents can take the initiative and achieve their own goals (Pro-activeness).

It is therefore possible to implement an EVE with different agents which have different types of behaviour and simulate people of different cultures, characters or language, thus assisting software engineers and students to develop the desirable skills work in elicitation groups in GSD.

C. *Virtual Human*

The virtual human is used in the EVEs to give a greater realism to the virtual world. These virtual humans are virtual agents who possess a graphical representation which simulates a person capable of interacting with human beings in a natural way.

Reference [30] shows three primary roles that the virtual Human can assume in a simulation with educational ends. These roles are:

1. *As a mentor*. Which provides knowledge or answers the students' questions in order to guide the process of knowledge discovery and construction [30]. In our case this may represent a senior engineer who accompanies a raw engineer (student) and advises him/her as s/he carries out the requirements elicitation during the first exercises in, for example, dealing with a stakeholder's cultural difference.
2. *As a member of a team*. In contexts in which it is necessary for two or more individuals to work together in the execution of a task, one or more virtual humans can form a team with one or more students for the execution of the assigned task [30]. In our case a virtual agent forms a part of the requirements engineering team.
3. *An actor who characterizes a role.* A virtual human plays a role in an interactive story which teaches the student certain aspects of human communication or

of interaction [30]. In our case the roles that will serve as the different stakeholders will be interviewed by the team of requirements engineers.

In each of these roles, the virtual human carries out the function of substitute since it is not always possible to use real instructors or fellow-scholars, with the necessary skills, or due to the high price of registering, editing, or delivering a live action video [30].

D. Simulation Processes

Simulation processes are used for different purposes. For example, they are used to support a decision-making process in which the simulator allows the analyst to visualize the consequences of a decision that might be made. They can also be used as a platform through which to combine and synthesize theories and models that have previously been developed, and to incorporate a wide variety of relevant factors. Thus, simulation models can be used to support authentic experiments and to enrich empirical studies, which will allow the evaluation of new theories and methods [12].

VI. Related Works

Reference [30] shows an EVE which uses a Virtual Human with the goal of training students in the Arabic language and in Arabic cultural familiarization. Some of the cultural aspects that are discussed in this EVE are:

- Appropriate and inappropriate use of honorific and family names.
- Colloquial terms for policemen, soldiers and strangers.
- Iraqi gestures that may be misinterpreted by Americans, and American gestures that may be misinterpreted by Iraqis.
- Methods to calm tense situations.
- Proper and improper ways in which to interact with Iraqi women.
- Showing respect for family relationships.

As in this environment, our proposal aims to teach these cultural differences with regard to the major cultures involved in the GSD (the West, India, China).

Another EVE appears in [26] in which the virtual Human is used to simulate the patients who are interviewed by medical students. The interaction between the virtual patient and the students is that of talking in a natural manner.

Within the scope of education in software engineering, reference [31] presents a simulator which allows students to assume the role of a software project manager. In this simulator, the student uses a textual user interface to hire or lay off employees, and s/he may be asked to perform any tasks that are useful in software development such as preparing requirements specification, reviewing the design document, or testing the code [31]. Most of the messages obtained are statements from his/her 'employees', such as "I have completed the specification", or "During the tests I found x errors" [31]. The student must carefully review such statements and react in an appropriate manner, because this is all the information that the simulator has delivered. When the game has finished, the player receives his score and internal variables can be analyzed to evaluate his/her performance [31]. This work is similar to that which we propose but in a different context, which changes the objectives of the learning: we focus upon education in the requirements elicitation process and not upon the software project administration process.

VII. Conclusion

GSD is a current trend, which greatly influences the way in which software is developed. This requires universities and the software industry to rethink the way in which software engineers are taught and trained.

In this paper we present the generic and specific competencies derived from our review of literature that a software engineer must have if s/he is to carry out requirements elicitation. From these skills we have outlined a tool to support the teaching of requirements elicitation in GSD. This tool is a simulator which, by using virtual agents, will enable students and professionals to acquire a subset of the skills necessary for requirements elicitation in GSD. These skills will be obtained after interaction with virtual agents through the communication tools most frequently used in this context: instant messaging, chat, email, and telephone video-conference.

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