Simulation of an Iterative Software Development Process for an Educational Repository System

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Abstract: The current paper marks the early stage of the PhD thesis of the first author of the paper. The thesis includes partial creation of an educational repository system, which should become a highly flexible portal that gives access to variety of educational resources. The simulation of the development of the repository system is the main topic of this paper. The human resources needed for the successful end of the project are centric for the simulation which can be quite useful not only for developers of similar systems but for a broader circle of specialists working in the sphere of software development. This is assured by the creation of the several control panels which gives the possibility for changing of the values of the key input parameters of the simulation very easily.

The paper starts with a brief overview of the Software Process Simulation (SPS) and a comparison between the different available simulation models. After that a chapter follows which describes the usage of the simulation. Then follows description of the simulation tool and its specifics. After that is given some insight into the building blocks of the simulation via description of one of its main diagrams. At the end, possibilities for future development and results from the simulation will be given.

Key-Words: Software development process, simulation model, repository system

1 Introduction

Software development history worldwide gives many examples of projects with late launching of the software product, exceeded budget and quite often of dissatisfaction from the client’s side. Years ago such problems used to be solved by long working nights of specialists with very broad technical competence. Nowadays, however, after successfully implementation of a step-by-step, standardized and foreseeable approach, known as software development process, more and more people adopt the idea of the simulation of the development process. Such simulation will certainly introduce new resources allocated to understanding and building of the simulation. Still the relatively high volume of statistical data in the sphere of software development makes the simulation quite often adequate and a preferred step at the beginning of the project for the simple reason of foreseeing possible problematic issues and taking measures earlier, which is proved to always be cheaper.

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2 Software Process Simulation

Simulation model is a simplified representation of a real, conceptually-complex system and further more is computational model of a dynamic system or a phenomenon [1]. Interesting subtype, representing self-contained center of the current paper is the simulation model of a software process or also known as SPS. According to Madachy [2] SPS focuses on a specific
software process. It can be followed at the moment or can be dedicated to a future project within the organization. Usually similar types of simulations are of use to the management team in a software development organization and a simulation or a set of simulations are carried out for the purpose of developing a project. A study in the subject matter by M. Kellner [3] from the university of Carnegie Mellon supplement to the definition of SPS by defining minimum duration at which the usage of SPS is considered adequate. This minimum duration is 12 months and the implementation of SPS for smaller projects seems to be too expensive and unreasonable investment.

SPS facilitates the risk reduction during the implementation period of a project as well as the adequate management at strategic, technical and technological level. The simulation can be of help while considering which is the most appropriate software process for the current case. As a whole the reasons for the usage of SPS can be divided as follows:

- better strategic management ad planning;
- better control and training;
- improvement of the process;
- implementation of new technologies;
- increasing of the understanding towards the project;
- strengthen the position of the organization.

3 Popular Research in the Subject Matter

Several famous pieces of work will be described in the following paragraphs. These are the most famous models dealing with the issues in human resource management for successful implementation of a software project. Most such models are based on the Brooks’ work [4] in this domain. That is why Brooks’ law will also be discussed. The models to be described are quite valuable because of the defined in them links and dependencies between the elements of the simulation model. Second very important source of information, which derives from the well-known models is the statistical data, extracted from a great number of successfully finished projects. Part of those statistical values are used as input parameters for the current simulation also.

3.1 Abdel-Hamid Model

Abdel-Hamid model [5] is the first model for SPS for which development were used Dynamic Systems. Software process here is not iterative, which is also true for the others famous simulation models which are dealing with the human resources issues. Another common feature for almost all of the described models is the lack of specified roles within the scope of the project’s implementation. The reason for this decision is mainly associated with uncertainty at the beginning of the project with regards to the division of the work and defining the exact roles with their parts in the project.

The simulation built by Abdel-Hamid is entirely deterministic. There are no unknown values when the simulation is started and that fact moves the simulation a bit away from the reality. In spite of that the Abdel-Hamid simulation is considered as a very useful one because of the statistical data gathered from a vast number of projects. Typical for this model is the definition of four levels of productivity, associated with the workers according their experience and knowledge. The simulation of Abdel-Hamid is one of the most detailed and profound work in this domain.

3.2 Stutzke Model

Stutzke model [6] is a relatively simple simulation model and the implementation is quite similar to that of Abdel-Hamid. Again the average duration of the project is supposed to be around one year. The finished model Stutzke tests with a project for which the staff was needed to be doubled during the course of implementation. Stutzke’s efforts result in a successful delivery of the project objectives, in spite of the time needed for training of the new-comers. Stutzke excludes many known parameters from his model. One of them is for instance the additional overload brought by the communication in the enlarged team.

3.3 Madachy Model

The Madachy model [2] is again a simplified variant of the Abdel-Hamid model. Additionally developed is the procedure for transferring the new-comers into the group of the experienced and productive specialists. This in fact was the main reason for the selections of this model for the iterative simulation described in this paper. The Madachy model is also criticized for the usage of some statistical data which is not relevant nowadays.

3.4 Brooks’ Law

Brooks law [4] is a famous principle which is considered valid for software development projects. This principle says that adding of human resources to a software project, which is late with regards to the initial plan, will result in greater delay of the whole project. This statement comes from Brooks in 1975 and it is based on statistical data from many late projects. Theoretically speaking, the basis for such a statement should be the fact that the software development projects are relatively complex and adding man power in the middle of the project will require working specialist to stop their work.
and start training the new-comers. Second the enlargement of the team usually results in increasing the number of communication channels. The workers dealing with one and the same module need to communicate, synchronize with each other which usually decreases the amount of work done by a worker.

4 Usage of the Simulation

The current simulation is targeted mainly at the managers of software projects, which require hiring and training of new staff members in order to successfully finish the project. The main aim of the simulation is to improve the process of management of the human resources at iterative software development process. When the work amount is specified as input parameter the simulation can produce or calculate the needed time for the completion of the work specified. Supported is simulation of the project lifecycle with different input parameters as current resource, labor market stability, time needed for training, human resources which can be attracted from other projects. As basis for the simulation are used links and dependencies between parameters taken from the Madachy simulation model as well as from other resources in the subject matter. Also, organization specific parameters were used which can have values based on the statistical data for a specific organization. To make the simulation closer to reality also were included factors as overload of the team due to the increasing number of workers as well as increasing the productivity by means of additional social bonuses. Included as an input parameter is also the rate at which qualified specialists leave the company.

The simulation gives the possibility for adding of an unexpected amount of work at any stage of the project lifecycle in such a way that to answer the two main questions – what will be the effect of the added work and will the project be finished on time. In order to do what has just been described the simulation requires input parameters. They can be “read” from external file or can manually be given values via the so called Control Panels which are diagrams of the simulation. Given is also the possibility for running the simulation multiple times with different input parameter and comparing the results. The results from the simulation are expressed graphically as well as numerically.

The proposed simulation gives the possibility for step by step running as at each step it is possible to change the values of the parameters manually. This is a consequence of the characteristics of the chosen tool for simulation development (Powersim Studio 7) and is very useful for getting closed to the real conditions of a project development.

The chosen step of the simulation is one day, which means that the parameters can change their values maximum one time per day. One day is also the step used for most of the above-mentioned simulation models. Thus the chosen step gives sufficient level of detail for representing a real situation and what is even more important the chosen simulation parameters as staff number, labor market conditions, bones existence could hardly change values more than once per day. Last but not least the chosen simulation tool only permits the usage of a step which is at least one day.

Major input parameter for the simulation is the amount of work to be done. This parameter is valued in days and as we have iterative process it is necessary to specify the amount of work to be done at each iteration. Before running the simulation it is also needed to specify the time in which the project is supposed to be finished. This is crucial information because it defines how many new workers the organization needs to hire and train for the successful implementation of the project. At this stage the simulation does not offer division per roles for the organization’s staff. This fact makes the simulation adequate for broader circle of projects but to some extent moves away the simulation from the real repository system development project for which the simulation has initially been developed. However the next foreseen version of the simulation is expected to include role decision. This will allow to define the need for more database and user interface specialists which will be needed for the repository system development lifecycle.

5 Simulation Tool Specifics

The above described simulation is defined in several diagrams in Powersim Studio 7. The elements available in the chosen simulation tool were used for the simulation definition and these elements are as follows:

- Level – this element is known as a container. In the diagrams it can be seen as a rectangle. This element is used for parameters which values increase or decrease during the running of the simulation.
- Flow – in the diagrams it is a cloud with an arrow and a circle. The flow element is linked with the level element. The flow points into or out of the level element. The flow is used to define the rate at which the level element changes its value.
- Auxiliary parameter – it is an additional element which permits to define special links between elements. It is a circle in the diagrams.
- Rhomb – this is a constant value and it does not change its value for the whole simulation.
- Link – it is an arrow in the diagrams and is used for define which parameter is used for
the calculation of the value of the element into which points the arrow.

For the change in the values of the parameters in the simulation is additionally used a language which is quite similar to C programming language. Examples will be given below. Also important to mention is that the simulation tool offers a great variety of standard functions and operators which are available for usage.

There are two types of diagrams used for building the simulation. These are the types allowed by the chosen simulation tool and are as follows:

- Control Panel diagram – the user of the simulation used those diagrams to give values to the input parameters and to observe the result of the simulation either graphically or numerically.
- Element diagram – it contains the elements of the simulation and its links. As mentioned above this is not enough to build the whole simulation for some of the elements can be added a portion of code in the simulation tool language which syntax strongly resembles popular programming languages as C and C++.

### 6 Diagrams of the Simulation

There are two control panels for the simulation. The first one contains the basic input and output parameters and it sufficient for running a set of simulations. The second control panel diagram contains more input parameters and gives the possibility for better tuned simulation.

The other three diagrams are the building blocks and they are:

- Human Resources Management diagram (fig. 2 from the Appendix).
- Project Management diagram.
- Time Management diagram.

Due to the large amount of logic implemented in the three diagrams only the major one will be briefly describes.

#### 6.1 Description of the Human Resources Management Diagram

The diagram consists of 5 containers (levels) of which the most important are:

- New employees – current project. The already defined Published job offers transfers into New employees at the Rate of staff hiring. This rate is dependent on the Average delay at staff hiring and Labor market conditions. The first parameter is constant of 45 days. The Labor market conditions can have three values depicting poor, average and rich market.
- Experienced employees – current project – The New employees transfer into Experienced employees at the Training rate, which is defined as follows:

```plaintext
New employees / Time spent in training
```

```
Time spent in trainings is:
GRAPH('Correlation between new and all employees', 0, 0.1, {169, 117, 85, 91, 104, 115, 127, 136, 139, 147})
```

According to this definition the training time depends on the correlation between the new and all employees. The values for defining this training time are taken from the Madachy model.
- Experienced employees from other projects – this is a resource which we use only when really needed. The Rate of moving experience employees is defined as follows:

```plaintext
IF('Number of needed workers'>10\&\&'Experienced employees from other projects'>0, 1, 0)
```

### 7 Simulation results

We will give one example of the many performed simulations. The input parameters are as follows:

- Average Labor market.
- 13 Experienced workers at the beginning of the project.
- No available human resources from other projects.
- 3 new employees at the beginning of the project.
- 300 days for the completion of the project.
- 4 600 man-days is the work to be done divided per iteration as follows: 600, 1000, 700, 300, 2000.

Fig. 1 from the Appendix shows the result of this simulation. For the first graphic the blue line represents the completion of each iteration, while the red one the completion of the project. For the second graphic the red line represents the experienced workers, the blue line represents the needed workers, the green line represents the new employees for the project and the brown line.
represents the workers who the organization needs and cannot find.

8 Conclusion

In this paper we presented simulation model which treats the human resources issues during the development of a software project. The model is based on the Madachy model but in addition iterations were introduced into the model. The major possibility for development will be the adding of different roles of the workers in the simulation. This will make the simulation even more precise and adequate for specialized projects as the repository development system development for which the simulation was initially developed.

9 References


Appendix

![Sample simulation results](image)

Fig. 1 Sample simulation results