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## BUSINESS RULES-DRIVEN SEMI-AUTOMATIC PROJECT EFFORT ESTIMATION

### PÓŁAUTOMATYCZNE ESTYMOWANIE PRACOCHOŃNOŚCI PROJEKTÓW STEROWANE REGUŁAMI BIZNESOWYMI

#### Abstract

A new approach to project effort estimation is presented in this paper. It is related to Delphi method of estimation by experts. It also makes use of the business processes and business rules related to the newest OMG standards. A software tool implemented to verify the concept correctness is described.

*Keywords: project effort estimation, project cost estimation, Delphi, expert, ruleflow, business rule, business process, domain model*

#### Streszczenie

W artykule przedstawiono nowe podejście do estymowania pracochłonności projektów. Z jednej strony nawiązuje ono do metody Delphi estymowania przez niezależnych od siebie nawzajem ekspertów, a z drugiej strony, w ramach najnowszych standardów OMG, wykorzystuje procesy biznesowe oraz reguły biznesowe. Opisano również opracowane narzędzie stanowiące weryfikację poprawności koncepcji.

*Słowa kluczowe: estymacja pracochłonności projektu, estymacja kosztu projektu, metoda Delphi, ekspert, przepływ reguł, reguła biznesowa, proces biznesowy, model dziedzinowy*

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## 1. Bibliographical review

The approach presented in this paper is new, and it refers to OMG standards introduced in 2011 and applies the newest information technologies. That is why there is no literature directly connected to the presented problem, except [22]. And that is also why the discussion of publications connected to project effort estimation problems and usage of experts' knowledge are contained in a separate section dedicated to presentation just the literature background playing the role of introduction into problems presented further.

The problem of project effort estimation is the subject of investigations from more than 40 years. Many different approaches were described in thousands of papers and new approaches are still and continuously invented, also in the last years. All mentioned approaches can be classified generally, according to the proposal presented in [18], into two categories: formal methods or expert evaluation methods. The comparison of both approaches treated as separated can be found in the cited paper. These approaches are even presented as two extremes. However in practice the solutions located somewhere between seem to be much better. That is why in our paper the presented approach joins advantages of both two kinds of approaches standing between the ones described in [18].

Many different approaches for effort estimation of project from different business domains were used, as it was already mentioned above. This diversity results from the fact that both formal methods and methods based on experts' knowledge were used for project effort estimation.

The huge amount of formal methods was described starting from the well known in IT community COCOMO/COCOMO II [6], through function points [27, 9], story points [10] and object-oriented function points [17]. to use-case points [2] together with further modifications of the last one [26]. More universal approaches are also known, which are used in many business branches, like artificial intelligence systems the solutions based on expert systems [13] or neural networks [14] can be counted, statistical methods [28], morphological methods [3,4], fuzzy logic [1, 25], newest approaches resulting from complex systems theory, like for example grey system theory [30].

There are also known methods from the second extreme described in [18], that is methods based on experts' knowledge used for project effort estimation. They were recognized by the authors of [18] as the ones working much better in practice than formal methods. In this thread of publications the way of fighting with some specific problems can be observed, like for example estimation of reliability of experts' evaluations [34], gathering knowledge from distributed experts [11], as well as elaborations focused on sociological aspects in experts' knowledge construction [7] and exploring commonly known social techniques like voting [24]. The important problem of choosing right estimation strategy to be followed by experts is also described, for example in [20] as well as making usually under evaluated estimates more trustworthy and realistic [19]. One of the most important from the perspective of presented paper methods from this thread is the one of much more general spectrum of applications [15] than just the effort estimation - Delphi method. The specific problem for this method is the necessity of experts' opinions negotiation [12].

Wider spectrum of different approaches to project effort estimation can be found in overview publications [21, 5, 35, 29] or in the ones discussing different approaches in wider context, like [23].

Huge, mentioned above, diversity of approaches which are used for project effort estimation led to chaos in notions and terminology. The proposal of coherent nomenclature was submitted in [16]. In our publication the terminology proposed in [16] is used to avoid misunderstanding.

In our publication the approach joining experts' knowledge optionally supported by any formal method with Delphi technique is proposed. This is not a completely new concept as in [32] the discussion of such combination can be found, however not applied to project effort estimation. The approach presented in [32] is also far from our approach. A little bit similar subject is discussed in [9], however the subject is limited there to project cost calculation based on function points method, so it is not so general. The consequence of such limitation in paper [9] is that estimation is limited in consequence to systems specified by functional requirements only which is characteristic for IT and electronics projects. Even in these disciplines the functional description is only one aspect that impacts the whole project effort, thus is not complete enough. Moreover the notion of rules is addressed to expert system rules and not to business rules, which in consequence means that the approach [9] does not refer to a domain model. In contrast, our concept makes use of business process model referring to business entity model playing the role of our meta-model. Another quite similar approach exploring meta-model can be found in [31], however that meta-model is not addressed to estimation but to iteration planning and release planning for software projects in iterative processes. Moreover it is worth of notice that prior to planning the appropriate effort estimation must be done in advance as a source information for planning.

It is worth mentioning at the end that the approach presented in our paper is not functioning in isolation from other problems of projects conduction, not only software projects. Presented solution makes possible to join its results, effort estimates, to the further project tasks planning, for example, in the form presented in [36] or [33]. Also the conformance between actual project realization and prior estimates can be investigated like it was presented in [17].

## 2. Project estimation role

There is always a risk connected with any kind of project. It exists during the whole project lifecycle. It appears for the first time on the stage of trying to obtain a contract by potential project executors. They have to estimate the total cost of project realization to be able to propose the competitive price to win the contact and price high enough not to lose money while its realization and in consequence not to lose the customer. Such estimation is needed to fit in a budget and time proposed. Otherwise the customer may be disappointed. Another consequence of project complexity calculation may be direct loss of quality of the final product or very probable the decrease of product quality caused by savings got through lowering quality of the process.

Initial project effort estimation are very unprecise due to limited information. In consequence they must be continuously updated according to the growing amount of information during project realization. This is one of the important reasons forcing the necessity of recurring project effort estimations.

Moreover, during realization of the project some unexpected circumstances may appear impacting positively or negatively to the project realization process – we talk about positive or negative risks. In order to be able to react correctly to each of materialized risks they must be

monitored. When the risk materialization will be recognized it requires some reaction, usually planned in advance. Some kinds of risks can influence positively or negatively on project effort. In order to understand how a particular risk can influence the project effort and what is current project status the project effort should be re-estimated. The process of risk monitoring is and estimation triggering is continuous. This is another important source of estimating need.

Human and non-human resources should be planned in such a way that the project cost is at an assumed level. The project resource planning is however influenced by all factors presented above. As the consequence it requires continuous re-estimations as the factors appear or change also continuously. We can plan resources only if we know current project estimates. This is another important reason for performing estimation frequently.

The next reason for estimating project effort is connected to the project finalization - the necessity of closing the contract and keeping assumed time and possibly minimizing costs of breaking deadlines. Project estimation is again the best way not to fail at the end of project as it helps to plan all final tasks precisely.

### **3. Manual estimation problems**

The idealistic situation was presented in the previous section. The characteristic feature of it is that all project risks are monitored and appropriate action are taken to minimize impact of materialized risks. The relationship between risk management and the need of continuous project effort estimation was also presented. It is worth noticing here that there is however some kind of danger connected to the pressing to much stress to the risk management in a project. Paradoxically, the very careful risk management may lead to not appreciation of it due to the kind of sense of comfort among all project team members as they realize that the risk is under full control [20]. Thus both underestimating as well as overrating the project risk management may introduce unexpected additional project risks.

Nevertheless, in practice continuous estimation is not applied. There are important reasons for that connected mainly to human factor.

One of such barriers leading to minimization of estimation activities in project is the need of scarifying time of usually several project members for executing the same activity in parallel, which is just estimation process. And that is why the project cost grows this way. At the same time estimators are taken in unpredictable moments from their carefully planned usual tasks to estimation activities. It disturbs the project. Estimation sessions introduce additional costs and influence the project schedule. That is why they are limited by project managers.

Reluctance among project members to participation in estimation is another factor limiting frequency of estimations. Project risks may appear frequently, which may force people to perform many estimations. It can be exhausting and boring for project members.

Both effects mentioned above help to minimize costs but at the same time make project risk management limited and thus lead to project risk growth. It means that resignation of continuous estimating introduces itself an additional project risk that should be also somehow managed.

One of important difficulties observed even in large companies or corporations is working day-by day in many projects is the lack of proper software tools making estimation process more convenient and easier. A spreadsheet program is the most frequently met tool for estimations. This solution is however usually a very inconvenient tool making estimation

process hard. The most difficult aspect of this style of work is manual, laborious, time consuming and error prone analysis process of all data coming from estimation participants – such a process is described in the next section. It results in discouragement to frequent estimations introducing also a risk connected to lower reliability of estimation process results.

Due to the large amount of unordered data that look very chaotic it is difficult to understand and recognize the total effort, distinguish between all estimation subjects and understand relationships among them. This is even harder to solve all important inconsistencies between estimation subjects' estimates as these inconsistencies are invisible in such information noise. This kind of difficulty leads in turn to increase of acceptable deviation level of estimates. In consequence it may lead to estimation analysis process shortage and oversimplification. In effect many important estimation subjects may remain unidentified. And, going further, the total estimation error may occur to be much higher than it results from increased deviation level. The tasks that remain unidentified cannot be planned in future in the right moment.

Our publication shows how to limit all negative effects presented above influencing the estimations frequency and the quality of estimation process. The right way to do that is the partial automation of the estimation process especially in the most critical aspects. Our proposal is also designed to support well known and widely accepted good estimation practices.

#### **4. Manual estimation process characteristics**

All problems presented above are universal as they are characteristic for all kinds of projects, not only for IT projects. However, in this chapter the project effort estimation process specific for IT projects is presented. This restriction is introduced as we believe that this is a good idea to refer to the branch we know best.

One of well functioning approaches is conjunction of Delphi method based on independent experts' knowledge with formal estimation methods like for example COCOMO/COCOMO II, function points, use-case points, comparative study for historical similar projects. Each of these techniques should be chosen according to the specific situation and the choice may depend on knowledge and experience of estimation participants. It is also a good practice in this domain to choose more than one, but still fitting well to the situation, formal methods for one estimation in order to improve reliability of the results.

Such a process has several well known on the market good practices, like:

1. Specification of the estimation techniques before start of estimation.
2. Not suggesting any of the potential estimation subjects.
3. Building estimation team from people with different perspectives (knowledge, experience, skills, responsibilities in the project, business roles in the context of the project to be estimated,...).
4. Keeping rule of estimating project effort by each expert independently from the rest of expert – no information flow between experts.
5. Drafting one person who is not playing the role of an expert in this estimation to be estimation process manager.

The goal of introduction of such rules is to find the maximal set of estimation subjects (2,3,4), and at the same time to find such estimation subjects that could be compared (1) and analysed by a independent person which is interested in success of the estimation (5).

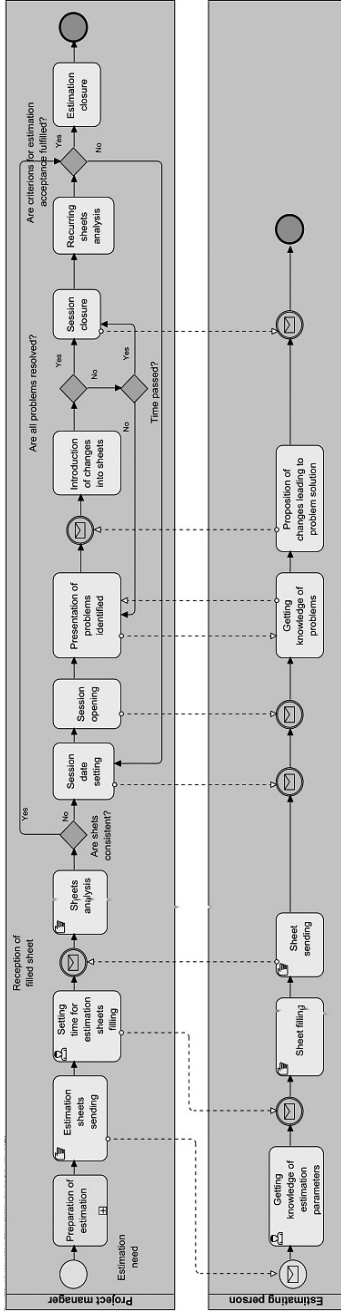


Fig. 1 Manual estimation “as-is” process model  
Rys. 1. Model manualnego procesu estymowania „as-is”

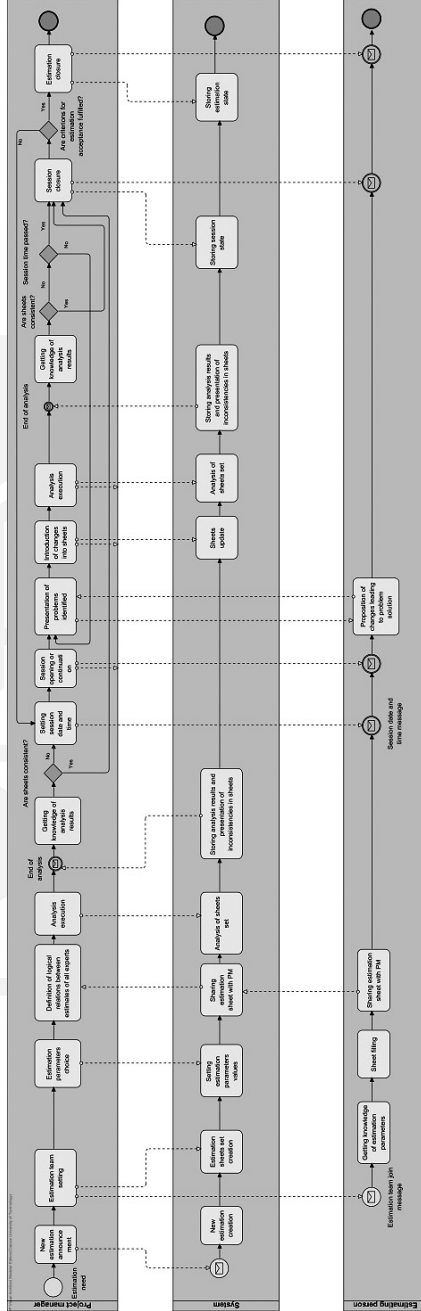


Fig. 2. Automated “to-be” process model  
Rys. 2. Model procesu zautomatyzowanego „to-be”

It is worth noticing here that currently dominating software development processes on IT market are iterative and evolutionary in nature and especially unified processes. This is also the source of tendency of joining traditional formal estimation techniques like for example COCOMO/COCOMO II with iterative processes, like for example IBM/Rational Unified Process, which is visible in several publications, eg. in [8]. The necessity of frequent estimating results from the character of iterative processes. It is caused by the planning distribution in time – coarse-grained planning of the whole project and of each phase and detailed planning of each iteration. There is usually many iterations in larger projects and they are used for advantageous distribution of project risks in time – the way of risk minimization. This is an important factor in iterative software development processes involving the need of high estimation frequency. However the specific feature of this way of estimating is that the project is not estimated as a whole many times, but successive parts of project (its evolution steps) are estimated. It means that estimation subjects change in time. A different situation can be found in other business domain where waterfall projects work well. In these domains the estimation is focused on Work Bench Structure (WBS). In our publication such an approach is used that fits well to both approaches and in consequence to all business domains.

According to the best authors' knowledge there is no tool on market that could support estimation conduction led under the assumptions presented so far.

The traditional manual estimation process is presented in Figure 1 in form of standard OMG BPMN2 business process notation. This is an as-is process, automation of which is described in the next section in the form of to-be process with the software system, being the subject of this publication, represented in the form of a business worker.

Information presented in Figure 1, Figure 2 and Figure 3 is discussed below in subsequent subsections from the following perspectives: roles in the estimating process, activities in the process and business entities access rights.

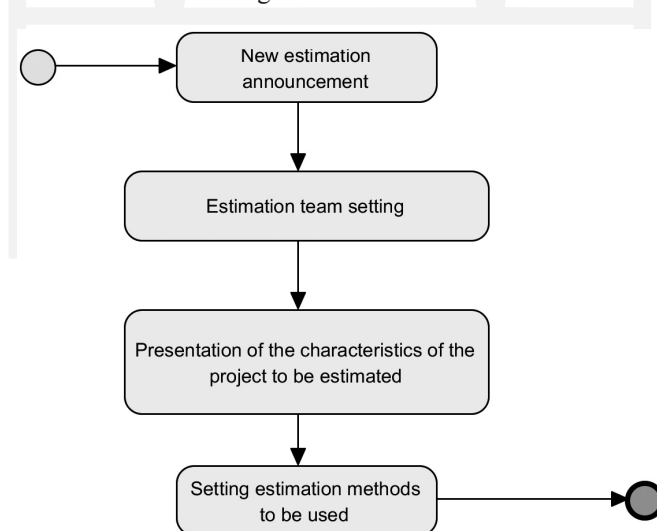


Fig. 3 „Estimation preparation” subprocess model”

Rys. 3. Model podprocesu „Estimation preparation”



#### 4.1. Manual estimation process characteristics

In as-is process presented in Figure 1 two roles are shown. The roles are characterized below on the background of two main estimation process stages.

##### “Estimation preparation” subprocess presented in Figure 3:

- *Project manager* (PM) – manages the project and it may be assumed that is responsible for estimation process flow and coordinates it. He/she establishes the team consisting of estimating people with different experience and different perspectives, informs all of them about introductory assumptions, gives access to project documentation and asks each of them to fill estimation sheets. His/her goal is to get project cost estimates in the form of person/day unit.
- *Estimating people* (Experts) – they do not fill questionnaire but estimation sheets, in which all estimation subjects must be identified and filled-in by them. Subjects are not proposed in advance in any form to get experts enough space of freedom. For each estimation subject an estimating person must suggest an optimistic, a realistic and a pessimistic estimation value.

##### The rest of “as-is” process presented in Figure 1:

- *Project manager* – collects estimation sheets and performs manual analysis. It consists in summarization of estimation subjects and comparison of them. First the probable estimation value should be calculated for each estimation subject. It can be calculated for example from the following equation:

$$P_r = (a*O + b*R + c*P) / (a + b + c)$$

where:

$P_r$  – probable estimate value

$a, b, c$  – predefined weight coefficients

$O$  – optimistic estimate value

$R$  – realistic estimate value

$P$  – pessimistic estimate value

The next step is calculation of summarized optimistic, realistic, pessimistic and probable estimation values for each estimation sheet. The arithmetic average value of probable estimate values is then calculated for all sheets. Having all values calculated PM compares them looking for potentially inter-related estimation subjects. If the subjects seem to be similar and estimation values for them are too different, then confrontation of experts is required and recalculation of estimates by these experts.

- **Estimating people** – together with PM take part in estimation session the goal of which is explanation of the character and reasons of inconsistencies recognized during former PM analysis. After session closure the experts involved into inconsistencies introduce changes to their estimates and possibly restructure their former set of estimation subjects or PM does the same during session.
- **Project manager** – decides if the estimating process may be closed on this stage or if the estimation session must be repeated in order to eliminate remaining inconsistencies. This decision should be made on the basis of estimation quality criteria accepted by an organization or by the project team.



#### 4.2. Estimation process activities perspective

The following five stages can be find in the process shown in Figure 1:

- **Estimation preparation** – includes estimation team roles construction, definition of general assumptions and characteristics of system to be estimated. On this stage PM does not communicate with experts.
- **Session preparation** – includes distribution of empty estimation sheets between experts with information about deadline of filling them. On this stage experts do not communicate. After sending filled sheets to PM he/she performs the analysis.
- **Session conduction** – this is meeting of session coordinator (usually just PM) with all experts. The discussion is focused on identified inconsistencies. PM successively introduces changes to sheets and if possible he/she checks if the new decisions solve the inconsistency problem not introducing the new one.
- **Session closure** – recurring sheets analysis by PM. He/she must analyse many estimation sheets step-by-step (for example in the form of Excel worksheets) and diagnose inconsistencies. Additionally while making estimation subjects more detailed, which is natural consequence of inconsistencies resolution, different experts may use different notions systems which makes such comparison more difficult.
- **Estimation closure** – on this stage PM must decide if the estimation result fulfills the closure criteria. If yes, then estimation can be closed. Otherwise the new session must be prepared and performed.

Such manual approach to the estimation process is very time consuming both for experts that have to take part in estimation session several times and for PM.

#### 4.3. Business entities access rights perspective

The business entities access rights result from the process presented above.

- **Project manager** – as a role managing the whole process has the most strong permissions. He/she creates and controls all required artifacts. He/she can add and remove estimation sheets, edit all sheets previously shared with him/her by experts, set all parameters used for verification of estimation results, diagnose relationships and inconsistencies between subjects estimated by different experts.
- **Estimating people** – should be able to view and edit all their estimation sheets, block and share them with PM. Additionally they cannot see any estimation sheet filled by other expert before the first estimation session.

### 5. Estimation process automation opportunities

Automation of the estimation process was achieved by introduction of the software system between the two business workers presented in the previous section. From now both business workers communicate via the software system. The new, automated process is presented in the to-be process diagram in Figure 2 in standard OMG BPMN2 notation. It is worth noticing the tasks taken by the software system.

It is clear that the software system supports PM from the very beginning. The system is used for preparation of estimation. The new virtual folder and new estimation sheets set each for separate estimation team member are created. All data needed for estimation analysis is introduced into the system. In place of sending estimation sheets via e-mails they are stored in a database and shared by each expert with PM. The analysis is performed by the system and PM is informed about the end of the analysis process. During estimation session the analysis process can be executed many times, giving PM the full control over continuously changing inconsistencies. The only problem is the limited time for a session and it may cause the need for organization of further sessions. It seems however that thanks to the software system the number of sessions may be reduced even to one per each estimation.

The domain model presented in Figure 4 is created on the basis of to-be process shown in Figure 2 and results from the analysis of business entities used to store the key data for that process and on the basis of previous divagations concerning rights to access some business entities.

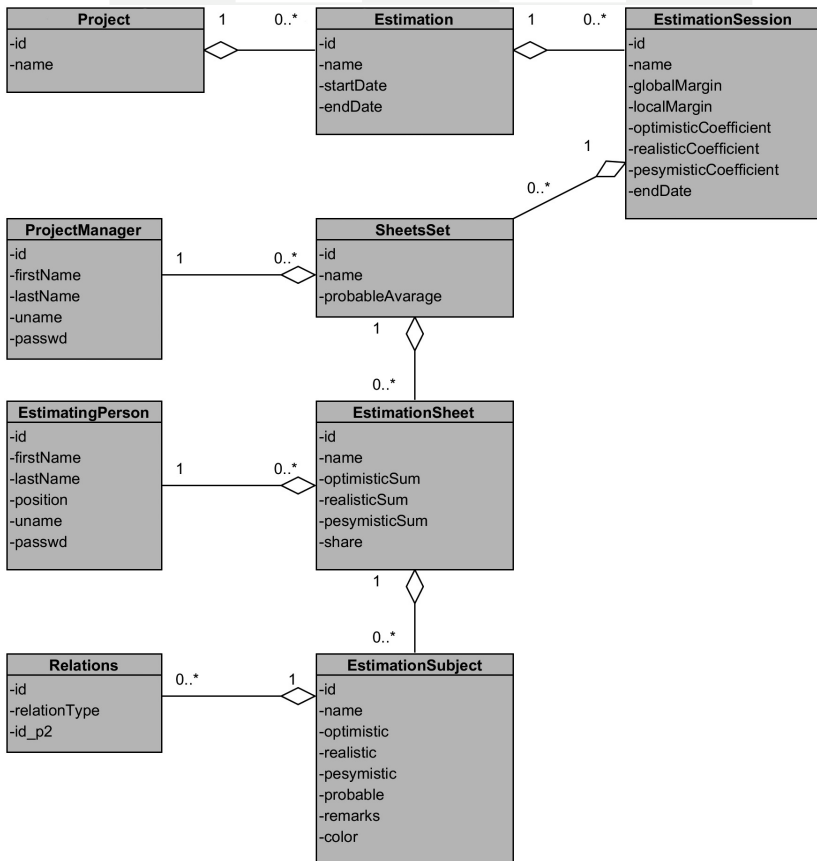


Fig. 4. Business domain model

Rys. 4. Dzia dzinowy model biznesowy

## 6. Business rules

First the ruleflow diagram (Fig. 5) resulting from “to-be” business process model (Fig. 2) is presented. Then the appropriate business rules associated to the ruleflow are shown. Both ruleflow and business rules are specified and implemented in JBoss Drools environment. The natural language is also used to specify the rules independently from this environment.

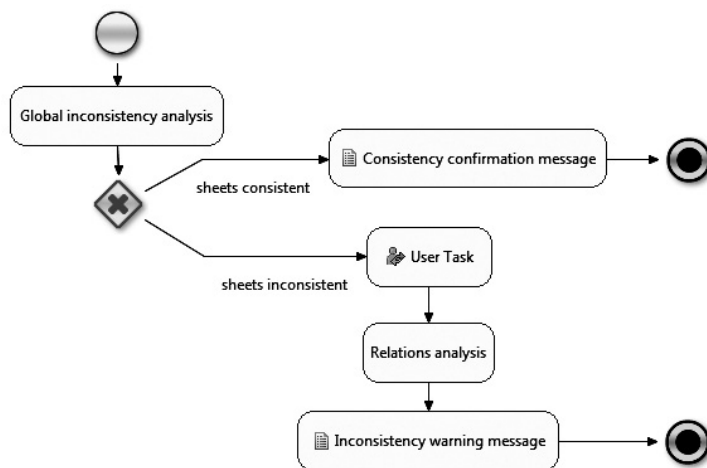


Fig. 5. Ruleflow specification in JBoss Drools

Rys. 5. Specyfikacja przepływu reguł w JBoss Drools

The first and the only rule associated to the “Global inconsistency analysis” rule-task makes possible to identify the estimation sheets for which the probable estimation value deviates too much from the average value calculated for all sheets in the set. The appropriate margin for this inconsistency is assumed.

### WHEN

*the sum of values of probable estimates is lower than the average value of probable estimates for all estimation sheets decreased by acceptable deviation value or the sum of values of probable estimates is greater than the average value of probable estimates for all estimation sheets increased by acceptable deviation value*

### THEN

*add the estimation sheet to the list.*

The Drools source code for this rule is presented in Listing 1.

### Listing 1

```

rule "sheets not satisfying the general restriction "
ruleflow-group 'group1'
dialect "mvel"
  
```

```

no-loop true
when
  $sheet: EstimationSheet ( probableSum < (setAvarage - globalMargin)
  || probableSum > (setAvarage + globalMargin))
then
  iSheetsList.add($sheet);
end

```

The next group of rules associated to the „Relations analysis” rule-task is focused on identification of all inconsistencies among estimation subjects effort estimations between inconsistent sheets identified by the previous rule and all remaining sheets. The analysis is performed for evaluation of exact deviation values for estimation subjects from inconsistent sheets. Unfortunately, the necessary condition for correct execution of the rules presented below is manual identification and definition of relationship between similar estimation subjects from different sheets which must be done in advance by PM. This relationship is equality or inclusion. Relations mentioned above may be complex and difficult to understand and manage without software support. The estimation subjects from inconsistent sheets will be compared with related estimation subjects from consistent sheets during analysis.

The rule presented below makes possible to compare two logically equal estimation subjects.

#### WHEN

*difference between probable estimation value of an estimation subject from the sheet not conformant to the sheets set average probable estimation value and the same estimation subject from the sheet conformant to the sheets set average probable estimation value is greater than the assumed inconsistency margin*

#### THEN

*set this difference as the deviation value for this estimation subject.*

The Drools source code for this rule is presented in Listing 2.

#### Listing 2

```

rule "estimation subjects - equal "
ruleflow-group 'group2'
salience 40
dialect "mvel"
when
  $sheet : EstimationSheet (probableSum < (setAvarage - globalMargin)
  || probableSum > (setAvarage + globalMargin))
  $p1 : EstimationSubject (eval(sheetID.id == $sheet.getId()) &&
($id1 : id))
  $r : Relations(eval(p1ID.id == $id1) && (relationType == 1) &&
($id2 : id_p2))
  $p2 : EstimationSubject (id == $id2)
  eval(Math.abs($p1.getProbable() - $p2.getProbable()) > localMargin)

```

```

then
    $d = $p1.getProbable () - $p2.getProbable () ;
    $p1.setColor("Deviation: "+$d);
    iEstimationSubjectUpdater.update($p1);
end

```

In case of inclusion of one or more estimation subjects from the analysed sheet in an estimation subject from other sheet the following rule will be used.

#### WHEN

*difference between sum of probable values for the inconsistent sheet and the probable value for the including estimation subject from the consistent sheet is greater than a predefined margin value*

#### THEN

*set the difference as the deviation value for all analysed estimation subjects from the inconsistent sheet.*

The Drools source code for this rule is presented in Listing 3.

#### Listing 3

```

rule "estimation subjects - is included"
ruleflow-group 'group2'
salience 30
dialect "mvel"
when
    $sheet: EstimationSheet ( probableSum < (setAvarage - globalMargin)
    || probableSum > (setAvarage + globalMargin))
    $p1 : EstimationSubject(eval(sheetID.id == $sheet.getId()) &&
($id1 : id))
    $a : EstimationSheet( this != $sheet)
    $p2 : EstimationSubject(eval(sheetID.id == $a.getId()) && ($id2 : id))
    // subject p1 is included in other subject(s)
    $r : Relations(eval(p1ID.id == $id1) && (relationType == 2) &&
(id_p2 == $id2))
    $sum : Double( )
    from accumulate(EstimationSubject((this == $p1) && ($value : prob-
able)), sum($value) )
    eval( Math.abs( $p2.getProbable() - $sum ) > localMargin)
then
    $d = $p2.getProbable() - $sum;
    $p1.setColor("Deviation: "+$d);
    iEstimationSubjectUpdater.update($p1);
end

```

Otherwise, if the analysed estimation subject includes one or more estimation subjects from other sheet, the following rule can be applied.

**WHEN**

*difference between probable value for the inconsistent sheet and the sum of probable values for the included estimation subjects from the consistent sheet is greater than a predefined margin value*

**THEN**

*set the difference as the deviation value for the analysed estimation subject.*

The Drools source code for this rule is presented in Listing 4.

**Listing 4**

```
rule "estimation subjects - includes"
ruleflow-group 'group2'
salience 20
dialect "mvel"
no-loop true
when
    $sheet: EstimationSheet( probableSum < (setAvarage - globalMargin)
    || probableSum > (setAvarage + globalMargin))
    $p1 : EstimationSubject( eval(sheetID.id == $sheet.getId()) && ($id1
: id) )
    $a : EstimationSheet( this != $sheet)
    $p2 : EstimationSubject( eval(sheetID.id == $a.getId()) && ($id2 : id) )
    // subject p1 includes other subject(s)
    $r : Relations( eval(p1ID.id == $id2) && (relationType == 2) &&
(id_p2== $id1) )
    $sum : Double( )
    from accumulate( EstimationSubject( eval(id == $id2) && ($value :
probable)), sum($value) )
    eval( Math.abs( $p1.getProbable() - $sum ) > localMargin)
then
    $d = $p1.getProbable() - $sum;
    $p1.setColor("Deviation: "+$d);
    iEstimationSubjectUpdater.update($p2);
end
```

Four rules presented above make possible to find automatically all inconsistencies between experts' estimation sheets making the analysis process significantly faster and less error prone.

There is also one more rule introduced in order to find and visually mark all estimation subjects that are not involved into any logical relation with subjects from other sheets.

**WHEN**

*there exists a relation for the estimation subject from the inconsistent sheet*

**THEN**

*do not set the deviation value and mark this estimation subject as a consistent one.*

The Drools source code for this rule is presented in Listing 5.

### Listing 5

```

rule "estimation subjects - relationship existence "
ruleflow-group 'group2'
salience 50
dialect "mvel"
no-loop true
when
    $sheet: EstimationSheet ( probableSum < (setAvarage - globalMargin)
    || probableSum > (setAvarage + globalMargin))
    $r : Relations(($id1 : p1ID.id) && ($id2 : id_p2))
    $p1 : EstimationSubject(eval(sheetID.id == $sheet.getId()) &&
    (eval(id == $id1)|| eval(id == $id2)))
then
    $p1.setColor("OK");
    iEstimationSubjectUpdater.update($p1);
end

```

A dedicated software tool was implemented on the basis of the ruleflow presented in Figure 5 and on the basis of all business rules shown on Listings 1 to Listing 5. This tool automates the analysis of estimation data submitted by many estimation participants.

## 7. Estimation Manager tool

The software that constitutes an implementation of the concept presented above is a prototype. That is why it has the form of a desktop application. The set of technologies used for the implementation is presented below.

- JBoss Drools –drools-5.0.0.M5-bin library
- MySQL Server – version 5.1
- Hibernate for ORM
- Java SE JDK
- Swing for GUI implementation

Eclipse 3.6 (Helios) with Visual Editor PlugIn for Swing library were used as a development environment.

Beside elaboration of the whole concept and business rules the design of user interface was a significant implementation difficulty. The specifics of GUI problems was as follows:

- necessity of support for management and ordering of potentially large amount of interconnected pieces of information  
and
- necessity of definition of relations between any estimation subject.

Two screenshots one per each role are presented in Figure 6 and Figure 7 to illustrate the way of the solution of the first problem mentioned above.



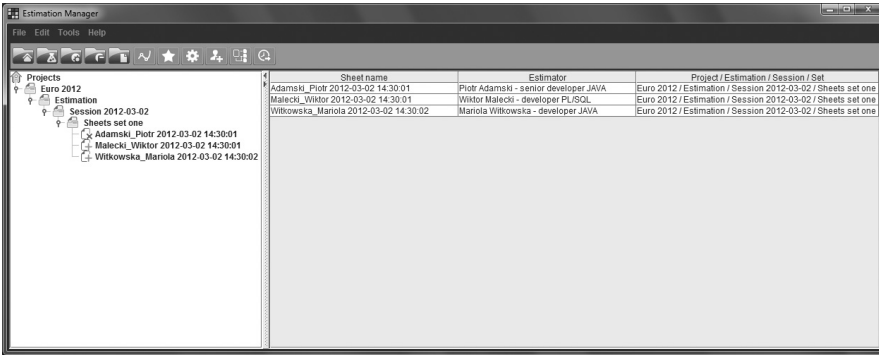


Fig. 6. Presentation of estimation sheets available for project manager (PM)

Rys. 6. Widok arkuszy estymacyjnych dostępny dla project managera (PM)

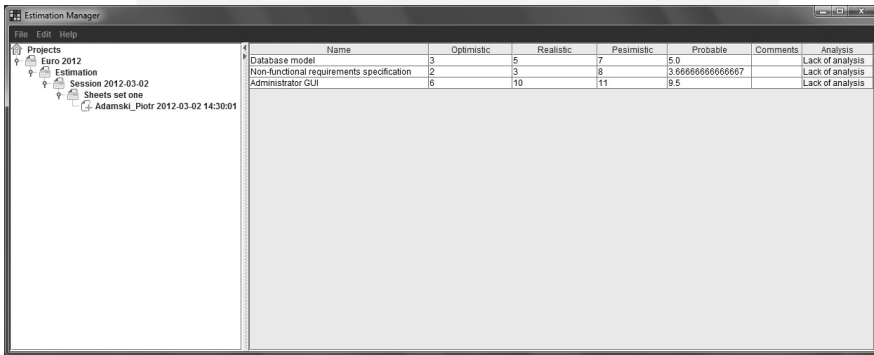


Fig. 7. Presentation of estimation sheet available for estimating person (expert)

Rys. 7. Widok arkuszy estymacyjnych dostępny dla osoby estymującej (experta)

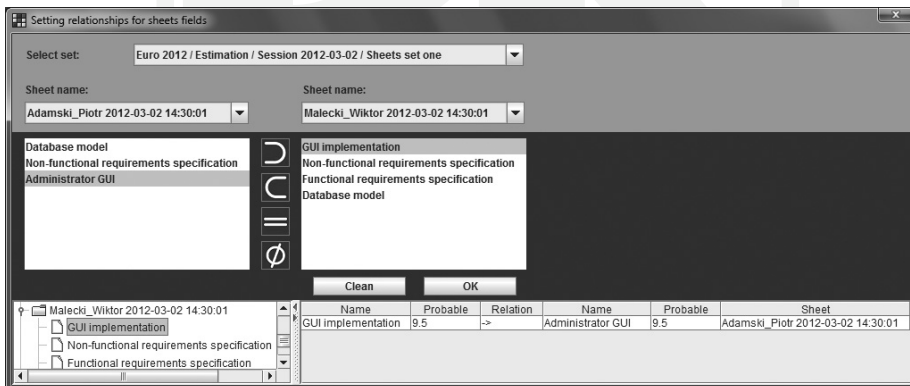


Fig. 8. Presentation of relations between estimation subjects available for PM

Rys. 8. Widok relacji pomiędzy przedmiotami estymacji dostępny dla PM'a

Name	Optimistic	Realistic	Pesimistic	Probable	Comments	Analysis
GUI implementation	6	10	11	9.5		OK
Non-functional requirements specification	1	2	3	2.0		Uncompared
Functional requirements specification	1	2	3	2.0		Uncompared
Database model	3	5	6	4.83333333333333		Deviation: -10.8855555555556

Fig. 9. Presentation of analysis results available for project manager (PM)

Rys. 9. Widok wyników analizy dostępny dla project managera (PM'a)

The second problem mentioned above is the key view for correct definition of relations between estimation subjects. The appropriate screenshot is shown in Figure 8.

For efficient analysis of estimation sheets as well as conduction of estimation session the clear view to the results of the analysis for the PM is required. The appropriate screenshot is shown in Figure 9.

The approach presented in this paper constitutes the first but prospective attempt to automation of any kind of project effort estimation. It also gives a chance to extend this concept in several directions:

- separation of data layer from business rules
- introduction of web services for separation of presentation layer technology from business logic layer
- implementation of the tool in the form of web application
- enrichment of the domain model with task hierarchy and extension of business logic layer by extra functionalities - addition of new business rules group
- enrichment of the domain model with association of estimation distance measures with already existing relations
- enrichment of the domain model with estimation sets due to possible application of at least two different estimation methods at the time, which is a good practice
- introduction of estimation sheets versioning functionality
- elaboration of a concept of application of a domain-specific language for simplification of day-by-day work on business rules executed by estimating people

The approach presented here is not free from some limitations of business nature, of course. One of them is the requirement of having access to a special room with computers available for all estimation team members. This requirement is not a necessary condition for applicability of this solution but makes the estimation process more efficient. In the current version of the solution it is assumed that a project manager edits all the sheets during estimation session. However, it should be done by the participants in their estimation sheets. In such a case the system should perform analysis of the continuously changing estimates on the fly and present the results to the whole audience. This way the resolution of inconsistencies during estimation session would be the most effective.

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