Software Process Assessment and Contract Monitoring

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Abstract

Software process assessment and improvement methodologies represent, for a software supplier, a well known approach to achieve quality and efficiency in its development process. For the customer, contract monitoring is an emerging approach to control the quality delivered in a specific supply. This paper aims to show how software process assessment and contract monitoring both address the customer satisfaction and the improvement of the supplier process capabilities. In this perspective, they can be considered complementary and profitable approaches in the achieving of software quality.

1. Introduction

The goal of my management was to achieve quality in the development process of our company. It is my pleasure to inform you that this goal has been reached: our products are still clumsy, but we are very proud of the way we realize them.

J. Random, chairman of FuzzBuzz Software Inc.

In each customer-supplier relationship the crucial issue is product quality. While customer satisfaction is strongly related to the quality of the product, the customer is not interested in how the supplier develops the product or in the problems that led to a low quality product. We do not want to discuss the validity of the idea that quality must be related to processes, but to emphasize that this is a point of view of the supplier. The value of this approach relies on the real and immediate benefits for the developer. Benefits for customers, although present, are limited in their extent.

It is difficult to say that the required quality can be efficiently delivered without a well defined, enacted, and controlled process. Efficiency is, however, an advantage for the supplier: efficiency is the mean to be profitable. The customer has a special interest in receiving in due time the required product, but the economical aspects of the production process of the supplier are not relevant issues for the customer.

A supplier with a process certified with respect to an international standard offers only limited warranties that do not explicitly refer to the quality of the delivered product. The benefit for customers derives from the capability of the developer process to be classified and controlled. A process rigorously defined, that adheres to a commonly accepted framework, can be easier controlled by an external subject, in
particular by customers willing to directly control the quality of the product. Moreover, the supplier, proud of its development process, will positively accept an external control.

Software Process Assessment and Improvement (SPA-I) methodologies represent a well-known and widely adopted approach to achieve quality in the development process of a supplier. Contract monitoring is an emerging approach to control the quality delivered in a specific project. While the context of SPA-I is the general model of the supplier process, the context of monitoring is the specific contract between the supplier and the customer, that performs the control activities.

In this paper we show how software process assessment and contract monitoring are complementary approaches in the achieving of software quality. The will of suppliers to improve their processes has a new partner in the determination of customers to control the development of the product.

In Section 2 we make some considerations about “preventing and healing” as a natural approach to face problems, with particular regard to the software development context. Section 3 is devoted to highlight the characteristics of SPA-I approaches. Section 4 describes monitoring as used in the contracts signed by Italian Public Bodies: up to now this is the field in which monitoring is better defined and most widely applied. Section 5 shows how SPA-I methodologies and contract monitoring can be profitably paired to gain better results in software development and supply.

2. Preventing and Healing

Preventing and healing are two aspects of a complete, albeit intuitive, approach that can be applied to almost all problems. We must be able to minimize the chances that a problem will arise, but we also want to react to the manifest problem in those cases – hopefully few – in which prevention was not successful.

The software development life-cycle is full of examples that corroborate the “preventing and healing” strategy. Analysis, specification, design, coding according to rigorous standards, are all activities whose aim is to prevent. Verification, validation, inspection, unit and system test, debugging, are activities in sequel that aim to detect and fix the non-conformities for which prevention was not effective.

To be effective, quality control must comprehend both approaches. Software industry is still too young to rely on mature methodologies: the turn over of technology is so fast that it is impossible to imagine and trust in stable platforms. This scenario depicts a situation so critical that is mandatory to face quality control with all possible means.

Rigorously defining the development process is a kind of prevention in itself. It is the supplier that totally manages prevention, by deciding how to define, enact, and control its process. As we previously noted, the definition of the process, although rigorous, does not offer any special warranty to the customer. Moreover, like all prevention strategies, there is some amount of risk. In the case of software development, such risk depends on many and extremely variable factors, one for all the human one. Programmers, for instance, often and wrongly treated as raw man-power, carry out a critical work that can have a strong impact on the final quality of the product.
Process assessment methodologies enable the evaluation of the development process. In practice, following these methodologies the supplier can express a measure of its capability to manufacture products of defined quality or, in other words, to prevent the rise of problems that could compromise the delivered quality. The knowledge of the process is mandatory for its improvement: in this perspective, assessment methodologies are a valuable tool for a supplier in the quest for specific actions that will improve its development process.

If we accept the idea that process assessment is a kind of prevention, what is its ideal complement in the perspective of preventing and healing? Since prevention is in charge of the supplier, there exists a remedy under control of the customer?

Acceptance test is the traditional control that the customer applies when the product is ready to be delivered. The acceptance test, however, cannot face all the risks the customer is exposed to. First of all, it has no power against delays in the delivery. Moreover, when the acceptance test discovers defects in the product, it introduces further delays for their removal. The cost of the delay, even in terms of lost revenues, can overcome the whole cost of the software system. Only lawyers will find true benefits in customer control based on the acceptance test.

It is mandatory to anticipate control to prevent defects and delays: the customer has good reasons to invest resources in this attempt. The monitoring of the development process, performed by or on behalf of the customer, is therefore the right complement to the supplier commitment in continuously improving its process. The goal of monitoring is to control that the supplier process, instantiated for a specific product or project, conforms to the required quality levels and leads to the required results. Since this control is performed during the enactment of the process, the customer can also control that the development is not delayed, that costs do not increase, and in general that the overall quality of the delivery is not negatively affected.

In fact, “preventing and healing” is a standard approach of risk management strategies, where “management” comprehends prevention, control, and recovery activities. In the context of monitoring it is relevant that risk control is performed by initiative of the customer.

3. Process Assessment

Process assessment is the evaluation, performed according to a well-defined methodology, of the development process of a software company. The term Software Process Assessment and Improvement puts together the twofold goals that drive the evaluation: to define the quality level of the process (usually in terms of maturity or capability) and to identify improvement strategies. Figure 1 reproduces the classical model used to describe the SPA-I process.

A company that decides to submit its software process to assessment is repaid by numerous advantages. First of all, the company can be the immediate recipient of a certification, which evaluates its process with respect to a commonly accepted standard. The right side of Figure 1 shows the process followed by a company that, for instance, submits its quality system to ISO 9000 certification. In this sense, all the assessment methodologies adopt a scale to measure and certificate the capability of the assessed process.
More generally, the assessment induces a better knowledge of the process. This knowledge is the necessary condition for all the initiatives aimed to resource optimization and process engineering. Assessment contributes to the continuous improvement typical of the philosophy of Total Quality Management. It is widely accepted that continuous improvement is the most effective strategy that a company can adopt to be competitive. The left side of Figure 1 can be interpreted as an instance of the Plan-Do-Check-Act cycle defined by Deming [12].

The historical motivations in the use of SPA-I methodologies do not come from the software industry, but from customers of large systems that heavily depend on software, typically in the military and communication areas. The most widely known SPA-I model, the Capability Maturity Model (CMM) [5, 10] was developed by the Software Engineering Institute to satisfy the needs of the US Department of Defense regarding classification and selection of suppliers. The evolution of the software process, from chaotic to engineered, from craftmanship to industry, is in the CMM perspective a route of five steps that identifies the maturity of a software company. Each level is characterized by precise aspects of both the company organization and the adopted control techniques. The model also identifies the actions needed to progress from one level to the higher one. In this sense, CMM is not only a classification tool but also a concrete methodology for process improvement.

In the search for software quality the organization of the development activities and, more generally, the whole organization of the company are aspects of primary relevance. In this perspective, the ISO 9000 series of standards [6] is a commonly accepted reference. In some market areas ISO 9000 certification of the supplier is a mandatory requirement to have access to bidding procedures both at the national and international level. For instance, this is the rationale of the directives of the European Union for the acquisition of information systems with bidding procedures open to all the members of the Union. While ISO 9000 is a general series of standard that addresses the quality system instead of the software development process, there are many issues shared by ISO 9000 and SPA-I [10]. In this context, ISO standards become a mandatory reference for assessment methodologies. The Bootstrap project [9], sponsored by the European ESPRIT programme, merged in a single SPA-I methodology the CMM approach with the ISO 9000 directives for quality system management. In doing so, the maturity level scale has been refined.

Other SPA-I methodologies have been developed, mainly for internal use, by leader companies directly involved in software development (software factories or companies that develop software as basic component of their systems). The Software Process Improvement and Capability dEtermination (SPICE) project [13] aims to merge different approaches with the goal of defining an SPA-I standard. ISO/IEC is a partner in this project: the expected results will give raise to the ISO 15504 standard (currently in the approval phase as ISO TR 15504). The standard covers assessment and improvement of all the facets of the software process: acquisition, development, management, maintenance, support, and related services. The goal of ISO 15504 is to establish a framework that allows an assessment methodology to express the capabilities of a process with respect to a common scale. Another goal of the ISO 15504 standard is to suggest directives on how to migrate from the current SPA-I models to new models compliant with the standard. The need of an SPA-I standard is mainly perceived by the market: customers will be able both to determine the supplier capabili-
bilities with respect to a common framework and to evaluate the risks deriving from the choice of a supplier. A dual advantage of the existence of a standard for SPA-I is on the side of suppliers that can choose with better confidence the tools for improving their processes.

At the current state of the art, SPA-I has its foundation in two elements: a scale to express the capabilities of the development process, based for instance on the maturity concept, and a set of key practices used to derive the quality attributes of the process. Key practices cover all the aspects of a software factory: company organization, management policies, development methodologies, technologies and tools used to support the software process.

Coming back to the leit-motiv of “preventing and healing”, we are quite confident that SPA-I is an effective preventing tool. For customers, the advantages that come from software companies positively following this approach are better chances to choose the right supplier and all the benefits derived from their continuous improvement: reduced risk levels, better products, low costs.

4. Contract Monitoring

Monitoring is a kind of quality control that must be performed during the carrying out of contracts regarding the information systems of Italian Public Bodies. Monitoring has been introduced in the Italian law that rules implementation and acquisition of information systems for Public Bodies [3].

Monitoring main aim is the early identification of problems that may arise before the delivery and that can introduce delay or quality defects in the supplied product. Monitoring can be performed by the customer itself or by a third party that acts on its behalf. As defined in the Italian context, monitoring represents a complete and innovative kind of control that for the peculiarity of its first application area promises to
be valid and effective. However, monitoring has characteristics that make itself applicable to other contexts: Public Bodies of other countries and companies that strongly rely on software systems.

The official document [2] contains the first definition of the monitoring characteristics and of its enactment. It envisages six phases in contract enactment: for each of them we highlight the limits and the goals of monitoring.

- **Design**: this phase aims to identify the requirements of the Public Body and to formulate a definite solution; it produces the documents involved in the contract enactment, such as the project plan, the quality plan, and the cost/benefit analysis. These documents are then used, in subsequent phases, as items of reference for monitoring. In the design phase, the purpose of monitoring is to ensure correspondence between the documents produced and the guidelines laid down in the feasibility study previously drawn by the Public Body.

- **Implementation**: this is the phase in which all the activities listed in the project plan – and whose goal is the realisation of the product or the service defined in the contract – are performed. Here monitoring verifies the match between the activities performed and those specified in the design documents. The main item of reference is the project plan.

- **Acceptance**: this phase comprises all the tests, verifications and proofs needed to guarantee that, prior to installation, the products or the services provided satisfy the contract requirements. Monitoring should neither replace nor overlap with the acceptance test, since this is a standard control activity. In this phase, monitoring rather ensures that all the tests, verifications and proofs performed during the acceptance test are adequate to guarantee the product or the service quality levels, as stated in the quality plan.

- **Installation**: this phase comprises the preparation of the operating environment, the application set-up and the training of personnel. For those aspects not covered during the acceptance phase, monitoring here checks the adequacy of the packaging, of the user documentation, and of whatever else is needed to guarantee maximum operationality of the information system; the main item of reference is the quality plan.

- **Management**: this phase identifies the operative life and the actual usage of the information system. Monitoring here evaluates the gaps between both the actual system performance and the customer satisfaction on the one end, and the requirements stated in the cost/benefit analysis document on the other.

- **Maintenance**: in parallel with the previous one, this phase identifies the specific activities which, though they belong to the management phase, are characterised by correction and improvement of the product or service. Thus, monitoring verifies that the changes performed to the system are relevant to the needs of the Public Body and that they will not compromise the characteristics expressed in the quality plan.

We have seen that monitoring prescribes, phase by phase, how to control the performance of the activities defined in the contract and how to validate their adherence
to the needs stated by the Public Body. From an orthogonal point of view, monitoring can be seen as an activity aiming to control specific facets of the contract enactment which, though bound to the quality of the final product, are not directly related to the phases of its realisation. Four “specialised” facets of monitoring have been identified.

- **Supplier process monitoring.** Monitoring is here seen as a control of the adequacy and reliability of the supplier. The objects of analysis are the way in which the supplier works, its competence in the area concerned, the structure of the supplier’s organisation and the warranties, including the financial ones, offered by the supplier. The supplier process is evaluated with respect to a reference model chosen by the monitor, either derived from a maturity model or conforming to international standards such as the ISO 9000 series. The best situation – and for this reason the one to be preferred in the contract assignment – is when the supplier adopts a well defined and, if possible, certified process. In this case, the monitor must analyse the supplier quality manual and subsequently verify that all the directives therein contained are effectively applied during the contract enactment.

- **Project management monitoring.** Monitoring here has the purpose of controlling the correct development of the activities prescribed in the contract. This control focuses on schedules, costs, and risk prevention. The main reference document is the project plan. In addition to discovering gaps, the monitor is required to help identify the causes of underlying problems. In this specific context it is important to stress the co-operative nature of monitoring: the monitor can suggest a course of action, though always without any prescriptive authority. By contrast, it is a precise duty of the monitor to subsequently verify that the suggested actions, eventually endorsed by the Public Body, are followed by the supplier.

- **Product quality monitoring.** Here monitoring concerns the control of the match between the supplied product or service and its quality specifications. The main reference document is the quality plan: besides stating the needs of the Public Body, this document must specify the indicators to be used for evaluating and controlling the product quality characteristics.

- **Investment benefit monitoring.** This monitoring facet has the purpose of ensuring that the added value of the product or service fulfils the Public Body’s expectations, mainly with respect to the financial resources invested. The reference document is the cost/benefit analysis prepared by the customer in the early phases of the acquisition process.

These facets should not be interpreted as a breakdown of monitoring. Indeed such a breakdown might encourage the application of only one or some of the facets of monitoring. Monitoring, by definition, aims to be complete and accurate: the identification of the above facets should be understood as an explicit description of the coverage level expected from this kind of control.

The fourth facet of monitoring is not really pertinent to our perspective, which strictly regards the software development process. However, it is worth noting that, should the other facets of monitoring not reveal any problems, investment benefit
monitoring does not scrutinise the work done by the supplier but rather the investment plan devised by the customer.

Figure 2 depicts the process model of contract monitoring. Besides the graphical similarity with the SPA-I model, the picture shows how monitoring, that controls the contract enactment, can lead to changes in the supplier process. Because contract enactment is based on the supplier process, solving the problems discovered during monitoring is also a way to discover defects in the process and to identify changes that will improve it.

The most interesting aspect of monitoring is that it entails a high degree of customer initiative: in Italy, monitoring is a control activity required by law and aiming to ensure the satisfaction of the customer, i.e. a Public Body [1]. Quality control should be – and is generally presented as – a supplier initiative, determined by competition and market considerations, aimed to give confidence of the delivered quality to the customer or to the company management. Monitoring is a continuous, very specific, and pervasive activity imposed and performed by the customer. The introduction of such a control, especially at the customer’s request, is a sign of dissatisfaction, often accompanied by suspicions of dishonesty.

More rationally, we prefer to ascribe the monitoring initiative to an achieved level of maturity of the customer. Monitoring represents the will of actively participating to the development process of a required and crucial product: it is important to note that the customer, setting up a monitoring activity, supports an additional cost.

From 1993 – when it was introduced by law – to now, monitoring was applied to many important contracts regarding acquisition of information technology by Italian public bodies. A significative part of these contracts was signed before the law; as a consequence, monitoring activities encountered strong opposition on the part of the suppliers and, in some cases, also on the part of the public bodies, which dislike a too much rigorous control of their affairs. Other problems in the application of monitor-
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<td><strong>a. number of closed contracts that was subjected to monitoring</strong></td>
<td>9</td>
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<td><strong>b. number of outgoing contracts that are subjected to monitoring</strong></td>
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<td><strong>c. number of starting contracts that will be subjected to monitoring</strong></td>
<td>29</td>
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<td><strong>total amount of contracts in a (in ECU)</strong></td>
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Fig. 3. Some data about contracts of Italian public bodies that are subjected to monitoring

ing derive from the additional costs and the lack of skills necessary to perform monitoring with resources internal to the public bodies.

While it is early to have an objective judgement about monitoring results – contracts take several years to be completed – it is evident, both from the public bodies and the information technology suppliers, an increased commitment in the carrying out of the contracts. Thanks to monitoring it exists, for instance, a good documentation of all the supplier activities, and it is read by the customer too. Figure 3 collects some data about monitoring of contracts of Italian public bodies.

5. A Profitable Pair

The existence and the application of contract monitoring, as defined by the Italian law, brings new perspective in the interest that a customer can have both in the supplier process and in the methodology used for its assessment and improvement.

Monitoring is an investment of the customer that invests additional resources to help the supplier in quality assurance. The return of investment is that the project will succeed in due time and within the estimated costs. In Italy, Public Bodies are asked to control the supplier process by mean of monitoring, but the Italian law on monitoring is not an exceptional case. Contract monitoring is an activity defined (although not yet fully specified in its details) even in the context of European projects that aim to introduce rationalization and control in the acquisition process [4]. The ISO model for the software development process also prescribes such activity [8]. Moreover, the idea that the supplier may be object of a control directly performed by the customer is already present in the ISO standard that rules auditing [7].

While useful for the indirect benefits to the customer, SPA-I methodologies are tools used and controlled by the supplier. Monitoring represents the complementary tool that gives the customer the ability of evaluating the supplier. Moreover, the evaluation is not performed with respect to a general process model, but during the development of a required product. The goal and the advantage of monitoring is its ability to detect and to timely solve problems that may arise during the enactment of a contract.

Monitoring shares with SPA-I its main goal: to realize satisfactory products controlling the efficiency of the processes. Can monitoring share SPA-I approaches and methodologies too?
Each SPA-I approach defines a framework of key practices. The way key practices are carried out in a specific process is the base for process capability assessment. The same framework can be used during monitoring to control the realization of the product. The different aspects of monitoring (supplier process, project management, product quality) can be related to the hierarchy used to structure key practices (as for instance in Bootstrap, organization, methodology, technology). The existence of a standard for SPA-I is a benefit also for monitoring: a process assessed with respect to a defined framework can be more easily controlled referring to the documentation of the assessment process. The supplier can offer a better support to the monitor and, as a benefit, the monitoring results can be used to define improvement actions.

6. Conclusions

In this paper we discussed some issues about quality in the software development process and in the customer-supplier relationship. The following points summarise our ideas:

- “preventing and healing” is a natural and widely adopted approach to achieve quality during software development;
- in the relationship between customer and supplier, SPA-I methodologies represent “preventing” while contract monitoring is a kind of “healing”;
- there is a natural and sound distribution of responsibilities, since “preventing” is driven by the supplier and “healing” is in charge of the customer.

Monitoring is a need, required by Italian law but also defined in other contexts (Euromethod and ISO 12207, for instance). SPA-I methodologies are widely accepted by the supplier community. This suggests that the two approaches can be fruitfully paired leading to a better co-operation between the customer and the supplier:

- SPA-I methodologies and future standards define a framework for process evaluation that can be profitably used also as a reference for the control activities of contract monitoring;
- monitoring activities and results can be used by suppliers to define actions that will lead to improve their process;
- support to monitoring activities should be considered as a valuable capability in the evaluation of a software process.

This paper is the result of our work in the study of new methodologies for contract monitoring in the context of Public Bodies. The research has been performed in the context of the project “Metrice e strumenti di valutazione per la Pubblica Amministrazione - Protagora”, sponsored by Progetto Strategico del CNR “Informatica per la Pubblica Amministrazione”. In the future we plan to investigate on the relationship between contract monitoring and SPA-I with the goal to export the monitoring approach in a more general context.
7. References

Some of the listed references cite Italian laws: [3] is the Italian law in which monitoring was defined for the first time; [2] is the first edition of the official guidelines for monitoring.


