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The Role of Process Improvement in Attaining Strategic Goals and Providing Financial Value

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I. Introduction

Customers are demanding increasing value for the money they spend on high technology products. Moreover, competition in the high tech industry is increasing - nationally as well as internationally. As a result, satisfying the customer and providing increased customer value are becoming primary objectives for high technology executives and managers.

Many firms that once considered themselves "hardware companies" are now finding that they are developing a significant amount of software. This software is becoming increasingly sophisticated and costly. Moreover, software projects are increasingly "on the critical path". Software developers can put in more effort and work harder. However, it is the process used to develop the software which coordinates developer efforts and tools. This process can make or break the ability of the firm to deliver.

From a strategic standpoint for many high tech firms, improving the software development processes is becoming critically important. However, it is difficult to determine which processes to improve. Studies have shown that firms are finding it difficult to quantitatively justify the resources required to successfully improve their software development processes [5]. Still, many firms are involved in software process improvement efforts.

This paper provides summarized results from several companies who have been involved in process improvement activities to show the potential which can be achieved. We then discuss a framework for viewing process changes along strategic lines - with the goal of improving customer value. Once a set of potential process changes has been identified, these changes need to be evaluated. We discuss an approach which can be used to evaluate and tradeoff among proposed alternatives. This approach predicts the performance of process alternatives quantitatively in terms of development cost, product quality, and project schedule. In addition, financial measures such as return on investment (ROI) and net present value (NPV) can be obtained.

II. Why Process Improvement is Important

Market conditions and competitive pressures are requiring companies to shorten cycle times, reduce costs, and improve quality. Process improvement is an essential part of development activities. In the past, companies have focused on utilizing new technologies (e.g. faster computers, high level languages, new case tools) and hiring highly skilled software engineers. However, for today's high technology products which often require peak development staffs of 50 developers or more, it is extremely difficult to hire and retain the needed number of high-end developers. Teamwork and coordination are required. It is the software development process that coordinates the technology and people in order to get the job done. It is well documented in the manufacturing and TQM literature that the process has significant influence on the product which is developed.

In the past, many companies have not focused on their development processes or on process improvement. Some of the possible reasons include:

- Process improvements could not be justified.
- Process changes to the project present a risk. With so many other things that are unstable about a project, such as requirements or technical feasibility, it is difficult for project managers to introduce one more level of complication and opportunity for things to go wrong.
- Process improvements can take a long time to return tangible benefits.
- The perception by management that allocation of employee effort to process improvement activities takes away from their "productive time" coding or conducting some other direct activity.
- A feeling that process improvement is not very important (compared to other issues facing their firm).
- Process improvement can be expensive.
- Process improvement does not always succeed.

III. Benefits Observed by Other Firms

It can take considerable resources to initiate and maintain process improvement activities. There are ways to minimize the costs, but in general, it takes management perseverance as well as significant effort on the part of the staff. Table 1 provides summarized results from 13 companies who have been involved in process improvement activities. The results show the potential that can be achieved when companies make a sustained commitment to process improvement.

IV. Linking Company Strategy with Process Improvement

In order to maximize the benefit for the firm, process improvements should be designed with the goal of improving customer value. How customers perceive value depends on the type of product and the relative level of competition in the market. (The "competition" to a great extent sets the level of customer expectations.) In some markets, quality is more important than in others. The same is true for schedule. Depending on the market and the specific product being developed, different concerns and constraints will apply. The "one size fits all" approach is not correct. Functionality, ease of use, reliability, customer service and support are other attributes which are important. Designing a software process that can be tailored to support these customer values is key to success.

We propose combining strategic issues with operational concerns. We use this combined set of goals to drive the creation of a set of process alternatives. Operational concerns can be derived from industry standards such as ISO 9000, the Capability Maturity Model (CMM), SPICE, and others. These standards specify known "good practices" for the development of software and provide guidelines regarding how to stabilize the process and improve the quality of the product. By combining these two sources of process changes, a firm would be faced with many process change alternatives. However, the question of which process change(s) should be selected for implementation remains. Moreover, of all the possible alternatives, which process changes provide the greatest positive impact on overall project performance?

V. Quantifying Financial Benefits

Once a set of potential process changes has been identified, these changes need to be evaluated. In order to accomplish this, quantitative models which deal with process level issues are required.

Process Models [2] support process improvement by providing operational guidance regarding the critical sequence of process steps, information flows, and organizational responsibilities. These models are distinct from other models because they delve into the details of the process used to develop software[8], [9], [1], [7], [3], and [4]. Much of the work in the area of process modeling to date has been in developing tools and methods for modeling software processes. However, process models can be used to quantitatively analyze and assess a variety of issues.

Work conducted by Kellner shows how process models could be used to support management planning and control activities [6] using both deterministic and stochastic models. The model presented in this paper extends Kellner's work [6], and incorporates analytic and empirical components into process models as well. This creates a synergistic combination which expands the range of issues that can be quantitatively assessed using a process modeling approach.

Table 1
Benefits Achieved for Software Process Improvement

CATEGORY	RANGE	MEDIAN
Total yearly cost of SPI activities	$49,000 - $1,202,000	$245,000
Years engaged in SPI	1-9	3.5
Cost of SPI per software engineer	$490 - $2004	$1375
Productivity gain per year	9% - 67%	35%
Early detection gain per year (pre-test)	6% - 25%	22%
Yearly Reduction in time to market	15% - 23%	19%
Yearly reduction in post release defect reports	10% - 94%	39%
Business value of SPI investment	4.0 - 8.8	5.0

SOURCE: Software Engineering Institute, Technical Report CMU/ SEI-94-TR-13, p15

Work conducted by Raffo [11] uses stochastic simulation models of each process alternative. The approach features careful modeling of process steps, information flows, and organizational responsibilities. In addition, there is explicit modeling of complex interdependencies among process components. Using this information, the model predicts development costs (effort), project schedule, and quality (remaining defects) that results from the process being used.

Quantitative predictions are made possible using a new technique called Task Element Decomposition which was developed to manage the computation of interdependent operation times in large-scale projects. The Task Element Decomposition technique enables a variety of product and process factors to be taken into account [10]. These factors can include source code size, quality, and complexity and developer skill. Looping and operation time dependencies with uncertainties are constructed to quantitatively measure important performance characteristics of the system and to support extensive sensitivity analyses. This enables the process model to be used to evaluate alternative processes and to assess the impact of potential process changes.

Once this kind of process model is developed, realistic process scenarios can be run to test important process related contingencies. A multi-attribute decision making framework (employing utility functions) is then used to tradeoff among the three performance measures of cost, quality, and schedule in order to compare the overall performance of the process alternatives.

This approach predicts the performance of process alternatives quantitatively in terms of development cost, product quality, and project schedule. In addition, financial measures such as return on investment (ROI) and net present value (NPV) can be obtained. This approach for evaluating process alternatives quantitatively has been applied at a leading software development firm. Results from this study are presented in [11] to provide an indication of the potential of this approach and the kinds of analyses that can be done. Each company is different. What works in one development environment is not guaranteed to work in another. The approach presented used process models which are tailored to a company's specific development process. The results of the analysis can be used to build a business case to justify process improvement efforts.

VI. Conclusions

Process improvement is a very valuable and essential aspect of software development operations. These days, everyone is developing software. Companies need to improve their development operations in order to be competitive. Those companies which provide superior customer value will succeed. Process improvements should be designed to support company strategic goals and to improve the firm's competitive position. This means providing improved quality, functionality, service, dependability, and reduced cost.

Process improvement does require a focused effort. Many companies have reported significant benefits from their process improvement efforts. Companies want to know the benefit they can expect from a process change on their own processes *before* they invest in implementing it. Because each company is different, it is important to find a method to predict the impact on specific project operations. We present a process modeling approach that is tailored to a company's specific development process. This approach predicts the impact of a given process change in terms of development cost, project quality, and task schedule. The results of the analysis can be used to obtain management buy-in and build a business case to justify process improvement efforts.

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