Towards an Ontology of Requirements for Pervasive Games Based Learning Systems: A Requirements Engineering Perspective

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Abstract. The ludic, the pervasive and the educational aspects of pervasive games based learning systems (PGBLSs) have huge impact on understanding, developing, validating, reasoning and managing requirements. We propose in this paper a computation independent model (CIM) driven requirements engineering process in order to improve the development of PGBLSs. This model is based on an ontology of requirements (RO). RO addresses the development of an ontology of requirements (RO) as a powerful formalism to assist requirements' analysts in order to fulfill changing requirements in the PGBLSs dynamic context.

Keywords: Pervasive games · Learning systems · Ontology · Requirements engineering

1 Introduction

The integration of ubiquitous computing in game industry, the intersection of urban phenomena such as mobile technology, fiction, reality and taking into account the context allows producing the pervasive games. These offer a game experience combining real and virtual worlds. According to Markus Montola [1], "Pervasive game is a game that has one or more salient features that expand the contractual magic circle of play socially, spatially or temporally". The spatial aspect means that the game can be played at different places and the location of the game can affect the game play. The temporal aspect means that the game can be played during the daily activities of the player. The social aspect means that the player may change his/her role in a flexible manner, because he/she switches from non-participant or a spectator to an active performer and vice versa. The spatial, temporal and social dimensions of pervasive games distinguished by Montola [2], are supposed to be built for fun and educational

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dimensions into an instrument promoting learning systems, hence the birth of pervasive games based learning systems (PGBLSs).

Due to the emergence of studies on technologies enhanced learning systems, the capacity to build pervasive games based learning systems that process dynamic context information and adapt the knowledge to meet the requirements of users, has attracted quite a bit of attention. A computation independent model (CIM) based on an ontology of requirements is considered necessary. As requirement engineering process consists on establishing the services that the user requires from a system and the constraints under which it operates and is developed. This paper intends to use the ontology of requirements within the requirements engineering process which is suitable for continually updating the user's changing requirements.

The rest of this paper is organized as follows: the Sect. 2 presents background and motivation. Section 3 presents the related works. Section 4 presents the proposed approach. Finally the Sect. 5 reports on the progress and the future works.

2 Background and Motivation

One of the challenges which encounter PGBLSs developers is requirements definition. This task, considered as essential step, treated at an advanced stage of the development process, completely changed status; it becomes a task to be considered throughout the development process of PGBLSs.

Requirements Engineering (RE) is the first fundamental step of any project of system development. According to GTIE (Working Group on Requirements Engineering) of the AFIS (French Association of Systems Engineering) [3], RE means all activities to discover, analyze, validate and evolving a set of requirements for a system. RE is essentially based on communication between different participants. The main objective is to enable a common understanding by the various project stakeholders, to design the system. In general, this understanding is represented in the form of written and graphical models, corresponding to the requirements specification.

Moreover, the PGBLSs requirements are requested by players. They want, for example and not for limitation, to play with real human beings in the same way that they would interact with them in the real world. Sometimes, the player needs to move in all location-based games like Can You See Me Now [4] and Uncle Roy All Around You [5]. Often, their needs change. QuaGauntlet [5] is a good example of a game in which the players need to change their postures to aim, fire, and activate their shields.

Since ontologies [6] allow formally presenting knowledge, describe the reasoning on that knowledge, sharing and reusing, we propose, in this research, using ontologies in the process of requirements engineering for PGBLS development. An ontology is an explicit specification of a conceptualization [7]. It can be used for both, to describe requirements specification documents [8, 9] and formally represent requirements knowledge [10, 11]. In contrast to traditional knowledge-based approaches, e.g. formal specification languages, ontologies seem to be well suited for an evolutionary approach to the specification of requirements and domain knowledge [11]. Moreover, ontologies can be used to support requirements management and traceability [8, 10]. Automated validation and consistency checking are considered as a potential benefit compared to

semi-formal or informal approaches providing no logical formalism or model theory. Finally, formal specification may be a prerequisite to realize model-driven approaches in the design and the implementation phase.

3 Related Works

Only little research concerning the modeling of PGBLSs requirements is found. Chen and Shih [12] proposed a prototype of a meta-model which puts together several partial perspectives of the Instructional Pervasive Games (IPG) and made a set of checklist as the reference for IPG developers. Context requirement, pedagogy requirement, and design requirement form the main body of the meta-model. With this mega model, a structured guideline for IPG designers can be drawn. The guideline consists of three sets of checklists: Context Requirement Checklist, Pedagogy Requirement Checklist, and Design Requirement Checklist. Tang [13] introduced a new game content model that can aid game designers document specification of game design. The content Model covers all the essential game design concepts for documenting serious game design in the role-playing and simulation genres initially (but this can be easily expanded upon to support other genres). The top level of the game content model consists of ten inter-related key concepts that best represent the rules, play and aesthetic information of a computer game. These are Game Structure, Game Presentation, Game Simulation, Game Rules, Game Scenario, Game Event, Game Objective, Game Object, Game Player and Game Theme. Laine, Sedano, Joy and Sutinen [14], illustrated a "technology integration model" for game-based pervasive learning systems, stated that an IPG needs to meet the following requirement: (1) Pedagogical requirements, (2) Game design requirements, and (3) Context requirements.

Other approaches exist in the domain of RE, some of them are designed specifically for pervasive systems. Those approaches take into account the characteristics of ambient intelligence and ubiquitous computing as context awareness, personalization or dynamics, etc. Sitou and Spanfelner [15] presented a model based on requirements engineering to analyze and specify the basic behavior of the system and the adaptive behavior based on the needs of the customers. The approach is based on the elicitation, analysis and specification of different parts of the context adaptive systems. The model enriches the context with aspects of participants, activities, changing behavior change, etc. This model consists of a user model, a task model, a domain model, a platform model, a model of dialogue and a presentation template.

Most of the works described previously don't exploit ontologies like the work of Chen. Tang used the ontologies but he doesn't take into account the key role of ontologies for the definition, the specification and the requirements management. Although ontologies have attracted much attention recently [13–15], the various existing approaches, using ontologies, are characterized by specificity and limits of developed ontologies. Generally, developers define domain ontologies which vary in their degree of generality (business level) and in their degree of specificity (technical level). They also vary in their coverage of aspects of the modeled systems. As we know, none of those approaches has considered the use of requirements ontologies in the PGBLSs development process which causes a generic and an incomplete definition

of requirements and requires the participation of actors with different skills (Analysts, Architects, etc.). Stakeholders in the PGBLSs development process don't provide a detailed and directional semantic model that explains the system, or how changing context affect users' requirements. A changing context essentially means that developers can't rely on reassuring assumptions by analyzing the requirements. That is why we also proposed a semantic formalism to represent, define, specify and adapt to PGBLSs requirements.

4 Proposed Approach

We aim to take advantage of ontologies and propose mechanisms and techniques to use them in a guiding approach in order to define and analyze PGBLSs requirements. Our ontology of requirements intended to reduce the ambiguity of needs and avoid incomplete requirements definition. In this context, Castaneda et al. [16] describes the benefits and challenges of using ontologies in the process of requirements engineering (RE). This is exactly the basis of our approach. Indeed, RE imposes a systematic series of activities to be conducted on the requirements. It contains the activities of elucidation, analysis, specification, validation and management [17]. Our approach takes those activities [18] but adapts them for the definition of PGBLSs requirements.

4.1 The Requirements Elicitation

The elicitation of the requirements consists on the collection, the capture, the discovery and the development of requirements from a variety of resources including human stakeholders. To do this, we suggest reviewing the literature to study the areas of learning systems and pervasive games. The result of this step consists of a first set of textual PGBSLSs requirements. Since the PGBLSs is characterized by the overlapping of two areas: Pervasive games and learning, we have broken the requirements into two categories of requirements which are pervasive games requirements and learning requirements. Literature review was conducted to get requirements for the development of PGBLSs. Unfortunately, no publications dealing with requirements for PGBLSs could be found in scientific literature. Instead, a list of PGBLSs influencing factors could be identified, which have an effect on the learning success and motivation of players like the works of [19–22]. In another hand, understanding of "learning" is the first step towards defining requirements of learning. Indeed, Learning is the activity or process of gaining knowledge or skills by studying, practicing, being taught, or experiencing something. In this context, Quintin et al. [23] defined a learning scenario as the scenario whose role is to describe the learning activities, their articulation in the training sequence and the productions which are expected. Paquette [24] defined the scenario as linking the activities of learners with the resources used and produced.

4.2 The Requirements Analysis

The analysis focuses on reviewing, understanding of elicited requirements and their verification for the quality in terms of accuracy, completeness, clarity and consistency in order to remove inconsistencies and to ensure completeness and non redundancy. The result of this step is a set of identified requirements but they aren't formalized. So, these factors have been analyzed and at the current stage of our research we have deducted twenty requirements for the development of PGBLSs. Table 1 shows an extract of the requirements list.

Table 1. Requirements list for the development of PGBLSs

Requirements of pervasive games
A PGBLS must pervades the real world in an undefined manner, and thus blends with it,
A PGBLS must be with a persistent presence in the real world, and thus available to the players at all times,
A PGBLS should make a specific setting of the game world within the real world,
A PGBLS should allow the gameplay to interact with elements of the real world, thus challenging standard gameplay conventions,
A PGBLS must make a mutual interaction among players and elements in the real world;
A PGBLS should blend with everyday experiences.
A PGBLS must allow movement,
A PGBLS allow the players to act,
A PGBLS allow the players to play in fixed time and fixed round or open ended time or open ended round,
A PGBLS allow the player to focuses on a clear goal,
A PGBLS can be played fixed in one place as most traditional computer games are,
A PGBLS can be played in large-scale outdoor places anywhere (often also played in everyday life),
A PGBLS can be played where the player must move in one place and physical actions are needed to change gesture, posture, etc. due to the requirements of gameplay,
A PGBLS should precise players relationships which can be Individually, A Simple Collaborative/Competitive/Opposed relationship, The Combined option, The Community, free relationship.
Requirements of learning
A PGBLS should allow the participation of learners,
A PGBLS must allow interaction,
A PGBLS should allow perception,
A PGBLS must offer a content to learn,
A PGBLS must offer a structured content,
A PGBLS should dispose players with resources,
A PGBLS can allow repeated activity,
A PGBLS should allow a feedback,
A PGBLS should define prerequisites,
A PGBLS should precise an objectives for learning,
A PGBLS should let formative and normative evaluation.

4.3 The Requirements Specification

The specification is the registration and the documentation of requirements so that they are usable by stakeholders, in particular, for developers who need to design and build the system. It is to establish the final list of requirements by organizing them according to categories. Here we suggest an ontology of requirements that represents the requirements and the relations between them and the relationships with the system.

There are a number of methods and methodologies one can employ to develop their own ontology in a domain. Among those methods [25] we find CyKB, Uschold and King's method, Grüninger and Fox's method, etc. For starting point, Noy & McGuinness's presented a guide to create ontologies. In this paper, we have adopted Noy & McGuinness's method to build our ontology of requirements due to the simplicity of the method. Noy & McGuinness's seven steps method requires one to [26]: 1. Determine the domain, scope and purpose of the ontology; 2. Consider reusing existing ontologies; 3. Enumerate important terms in the ontology; 4. Define the classes and the class hierarchy; 5. Define the properties of the classes – slots; 6. Define the facets of the slots; and finally 7. Create the instances. The next figure illustrates an extract of the requirements classifications (Fig. 1).

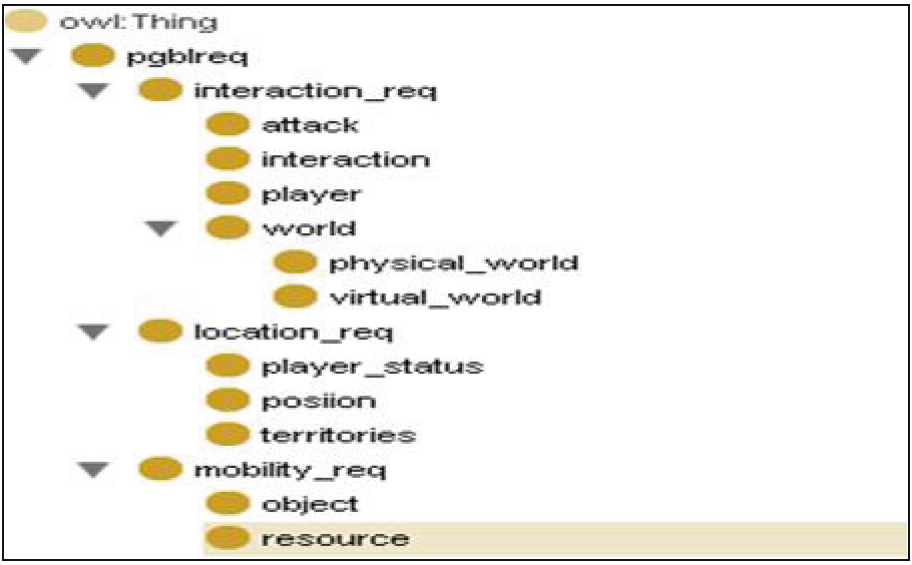

Fig. 1. An extract from the PGBLSs requirements ontology

4.4 The Requirements Validation

The validation is the confirmation of the quality of requirements and their compliance with the needs and desires of stakeholders. The requirements are tested using a prototype. Indeed, a validation of the quality attributes of those requirements (consistency, accuracy, completeness, wholeness) must be conducted.

We have modeled until now the ontology via protégé 4.3. Currently, we are inferring the requirements from a domain ontology in order to validate our computation independent ontology. We aim to test the incorporation of ontologies in the process of defining PGBLSs requirements. We focus on a case study in order to validate the feasibility of our proposed approach.

5 Conclusion

We presented in this paper our vision regarding an explicit classification of PGBLSs requirements following the two dimensions which are pervasive games and learning systems. The main idea of our approach is an ontology of requirements following the requirements engineering process. The guidelines of the ontology of requirements help developers to capture user requirements, to facilitate the updating of dynamic requirements due changing context and allow reuse of the ontology when the learning environment varies.

In future works, we plan to provide a formalized version of the current work with detailed axioms. Following that, an ontology of requirements is developed, focusing on different kinds of context changes. We hope that our work could be used as a foundation for the relating domains.

References

1. Montola, M.: Exploring the Edge of the Magic Circle: Defining Pervasive Games. University of Tampere - Game Research Lab (2005)
2. Montola, M., Stenros, J., Waern, A.: Pervasive Games: Theory and Design (2009)
3. AFIS, Modèle de données AFIS, version 2.0, groupe de travail Méthodes et Outils (2005)
4. Benford, S., Crabtree, A., Flintham, M., Drozd, A., Anastasi, R., Paxton, M., et al.: Can you see me now? ACM Trans. Comput. Hum. Interact. **13**, 100–133 (2006)
5. Magerkurth, C., Cheok, A., Mandryk, R., Nilsen, T.: Pervasive games: bringing computer entertainment back to the real world. Comput. Entertainment (CIE) **3**, 4 (2005)
6. Guarino, N., Carrara, M., Giaretta, P.: An ontology of meta-level categories. In: Doyle, J., Sandewall, E., Torasso, P. (eds.) Principles of Knowledge Representation and Reasoning: Proceedings of the Fourth International Conference (KR 1994), pp. 270–280. Morgan Kaufmann, San Mateo (1994)
7. Gruber, T.R.: A translation approach to portable ontologies. Knowl. Acquisition **5**(2), 199–220 (1993)
8. Mayank, V., Kositsyna, N., Austin, M.: Requirements engineering and the semantic web, Part II. Representation, Management, and Validation of Requirements and System-Level Architectures. Technical report. TR 2004-14, University of Maryland (2004)
9. Decker, B., Rech, J., Ras, E., Klein, B., Hoecht, C.: Selforganized reuse of software engineering knowledge supported by semantic wikis. In: Proceedings of Workshop on Semantic Web Enabled Software Engineering (SWESE), November 2005
10. Lin, J., Fox, M.S., Bilgic, T.: A Requirement Ontology for Engineering Design. Enterprise Integration Laboratory, University of Toronto, Manuscript, September 1996

11. Wouters, B., Deridder, D., Van Paesschen, E.: The use of ontologies as a backbone for use case management. In: European Conference on Object-Oriented Programming (ECOOP 2000), Workshop: Objects and Classifications, a Natural Convergence (2000)
12. Chen, C., Shih, J.: A prototype on a Meta-model for designing instructional pervasive games. In: Fourth IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning (2012)
13. Tang, S., Hanneghan, M.: A model Driven Serious Games Development, School of Computing and Mathematical Sciences, Liverpool John Moores University Byrom Street, United Kingdom (2013)
14. Laine, T.H., Islas Sedano, C., Joy, M., Sutinen, E.: Critical factors for technology integration in game-based pervasive learning spaces. IEEE Trans. Learn. Technol. **3**(4), 294–306 (2010)
15. Sitou, W., Spanfelner, B.: Towards Requirements Engineering for Context Adaptive Systems, Technische Universitat Munchen, Department of Informatics, Boltzmannstr.3, 85748 Garching/Munich, Germany (2007)
16. Castañeda, V., Ballejos, L.C., Laura Caliusco, M.: Improving the quality of software requirements specifications with semantic web technologies (2012)
17. Kotonya, G., Sommerville, I.: Requirements Engineering – Processes and Techniques. John Wiley & Sons, UK (1998)
18. Wiegers, K.: Software Requirements. Microsoft Press (2003)
19. Hong, G., Trætteberg, H., Wang, A.I., Zhu, M.: TeMPS: a conceptual framework for pervasive and social games. In: Third IEEE Information Conference on Digital Game and Intelligent Toy Enhanced Learning Kaohsiung, Taiwan (2010)
20. Jegers, K.: Pervasive game flow: understanding player enjoyment in pervasive gaming. ACM Comput. Entertainment **5** (2007)
21. Gentes, A., Guyot-Mbodji, A., Demeure, I.: Gaming on the move: Urban experience as a new paradigm for mobile pervasive game design. Multimedia Syst. **16**, 43–55 (2010). doi:10.1007/s00530-009-0172-2
22. Walther, B.K.: Notes on the methodology of pervasive gaming. In: Kishino, F., Kitamura, Y., Kato, H., Nagata, N. (eds.) ICEC 2005. LNCS, vol. 3711, pp. 488–495. Springer, Heidelberg (2005). doi:10.1007/11558651_47
23. Quintin, J.-J., Depover, C., Degache, C.: Le rôle du scénario pédagogique dans l'analyse d'une formation à distance. Paper presented at the Actes de la conférence EIAH, Paris, INRP, pp. 335–340 (2005)
24. Paquette, G.: Ingénierie Pédagogique. Presses de l'Univesité du Québec, Québec (2002)
25. Corcho, O., Fernandez-Lopez, M., Gomez-Perez, A.: Methodologies, tools and languages for building ontologies. Where is their meeting point? Data Knowl. Eng. **46**(1), 41–64 (2003)
26. Noy, N.F., McGuinness, D.L.: Ontology development 101: a guide to creating your first ontology, Stanford Medical Informatics (2001)