SPI with Lightweight Software Process Modeling in a Small Software Company

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Abstract. In small growing software companies, it is important to pay attention to software process improvement (SPI) in order to be successful and competitive in both domestic and foreign markets. However, limited resources and lack of knowledge about process culture may hinder the improvement efforts in small companies. In this paper, we present development activities done in a small growing software company in order to establish basis for SPI. Familiarizing to processes and SPI is done by modeling company's processes using a lightweight software process modeling technique. The modeling combined with external consulting provides the company with capability to visualize their processes and to identify the problems in the processes. The improvement activities have been triggered by pointing out the problems. In the presented case, the company has independently implemented quite significant improvements for identified problems by acquiring needed knowledge and by implementing new tools to support workflows.

1 Introduction

Small software companies (SC)[1] play in important role in the software industry, because they are innovative, exploit new technologies, create job opportunities and keep established firms on their toes as described in [1] [2] [3] [4]. Some of these innovative SCs seek constantly new business opportunities and new market areas. In countries where domestic software markets are quite limited, such as Finland, the SCs with desire to grow and pursue greater turnover are compelled to become international. Rapid growth implies increasing the personnel, creating new job descriptions, coping with cultural differences and business opportunities. SCs face the inevitable challenge of modifying their processes to match new and changing circumstances [5]. They are forced to notice the importance of processes and improving them, in order to become competitive and successful on international market. On the other hand, improved processes may result in expanding staff, new international sales, and pressure for more intensive release schedules.

However, introducing the concept of software process improvement (SPI) in SCs may not be possible, because the organization's maturity can be low. Organization

[1] A common abbreviation used for small companies with less than 50 employees [6].

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structure is often informal, implicitly defined processes evolve based on daily work and actions may not be planned beforehand [7]. Work is trust-based thus not often formally documented, and there is lack of knowledge about process culture. In addition, there is often lack of resources, skills, experience, and qualified and SPI motivated staff. Due to the reasons listed above, it can be very challenging for SCs to establish an efficient and competitive process culture and furthermore, concurrently manage the growth. One possibility to start preparations for SPI is to make processes visible by modeling them.

In this paper, we describe development project activities done in a small rapidly growing software company. In this case, CMMI, ISO 15504, CBA-IBI or other massive SPI approaches were not suitable choices, because they are designed for large organizations and require specialized SPI personnel. Instead, we chose to combine and adapt lightweight process modeling techniques [8] [9] that conform to characteristics required from a model used in SCs [10] [11]. The techniques are easy to use, flexible, applicable, and adapt to SCs limited resources. Usage of this combined modeling technique enables to visualize processes, to identify the flaws and problems in the process and deficiencies of knowledge and skills. Furthermore, more importantly using this lightweight modeling and carrying out related activities, promotes future formal SPI with measures and techniques that best serve the company's own operations. In this paper, we present our experiences of using a lightweight process modeling technique in familiarizing a small software company with SPI by visualizing their software development process and identifying problems in the process.

2 Objectives and Context

In this development project, the objectives were to explore how the lightweight process modeling contributes to small software company's SPI activities and how the process modeling can be initiated in a small low maturity software company.

The development project was carried out in a small growing Finnish software company. The company has been involved in the development project was founded at the beginning of 2000. The employees were also founders and part owners of the company. In the beginning, there were less than 10 employees, but the personnel expanded quite fast to 15 employees. By the end of 2006, there were 20 employees and during 2007, the company has estimated to hire 10 employees more. Despite earlier and planned growth, the company is still a SC and likely will be SC for some years.

The company started on domestic market. During past two years, the company has steadily expanded its operations to three foreign countries and will expand foreign business further during 2007. The company's offices are distributed around Finland and abroad. The company is now divided in two separate companies. Another company concentrates on product development and other one on sales and marketing.

The organization and hierarchy of the company are not clearly defined, though an informal structure exists. The company's management concentrates only on business decisions and running the company. The software development team and other employees work independently and the communication with management is informal and is done in ad hoc manner. The development team's varying work assignments and situations have an influence on employees' work methods. However, they have established working

practices though those are not documented in detail. A considerable amount of knowledge and skills that the employees possess is tacit knowledge, which is not generally distributed within the company. This has inflicted on blocks in information flows. The growth of the company has increased the awareness of need for SPI and establishing process culture.

3 Process Modeling Technique and Practical Implementation

In this case, we needed a modeling technique, which conforms to SCs limited resources. The technique itself serves as a tool for the company in order to analyze their own work in a structured manner and initiate discussion about their processes. We apply the techniques described in [8] and [9], which we use for modeling and making the process, its roles, and information flows visible. The techniques were chosen because they are flexible, easy to learn, understandable for non-experts and require minimal resources. We have combined and applied the techniques as follows:

- First Phase
  - Model the information flows of selected process with wall-chart technique
  - Analyze the gathered information and define the problems and points of improvement
  - Create an electronic version of the information flows
  - Inspect and approve the electronic version
  - Analyze and enhance the approved model
- Second phase
  - Model the selected process with wall-chart technique
  - Analyze the gathered information and define the problems and points of improvement
  - Create an electronic version of the process and its phases
  - Inspect and approve the electronic version
  - Analyze and enhance the approved model
- Third phase
  - Inspect the results and plan follow-up

The phases are carried out in chronological order. The first phase is now completed. In the first phase, the aim was to create an information flow diagram of the selected process. This information flow diagram describes who participate in the process and in what roles, and determines the information flows between the roles Problematic information flows were marked with red. By analyzing the diagram and by discussing with the employees, the problems of passing information from role to another can be perceived and analyzed. The discussions also assist in discovering deficiencies of knowledge and skills that relate to roles participating in the process. In the second phase, the aim is to make the actual process visible by defining the process phases in detail and define problems that relate to the process and its phases. In the third phase, the aim is to evaluate the modeling process, inspect the results, and plan future SPI activities.

Each phase includes modeling sessions, which are carried out as follows. Researchers, in this context referred as consultants, attend each modeling session.

They instruct the modeling technique to company‘s employees who participate in sessions, and guide and follow through the session. The employees participating in session are those who are involved in the process, which will be modeled. Modeling sessions last about three to four hours. Each modeling session functions also as a checkpoint for assessing what changes may have occurred.

The software process modeling sessions of the first phase began in February 2006. In the first phase, we have carried out three software process modeling sessions and had consulting meetings with the company’s employees after each modeling session. In meetings, the training needs were discussed, prioritized, and defined them as described in [12] to support the company’s independent SPI initiatives. The company has freedom to decide what problems they want to concentrate on and how to prioritize them. The company is also in charge of what improvement actions and steps will be taken. In order to carry out the necessary improvements, the employees are entitled to focused training and consulting through the development project, described in [13]. Taking advantage of training and actually implementing corrective measures is the company’s responsibility. However, these measures are discussed with employees and consultants at the beginning of new modeling session.

3.1 The First Modeling Session

The first session was carried out in February 2006. There were three consultants guiding the session and five employees from the company’s software engineering group, each responsible for different areas of software development process. First, the aim of the session was explained and the concept of process discussed and defined. Second, the employees were familiarized with wall-chart technique, and the main features of the modeling technique were explained. Third, the employees were instructed to choose the process that they wanted to model. They chose their software development process for modeling, which is the core activity of the company. For this most important and critical process from company’s point of view, all roles, and information flows were modeled.

All participating employees were actively involved in modeling and there was much discussion and interaction between them. They noticed and pointed out the problem of acting various roles. In SC, one employee has many roles and responsibilities and due to this, he or she should be able to assess the process and information flows from different perspectives. Despite this, there was not much disagreement about the roles or information flows between them and the problem areas were quickly identified. As an output from the first session, a wall-chart, an electronic diagram of the wall-chart and a draft text document describing roles and information flows were produced.

3.2 The Second Modeling Session

The second session was carried out in August 2006. Between the first and second session, the employees had a chance to inspect and approve the information flow model from the first session. There were two consults guiding and three employees participating in the session. The model from first session had been approved unchanged. However, the participating employees wanted to specify the modeling to software product development process. The wall-chart model was recreated to represent the roles and information flows of the software product development process.

The second session was easy to follow through, because the employees were already familiar with modeling technique and had already thought through the roles and information flows of the process. It was essential for the employees to go through the modeling and analyzing the wall-chart in tight collaboration with the consultants. Their motivation to proceed with the modeling and improvements had remained and even increased. As an output from the session, a new version of the wall-chart, an electronic diagram of the wall-chart, and a formal detailed text document describing roles were produced.

3.3 The Third Modeling Session

The third session was carried out in February 2007. Between the second and third session, the employees had a chance to inspect and approve the electronic version of model created from second session wall-chart. The model had been approved with slight modifications. The aim in the third sessions was to revise and enhance the approved model. There were two consultants and two employees attending to the session. However, during the session, analyzing the existing information flows, new problems occurred from the flows that had been considered functional.

There was no modeling with wall-chart included in the third session. Concentration was on extracting detailed information about the information flows, both problematic and functional ones, in the electronic wall-chart diagram. Each information flow and related roles were analyzed individually. Information flows, their contents and way of distribution, were defined in detail. The enhanced electronic version of the wall-chart was inspected and approved. As an output from the session, a formal document describing information flows was produced.

4 Key Points and Identified Problems

In this section, some of the noteworthy key points from the sessions are presented and the most important identified problems of the process are described at general level. These are summarized in Table 1.

In the first session, it was extremely important to create a confidential relationship between the consultants and employees, and among the employees themselves. The employees were able to recognize the roles quickly and there were not many conflicts about the roles. Concluding from this, the daily work in the company is reasonably organized and responsibilities in the process are defined at some level. However, adding the information flows between roles caused hesitation, but the problems that related to those were readily highlighted. The most problematic information flows concentrated on the critical design and implementation phase. Some noteworthy problems were related to project management. For example, the company had previously worked on only few projects simultaneously and now the growth has enabled to work on several projects at the same time, which has caused problems in resource management and the working hours follow up has been inadequate. Requirements and design documents are structured but the contents and the depth of documentation are fuzzy. There were also problems related to testing assignments and especially testing documents. Managing customer requirements was considered a problem, since the requirement documents were too detailed and exhausting to read.

Table 1. Key points from sessions and problems at general level

	Key points	**Problems at general level**
Session I	▪ Confidential relationship ▪ Software development process chosen for modeling ▪ Identified roles and information flows of the process ▪ Identified problem spots ▪ Problem area in critical design and implementation	▪ Project management ▪ Managing requirements and design documents ▪ Testing ▪ Managing customer requirements ▪ Working hours follow-up
Session II	▪ Software product development process specified for modeling ▪ Clearly better structured and specified view of the software development process ▪ Identified problem spots ▪ Software process improvement manager (SPIM) ▪ Product manager	▪ Managing requirements and design documents ▪ Managing customer requirements ▪ Assignments between some roles unclear ▪ Documentation maintenance
Session III	▪ Understanding distribution of work and what matters need attention ▪ All roles identified ▪ All information flow identified ▪ Process visibility ▪ Tacit knowledge to explicit knowledge	▪ Managing requirements and design documents ▪ Managing customer requirements ▪ Assignments between some roles unclear ▪ Product manager's role ▪ Documentation maintenance ▪ Undistributed tacit knowledge

In the second session, the employees specified the modeling to concern their software product development process and a new information flow diagram was created. Participating employees were already familiar with the modeling technique and the session was carried out smoothly. The model was better structured in the design and implementation phase. Concluding from this, the employees had given thought to the process between the sessions. However, even though the whole model was clearly more structured than the previous one, the process itself was not stabilized, some problems remained, and new ones occurred. The employees pointed out the importance of making the roles and their responsibilities clear for themselves. Some new roles had emerged, though the distribution of work between new roles is not yet completely defined. Two of the roles will have significant impact on the process. First role is a software process improvement manager's role (SPIM), whose responsibility is to assess current practices and to explore what actions can be taken for improving processes. Second role is a product manager's role, whose responsibility is to manage customer requirements in the future. The problems in managing the requirements and design phase's documentation and the exhausting

customer requirements documentation remained. In this session, the document maintenance was identified as a problem.

In the third session, one of the most important points the employees highlighted, was the need for converting the tacit knowledge of their common work methods to explicit knowledge. The distribution of organization to different geographical locations will bring further problems, if formal and documented working methods do not exist. The interfaces between companies' units need to be defined accurately, so that there would not be blocks on information flows and the employees would have a common way to communicate and work in a distributed organization. The third session was very important for revising the roles and especially the information flows in order to produce a well-defined and clear document of what these contain. The mere information flow modeling and specifying roles was valuable from the employees' perspective for visualizing their process. The process flows were also at this point becoming structured for the employees, and the point where the actual process modeling can begin was reached. There were still problems in the depth of documentation in definition stage, the assignments between some roles are not clear, document maintenance is not adequate, and the product manager for managing the customer requirements is not yet role of which some person would be in charge of.

5 SPI Actions Taken

As the process has been recognized, the improvement actions can be taken. The company is in charge of the improvement actions and the actual implementation. The company carries out the SPI activities the way that best suits their schedule and serves their business goals. The motivation for improvements is strong and it compensates the common SPI barriers and failed success factors presented in literature [14] [15] [16] [17] [18] [19]. The development project is used for supporting the SPI by modeling the process, by consulting and by organizing needed training for improvements.

The development project has encouraged the company for taking certain improvement steps, but additionally improvement actions have been carried out unprompted. Nonetheless, that some problems remain after modeling sessions and new ones occur, the improvements have been done and improvement work carries on. Some major improvements have been done in project management, testing and in documentation. Most recent improvements are related to managing customer requirements and are currently under strict definition. Project management has been improved by enhancing resource management policies and implementing a working hours follow-up system. Implementation of these has been quite successful and has provided clear advantages in project planning, scheduling, and resourcing. Document management and maintenance has been improved by defining document policies and by implementing document management software and document repository. The decisions made in meetings are also documented and followed that those will be carried out by the person in charge and this has improved traceability. Testing has been improved by applying IEEE standards of software testing (IEEE 829, IEEE 1008) and by implementing better software testing tool. Few employees have also qualified their testing capabilities by completing the ISEB foundation certificate in software testing.

Managing customer requirements is ongoing improvement effort, and now there is a clear role and job description for the person who will be in charge of this. For this role, the company is currently hiring new employees. The information documented during the development project has greatly clarified the capabilities and characteristics required from the person for the job. However, for the person in this role, they will need training, and this training is currently under definition. The decision to establish the role of software process improvement manager has also been an important improvement activity that the company has implemented. Now they have a person in charge of evaluating what improvements need to be done. Additionally, the person in this role is highly motivated, has academic and business experience, and can consider the SPI from both perspectives.

The company's employees have attended project management, testing, and technical documentation training, which have supported them in applying the improvements. Additionally, they have acquired general technical training in order to maintain and improve the quality of the products and the whole software process in general. These trainings have covered some of the identified minor process problems too. Altogether, the company has used 52 person-days for training within one year.

It is not possible to carry out a large number of improvements in a short period and it takes several months to implement one improvement effectively [20], as it is in this case too. The company has implemented quite exhausting number of small but significant improvements considering the effectiveness of their software product development process. The improvements have a direct affect to their daily business and indicate a change in work methods. The company has assimilated the importance and benefits of SPI work and established a role of a software process improvement manager. The company has prepared for the problems that growth will inevitably bring. They have the roles and information flows of their software product development process formally documented, thus having better knowledge of what characteristics and capabilities are required from new employees. The current employees have now clarified the process also for themselves and that will facilitate training and including a new employee in the process. They also have observed the need to convert tacit knowledge to explicit knowledge and the need for formal documentation and distribution of knowledge.

6 Discussion

SPI can be exhausting with all assessments, modeling, measuring, evaluating maturity levels and capabilities as presented in literature [20] [21]. SPI is resource consuming in large companies and it is that even more for small companies. SPI models for small companies are often based on some existing model that is originally targeted for large organizations [22] [23] [24] [25]. Furthermore, several factors affect the success of actual implementation SPI [14] [26] [27] and the period during which the SPI activities are carried out can be too short.

In this paper, we have presented case of lightweight software process modeling in a small software company and we have explored the usability of the model. The factors that contributed to success of the process modeling in this case were the initial awareness of the need for improvements and the employees' motivation and commitment to be involved in improvement efforts.

Small companies need some method for systematically going through their processes, work methods, roles, and information flows. However, the tool for this does not have to be a standard oriented and in-depth, since the most important thing is to make processes visible, identify problems in the processes, and initiate the SPI discussions in the company. This enables establishing the process culture and enhancing the SPI awareness. The modeling method has to be lightweight, applicable to current processes and relate improvement goals to business goals. The modeling work done in close cooperation with the company's employees and consultants, forces the employees to think about their own work, work methods, and skill deficiencies.

In presented case, the company has done needed groundwork for future SPI. In the beginning of the development project, the company did not have a clear concept of their information flows and roles of their software product development process. During this project, their knowledge about processes, process flaws and problems, own work methods and internal work distribution have enhanced greatly. The company has determinately followed through improvements for the selected problems. Improvement plans have been initiated by identifying problems using a lightweight process modeling technique, and the company has carried out the improvements with continuous motivation.

The second phase is now beginning with systematic modeling of the selected process. Prior to the development project, the company worked with the "experience and tacit knowledge", but now the process is structured for the employees so that it can be represented formally. The company has achieved the maturity needed for process modeling, the process culture is familiarized, and the selected process is structured. During the first phase, the company was not provided with clear guidelines and instructions what improvements and how they should implement. The second phase concentrates on defining a set of process phases. In the third phase, the improvements can be based on the results from the previous phases and at that point, follow-up and metrics can be used.

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