REQUIREMENT ANALYSIS OF AGILE INFORMATION SYSTEMS AND BUSINESS PROCESSES: AN AGRICULTURAL CASE STUDY

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Abstract: *The development of modern information systems is demanding and characterized by agility. Consequently, the extensive requirement analysis of these systems and the supported business processes has become vital for analysts, developers and the participating stakeholders. Use Cases are tested tools for analyzing the requirements of information systems. However, the difficulty in capturing use cases has triggered the proposal of methodologies which can derive use cases from business models. Nevertheless, modern agile information system development demands the reverse transformation as well. The current paper proposes the latter transition for analyzing business process requirements and describes it via a computer based pest scouting business process case study. The target business model for depicting business process representation workflows is the Business Object Relation Modeling method. The agricultural case study was selected because both the Business Object Relation Modeling method and the Use Case method have been already proposed for agricultural, food supply and environmental business process representation, and they are both easily comprehensible by all the involved stakeholders including farmers, growers and agronomists.*

Keywords: *Use Cases, Business Object Relation Modeling (BORM), Use Case To BORM Transformation Algorithm (UCBTA), Pest Scouting, Business Process Models.*

JEL Classification: *M15, Q16.*

Introduction

Modern information and communication technologies, hereinafter ICT, are applied to the majority of scientific domains. Agriculture, and especially the pest management domain, is one of the fields where the adoption of ICT tools is a necessity. When information systems are developed in order to be utilized in executing agricultural processes, a commonly understandable methodology between IT experts and agricultural practitioners is highly demanded during the requirement analysis phase of the developed systems. An ideal way for information sharing between IT specialists and domain experts is via conceptual models. According to Cakula et al (2015) conceptual schemes consist of data structures, which depict classes of objects, their relations, restrictions and characteristics.

Another way to merge ICT concepts to the execution of agricultural processes is the depiction of the latter through easily comprehensible business process models. Thus, an ideal approach to implement domain knowledge sharing is the incorporation of business process models which have also recommended as ontological tools to analyze ICT based business processes. The Business Object Relation Modeling (BORM) approach is one of these proposed theories. Pergl (2011) analyzes BORM from an ontological point of view. However, even if the BORM business process modeling solution has already been applied in agricultural and environmental sciences, a strong requirement documentation method, such as the Use Case approach, is a prerequisite before depicting the relative workflows.

The main goal of the current work is the depiction of a modern approach to analyzing requirements of ICT based processes by transforming Use Cases into BORM through a case study from agriculture and a software application developed by the author for this purpose. The transformation is achieved through an algorithmic procedure which has its roots in the finite automaton theory (Cooper, 2004).

An explanatory case study from Integrated Pest Management, namely pest monitoring, is used to demonstrate the functionality of the approach. The specific domain was selected since the agricultural, food and environmental business systems are specially such cases, when we need 'smart' modelling tools, because processes and data are instantly changing and modifying through the whole life cycle of such systems (Molhanec et al, 2011).

First partial goal of the paper is related to the promotion of the agile software development techniques for such scientific domains as the agriculture. The more active is the end users' participation during the whole software development process the more efficient the final software solution will be. Second partial goal is to enhance the software engineering skills of the end users and contribute to the amelioration of their communication with IT developers and experts. Final partial goal of the current work is the achievement of an in depth requirement analysis of software based pest management tasks even by domain users with limited computer skills.

1 State of art – Problem statement

Automation in agriculture and towards the protection of cultivations is a critical issue for today's global economy. Multiple experts have proposed modern software tools for protecting plants from pest infestations. In a recent study (Sharma et al, 2014) an ICT based management system for sustainable pulse production in India is delineated. The authors of the same study state that ICT based technologies are helpful in making quick decisions in order to apply appropriate plant protection measures as per level of pest infestation.

Moreover, multiple software requirement analysis methodologies have been proposed as assisting tools throughout the development life cycle of such applications. The BORM method has been proposed for the modeling of agricultural and environmental ICT based processes (Merunka, 2003, Nedvedova, 2015). Furthermore, the use case approach has also been applied to model agri-food supply networks (Lehmann et al, 2010). The specific approach is another widely accepted method towards the analysis of system requirements and is an important part of the Unified Modeling Language (UML).

Cruz et al (2014) state that a popular way to capture and describe those requirements is through the UML use case models. Thus, a possible combination of both the aforementioned methods, with Use Cases as a prerequisite, can lead us to an ideal and without gaps requirement analysis procedure. In the same study (Cruz et al, 2014) the authors underline that multiple experts have so far attempted to derive use cases from business process models. The main reason for attempting these transformations is the difficulty in successfully identifying use cases from scratch. These efforts, even though they follow the opposite direction from the approach used in the current paper, also reveal a possible gap in analyzing requirements using only use cases or business process models.

The currently proposed method enhances the BORM business model through standard use case requirements documentation and covers the missing workflow depiction in the use case model via BORM. Through the specific algorithm, which has never been proposed by any other expert so far, a business model is generated from use cases. This attempt is considered to be highly significant by the author since IT projects include several iterations which may force developers and analysts create business process models from use cases. Dietz (2003) underlines that the use cases' strong point is that once they are identified the development of the software application goes well.

Furthermore, the derivation of the business process model from the use case method is achieved through a specific software tool developed by the author. The tool is entitled UCBTA Projects and its delineation is beyond the scope of the present paper. The incorporation of a user friendly software application that can efficiently infer a business process model from use cases can prove to be time – saving, effective and more suitable for non-experts and end-users.

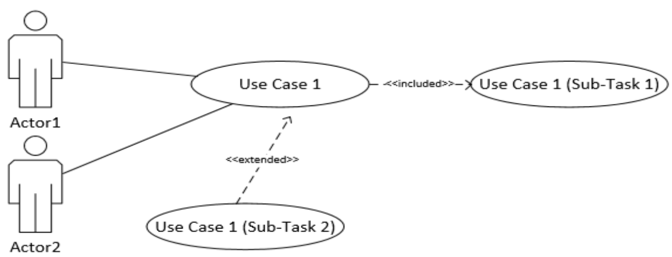
2 Methods

2.1 The UML Use Case Model

Use Cases have gained widespread acceptance as a means to describe interactions between a system and its environment (Neill, 2003) .The concept of Use Cases was first introduced by Ivar Jacobson in 1987 as a tool for modelling functional requirements (Jacobson, 2003). Hoffmann et al (2009) mention that the so-called use case model is actually a composite model consisting of two parts. One part is a UML model, capturing the use cases and their relationships, the other part is a set of textual descriptions of the behaviour represented by these use cases (Hoffmann et al, 2009).

On the one hand, the UML model is defined by the Use Case diagram (Figure 1). The Use Case diagram is a graphical representation of a process and completes its textual delineation. The diagram clearly depicts the actors, associations, the use cases and the possible extensions of each use case. On the other hand, the textual description of the model is typically illustrated via the template which has been proposed by Cockburn (2003).

Fig.1 A simple Use Case Diagram



Source: (Authors)

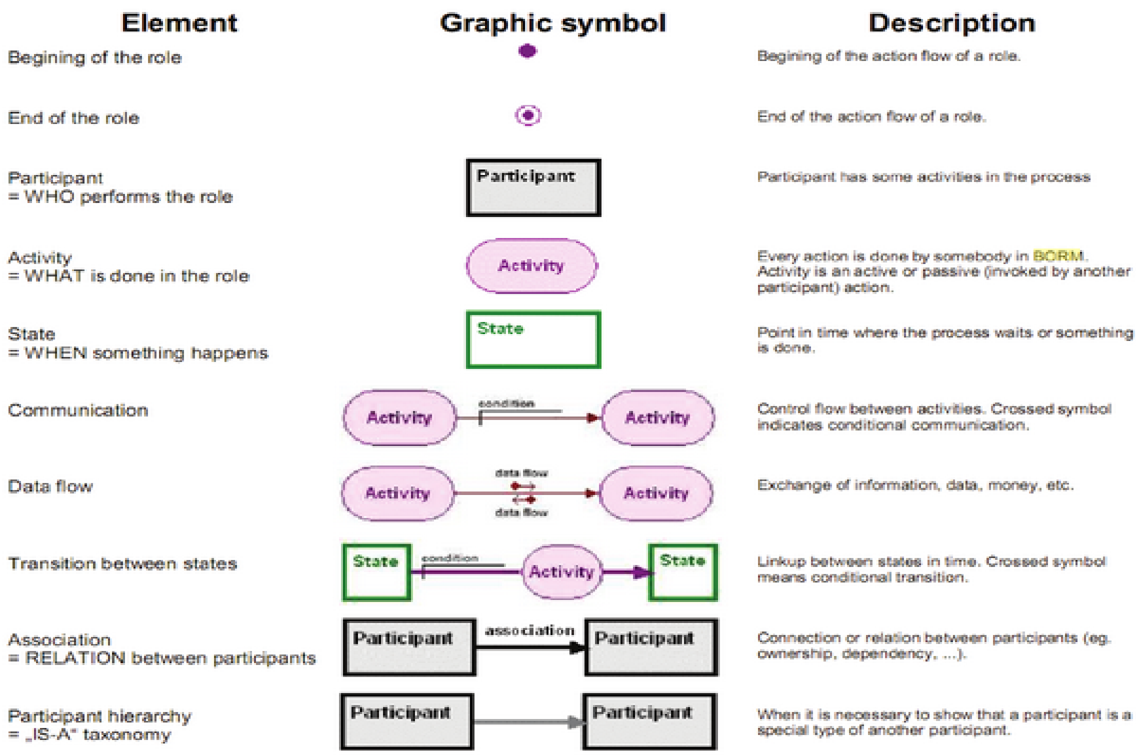
2.2 The BORM Model

As already stated, despite its analytical business process definition, workflow absence is the main disadvantage of the use case method. As a consequence, the use case method must be followed by another business model which includes the representation of the business process workflow. The BORM (Business Object Relationship Modelling) approach is considered ideal for representing the process workflow.

The method has been in development since 1993 and has been a considerably effective and popular tool for both users and analysts. Moreover, BORM has been applied to various agricultural and environmental case studies due to its advantage to involve only small number of concepts required combined with a considerable expressiveness (Merunka, 2003). This makes it easy to understand even for the first-time users with almost no knowledge of business analysis (Picka et al, 2011).

The BORM method uses for visual presentation of the information a simple BORM diagram (Fig. 2) that contains the following concepts (Polák et al, 2003):

Fig.2 The BORM business diagram elements and symbols



Source: (Molhanec and Merunka, 2012)

Participant: an object representing the stakeholder involved in one of the modelled processes, which is recognized during the analysis.

State: sequential changes of the participants in time are described by these states.

Association: data-orientated relation between the participants.

Activity: represents an atomic step of the behaviour of the object recognized during the analysis.

Communication: represents the data flow and dependencies of activities. Data may flow bidirectionally during the communication.

Transition: connects state-activity-state and represents changes of the states through activities.

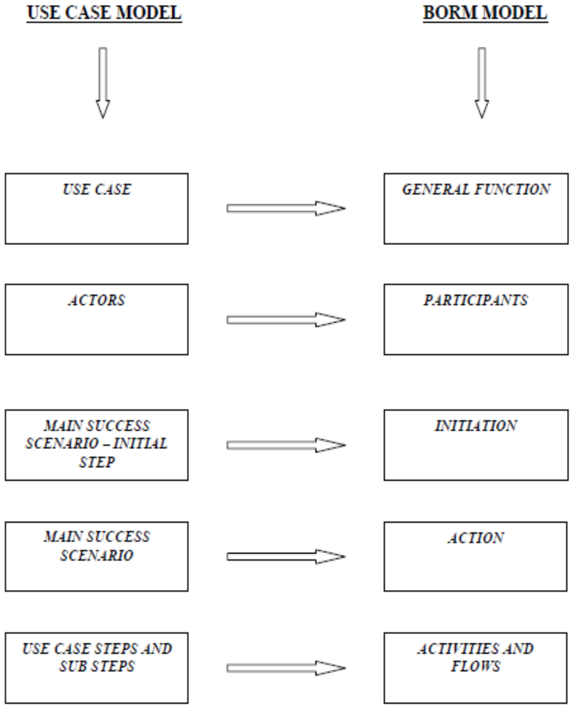
Condition: expresses constraint that holds for the communication or activity.

2.3 The Use Case to BORM Transition Algorithm (UCBTA)

The approach has been developed and described by the author (Podaras et al, 2012) as a simple and efficient algorithmic method for analyzing both software and business process requirements. The main advantage of the contribution is the utilization of two tested methods, such as Use Cases and BORM, and the mapping of their elements. The mapping is performed in order to fill the gaps in both methods. Even though the UML Use Case approach is a globally accepted tool for the standard definition of business process steps, it lacks a process workflow representation. Moreover, the BORM method has an excellent workflow representation, but lacks a formal definition of the steps of the delineated business process.

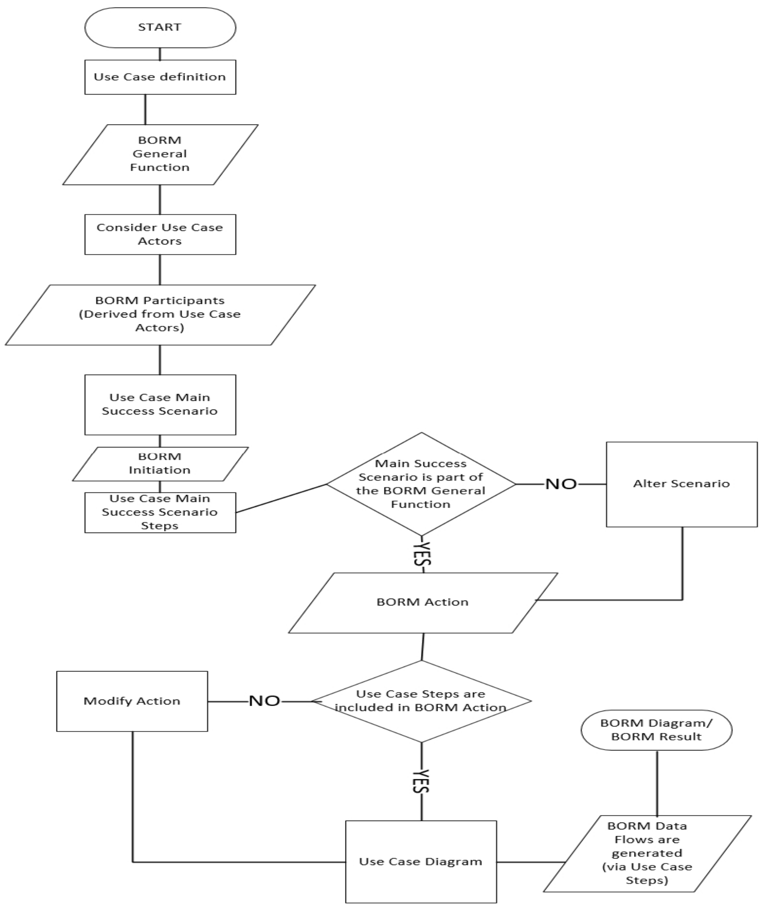
The combination of both methods and the transformation from the use case model to BORM through standard algorithmic steps ensures the successful delineation of ICT business processes. The algorithmic procedure is based on the finite automata theory and is represented by a flowchart (Fig. 4). The mapping between the Use Case model and the target BORM model is also depicted (Fig. 3). The approach is also useful for agile information system development projects where iteration issues are a major challenge for analysts and developers. The analysts should take into consideration the fact that the Use Case is the same or a subset of the BORM general function when implementing the UCBTA approach.

Fig. 3 Mapping between Use Case and BORM Models [19]



Source: (Authors)

Fig.4 Flowchart of the UCBTA Algorithm



Source: (Authors)

2.4 Monitoring for Efficient Pest Control

The primary goals of monitoring, else called scouting, are to locate and identify insect, mite and disease problems and to observe changes in the severity of infestation (Schnelle and Rebek, 2008). According to Dreidstadt (2001), regular scouting enables the grower gain the following profits:

- Prevent problems or reduce the amount of damage and the cost of control by providing early warnings that pest problems are developing
- Determine the specific cause and severity of the problem
- Identify the locations that require immediate and absolute treatment, so as to avoid unnecessary control actions
- Determine the most effective and economical timing and method of treatment
- Use slower-acting methods that are more environmentally friendly and much safer for workers
- Evaluate control efficacy.

The specific agricultural business process (Scouting - else Monitoring), has been selected as a requirement analysis case study due to the fact that, in order to support its execution, a demanding information system has to be designed and developed. Other agricultural business processes might have been selected but scouting is ideal due to the fact that it is related with various complicated decision making tasks (i.e. measurement of the degree of pest infestation, evaluation of pesticide effectiveness e.t.c.) which may even require the presence of a business intelligence system or a data warehouse. In contrast, simple record keeping of pests and the infected plant types can be supported by database tools or even worksheets in excel.

3 Results

3.1 Use Case model and BORM diagram of the pest monitoring (scouting) process

In order to analyze and describe in detail the scouting business process, according to the rules of the UCBTA algorithm, the delineation of the Use Case model is the primary step. The textual representation of the scouting use case model is based on the proposed by Cockburn (2003) template (Table 2) and its graphical depiction is implemented via the corresponding Use Case Diagram (Fig. 6).

It must be mentioned, that not all of the elements included in Cockburn's use case model are demanded in order to transform a use case model into a BORM model (Fig. 5). Only the underlined elements (Tab. 1) are the necessary preconditions for generating the BORM business model as suggested by the author. The specific mapping has been done based on common elements in both approaches.

Tab.1 Use Case textual delineation of the Scouting (Monitoring) business process

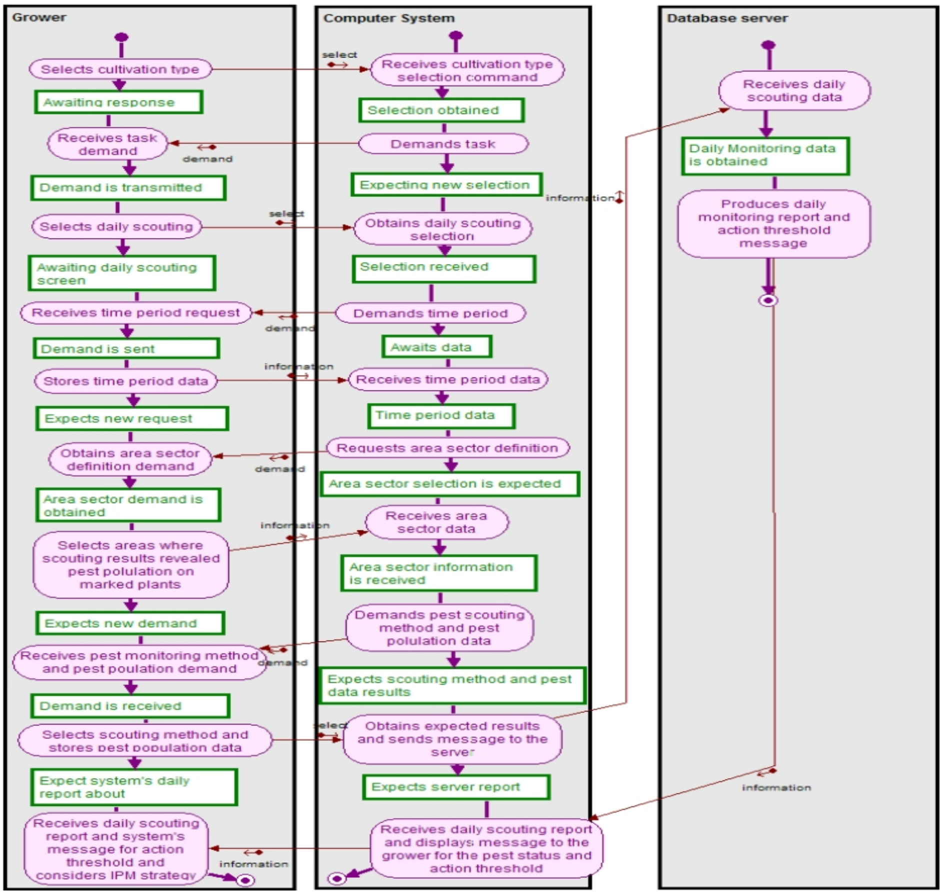
Element	Description of the element
Use case name	Performing Daily Scouting Record Keeping.
Context of use	Economic Integrated Pest Management administration
Scope	Economic, timely and ecologic pest management practices that

	include precise quantities of applied pesticides and only in the necessary areas of the cultivation, as they are proposed by the target information system.
Level	Economic, timely and ecologic pest management practices that include precise quantities of applied pesticides and only in the necessary areas of the cultivation as they are proposed by the target information system.
Primary actor	Integrated pest management system. Includes, a computer system and a Database server
Stakeholders and interests	Growers (i.e. farmers, agronomists)
Precondition	Process feasibility, computer based pest control is suggested by agronomists according to the size of the cultivation
Minimal guarantee	Efficient pest control (even if production is not increased)
Success guarantee	Efficient control of pest population based on computer based monitoring, including the increased production levels.
Trigger	The grower selects cultivation type in order to perform daily scouting, control pest population and keep the necessary records.
Main success scenario	Grower selects cultivation type Computer system demands task Grower selects daily scouting (monitoring) Computer system demands time period Grower stores time period data to the system Computer system requests area sector definition Grower selects areas where scouting results revealed pest population on marked plants Computer system demands pest scouting method and pest population data Grower selects scouting method and stores pest population data Computer system sends message to the server (Database server) Database server produces daily monitoring report and action threshold message Computer system displays message to the grower for the pest status and the action threshold
Extensions	1a) Grower awaits response 1b) Selection is obtained 1c) Computer system receives cultivation type selection command 2a) Computer system is expecting new selection 2b) Demand task is transmitted 2c) Grower receives task demand 3a) Grower awaits daily scouting screen 3b) Computer system obtains daily scouting selection 3c) Selection received 4a) Computer system awaits time period data

	5a) Grower expects new request 5b) Computer system receives time period data 6a) Grower obtains area sector definition demand 6b) Area sector demand is obtained 7a) Grower expects new demand 7b) Computer system receives area sector data 7c) Area sector data is stored 8a) Computer system expects scouting method and pest data 8b) Grower receives pest monitoring method and pest population demand 8c) Demand is received 9a) Computer system obtains expected results 10a) Computer system expects server report 10b) Database server receives daily scouting data by the computer system 10c) Daily monitoring data is obtained 11a) Computer system receives daily scouting report 12a) Grower receives daily scouting report and the system's message for action threshold and considers Integrated Pest Management strategy

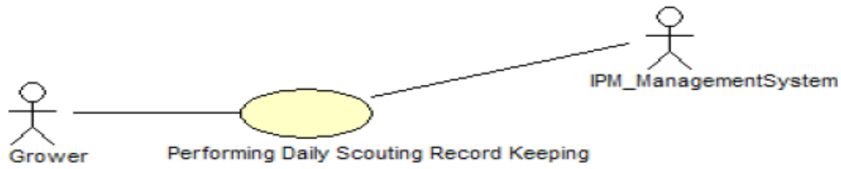
Source: (Authors)

Fig.5 BORM Diagram of the IPM Scouting Process



Source: (Authors)

Fig.6 Use Case Diagram of the IPM Scouting Process



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4 Discussion

When modern scientific methods are proposed, their validity should be examined from various aspects. Firstly, the method should be based on standard and tested theories. Secondly, the method's novelty, practicality and necessity should be justified. Thirdly, when the method is developed scientific gaps should be eliminated. Finally, when case studies from specific scientific domains are utilized, the method's value for these domains, has to be demonstrated. The UCBTA algorithm has all these characteristics. Firstly, the method is based on Use Case theory from UML for analyzing system requirements and, also, on the BORM model for depicting business process workflows. A unification of these 2 methods, yet without the presence of precise mapping between the elements neither with transition rules, has also been proposed in order to measure the complexity in IT projects (Struska, Merunka, 2007). This method, correctly, uses the elements of Use Case Points to derive the elements of BORM points. On the contrary, the current contribution deals with another issue, namely *business process requirement analysis* and utilizes precise mapping (Fig.3) and specific transition rules (Podaras et al, 2012) which, correctly though, are not present in the initial unification.

Secondly, the method's novelty is obvious due to the derivation of a business process model from Use Cases, contrary to the approaches described by (Cruz et al, 2014). Moreover, the creation of business models from use cases can be significantly practical, especially when developing modern information systems where agile methods are applied. Agile approaches to information system development include iterations. Agility is characterized by the breakdown of work in short, regular and frequent cycles of finished tasks, involvement of the customer in the process of planning (Antlová, 2014). This makes the derivation of a business process model from use cases extremely practical. Also, the involvement of the customer, or the practitioner, towards the design of an information system or an application makes the use of a business process modelling method that is comprehensible even by people with no IT skills or knowledge a necessity.

Thirdly, a critical issue with which the author had to deal when developing the method was to ensure data integrity. Data loss during the transition from use cases to BORM is prevented with the existence of the UCBTA transition rules (Podaras et al, 2012). The incorporated software tool performs transition according to these rules and the corresponding mapping between the two methods, thus eliminating all possible gaps in the model.

Finally, the selected case study, which is a scouting process for controlling pests, is a demanding agricultural task where automation needs are highlighted by agronomists. Greer and Diver (1999) claim that monitoring records should be kept in computer because computers are usually better for producing graphs, which show trends more easily. As a consequence, better and more precise diagnostic results with respect to IPM scouting will be produced when the supporting software/information system has been developed according to the requirement analysis rules of the UCBTA approach.

The approach which is analyzed in the current paper can practically assist agronomists in participating actively throughout an agile development of an agricultural information system. Use Cases and BORM diagrams are both comprehensible even by users which have no experience with the development of information systems but who are utterly confident regarding the required target tasks which should be executed via the developed software system.

A final issue to be discussed is the reason for mapping Use Cases to BORM and not to another business process modeling tool such as the BPMN (Business Process Model and Notation)? BPMN is not proposed due to the fact that it includes symbols, such as getaways (parallel, exclusive e.t.c.) which are not comprehensible by end users. Moreover, in BPMN a Participant can be a specific PartnerEntity (e.g., a company) or can be a more general PartnerRole (e.g., a buyer, seller, or manufacturer) (OMG, 2013). However, an Actor in a Use Case diagram specifies a role played by a user or any other system that interacts with the subject. Actors may represent roles played by human users, external hardware, or other subjects (OMG, 2007). It is thus difficult to map Use Case model with a BPMN in the occasion when the analyzed business process involves technical actors or interfaces, such as web servers, database servers, webpages, database systems and many more.

Conclusion

The UCBTA algorithm has been created based on a multidisciplinary logic. The core idea is to merge concepts and terminologies from information systems modelling with various scientific disciplines. The success of the proposed approach in analyzing information systems' requirements is based on the use of not one but two highly accepted methods, the Use Case and BORM. Deriving business models from use cases is highly demanded, especially in agricultural ICT projects where agility practically leads to multiple iterations. As a consequence, the produced business model derived from use cases and comprehensible by all stakeholders is a critical issue for the success in the execution of ICT projects in various scientific domains. The selected target business process representation model is BORM, which has been already proposed for modeling agricultural processes. Thus, the pest monitoring case study for the demonstration of the overall approach was not arbitrarily selected. The transition from the use case method to BORM is supported by specific transition rules which ensure data integrity during the transition. The target business model is expressed in the form of a BORM diagram. Future work will include a web-based platform, which is currently under development, for the automatic transition from the Use Case model into BORM. Web tools can be more easily accepted by agronomists nowadays since many of them are prompted to utilize modern ICT technologies, databases, and mobile devices. From this aspect, many agricultural practitioners, such as farmers, growers, greenhouse owners, as well as experts from other scientific disciplines will be more willing to participate in future agile ICT projects.

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