Assessing Value of SW Architecture

PASI OJALA
Hintanmutka 17 A 6, 90650 Oulu
FINLAND

Abstract: - During the last decades software architecture has become increasingly important for companies creating competitive product structures. Recently more and more attention has also been focused on the costs, cost-effectiveness, productivity and value of software development and products.

This study outlines concepts, principles and process of implementing a value assessment for SW architecture. The main purpose of this study is to collect experiences whether the value assessment for product architecture is useful for companies, works in practice, and what are the strengths and weaknesses of using it. This is done by implementing value assessment in a case company step by step to see which phases possibly work and which phases possibly do not work.

The practical industrial case shows that proposed value assessment for product architecture is useful and supports companies trying to find value in product architecture.

Key-Words: - software engineering, value-based approach, cost, worth, value, architecture

1 Introduction

The objective of the value-based approach [3] is to find ways to eliminate value loss in software development, software products, and software process improvement (SPI) using the value assessment framework of Koskela and Huovila [2]. Value-based approach uses economic-driven tools, which are based on economic studies including, for example, the areas of cost estimation, cost calculation (for example ABC and life cycle costing) and investment calculation. The value-based approach prefers calculating costs instead of estimating them, and also considers software development and SPI as investments, on which it is possible to spend too much money [1, 5]. In practice, it takes care that the customer requirements are met in the best possible manner, ensuring quality, timeliness and value in products as well as in processes, over their entire life cycle. In particular, the aim of ensuring quality connects it to the other methods aiming for quality improvement.

The value-based approach indicates a clear dependency between the process and products. It sees that we need to develop and optimize process activities so that processes produce the products needed. Furthermore, it sees that we must analyze products in order to reveal problems in processes and develop processes from the product point of view as well. This is vitally important, especially for companies respecting customer opinions and aiming to optimize costs in their processes, because the customers are the ones paying for the products and product-related services, and companies have to allocate all costs to products to be able to price them. The happier the customer is, the more worth he sees in buying the products from us. It is also clear that when we know our process and product costs, worth and value, our ability to estimate, budget and control future risks will improve significantly.

The purpose of this study is to collect experiences of using value assessment for product architecture in an industrial case. In more detail the purpose is to answer to following questions:

- How the proposed value assessment for product architecture works in practice
- Whether the company assessed sees the value assessment for product architecture useful
• The strengths and weaknesses of value assessment for product architecture

2 Value Engineering Process

In the literature there are several definitions for the VE process. However, in practice, they all state that VE collects and analyzes value-related information, to create new ideas using the analyzed results and to evaluate and further develop them into a meaningful package, with the reduction of costs or the increase of worth and improvement of value as ultimate goals.

This study categorizes VE process into three main phases: pre-study (orientation), value study (information, function analysis, creativity, evaluation, development, presentation), and post-study (monitoring, implementation). These phases are considered appropriate since they constitute independent areas of VE and have been justified in earlier discussion.

According to Value Engineering, value is a measure – usually in currency, effort or exchange, or on a comparative scale – which reflects the desire to obtain or retain an item, service or ideal. Cost is the price paid or to be paid. It can be divided into elements and, to some extent, functions. Park [4] defines cost as “an expenditure of money, time, labor, etc., to obtain a requirement.” Worth is usually defined as the lowest cost to perform the required function, or the cost of the lowest-cost functional equivalent. The most typical definition for value, is perhaps (1):

\[
\text{Value} = \frac{\text{Worth}}{\text{Cost}} \tag{1}
\]

where:

Value = The value of some object, product, service or process.

Worth = The least cost to perform the required function (product, service or process), or the cost of the lowest-cost functional equivalent. If possible can also be the worth in money, what customer sees in product, service or process.

Cost = The life cycle cost of the object, product, service or process (price paid or to be paid).

3 Value Assessment for Product Architecture

3.1 Background

Value assessment for product architecture was implemented in fall 2006. The basis of it was the requirement list done customer and vendor together. The requirement list contained requirements such as: Picture call, Emergency, User, Server, Distance configuration, Video, Service, Camera and Activities. The architectural component list (structure) defined by vendor contained components such as: Basic structure, Settings, Log, Telecommunication, Video, Emergency, Server, Users, Distance configuration, Sending, Activities, Surveillance and Services.

3.2 Information

The product to be assessed was a typical electronic product containing software and hardware. The vendor was responsible for developing the product and the customer for defining user requirements for it.

After the decision concerning the development and implementation project had been made, the vendor nominated an architect for the project, who was responsible for the creation of a more detailed technical solution for system architecture and development work. He was also responsible for calculating more precise estimates of the development resources needed for each component. After estimating resource needs the vendor selected designers and testing engineers for the project, and the customer selected other project members.

In the assessment opening meeting, the purpose of the assessment was discussed with the vendor and the customer. The definition value=worth/cost was discussed, and it was seen as extremely important to find out which components of the product gave the best value to the vendor without neglecting customer needs. The customer had a strong interest in analyzing priorities and worth in components, for further product development work.

It was considered natural that too much detail in the architectural description would probably cause problems when calculating customer worth, because the customer does not
necessarily have enough technical expertise to understand the technical product structure in this case. Therefore, in the assessment, an architectural list was provided which included functional descriptions defining the activities for each existing component.

After the discussion, it was decided that value would be calculated for the architectural components listed in the architectural description. This decision was strongly supported because the vendor’s cost accounting system made it possible to track real costs for the specified components.

As a final point of the initial meeting, vendor and customer roles were discussed. The vendor emphasized that it would like to undertake the phases from creativity to presentation without the customer being present, since these phases included brainstorming to gain a new understanding of all the processes used to develop products. The customer saw that the most interesting phase for them was functional analysis, where both sides would prioritize components, and give estimates of worth and cost using relative numbers like percentages (not stating real costs). This point of view was clearly understood by both parties, as the customer was primarily interested in evaluating component priorities, in order to see how well the vendor had understood their wishes. As a secondary issue the vendor was also interested in getting an idea of how much each component really costs compared to the worth it provides. The customer understood all wishes of vendor and saw that they did not have a strong interest in development methods and improvement proposals, which were considered to be more critical for the vendor’s business.

3.3 Function analysis

In the first assessment meeting four customer representatives (referred to as “customers”) and three vendor representatives (referred to as “vendors”) prioritized the architectural components. Afterwards, the customers allocated worth to each component using a percentage scale from 0% to 100%. The idea was to identify in percentages what kind of worth the customer sees in the components. The vendors allocated costs using the same percentage scale from 0% to 100%. As a result of this, the customers had given worth percentages for all components, and the vendors had given cost percentages for the same items. The calculated worth and cost were later compared, using percentages, to the real worth and cost, to find out the difference between “belief” and “reality”.

During the function analysis phase the technical representative of the customer pointed out that, when prioritizing, one cannot necessarily treat all components equally, because some components are tied together. In practice certain components have to be implemented before others. Some components are independent, and others are not. Certain components rely on certain other components for their existence. However, he emphasized that even though this is the case, it does not affect all components, and prioritization clearly gives one a better picture of components, and of their importance in relation to each other.

All the interviewees agreed that the prioritization of components clearly helped in the next phase, in which the same components were analyzed in terms of worth and cost. When asked to mark how much of the total price they would assign to each component, the customer representatives preferred to use percentages rather than actual monetary values. The vendors shared this viewpoint, and stated that it was easier for them to give cost information in percentages rather than in actual figures. As the final customer price and real production costs for components were all known, it was decided that these allocations would also be done, but for vendor use only.

For the technically-oriented customer representatives it was fairly easy to assign worth to components. The user-oriented representatives considered it slightly difficult at first, but once explanations of each component were provided they too found it quite easy (AV=average, C=customer, V=vendor). The results of prioritizing components were understandable and quite expected. During the prioritization all persons had an explanation list of the purpose of all components in front of them, which helped to understand the purpose of each component. Especially all customer
representatives saw this list helpful. Figure 1 shows the average priorities for components.

Fig.1. Average priorities for components including all interviewees (AV=average, C=customer, V=vendor)

In the interviews, all the customer representatives stated that they had prioritized requirements, and the vendor had presented the component structure to the customer before the sales agreement was signed. This was seen important because it was considered important that when there is a limited amount of money it should be used effectively both in terms of requirements and of components. During the interviews, two customer representatives also underlined that the architectural structure was evaluated separately before the project was begun because this was seen as vitally important for the future development of the product. Vendor representatives fully shared this point of view. How the customer prioritized components can be seen in Figure 2.

When comparing the customer’s and vendor’s priorities for components, one can see that variance is significantly higher among the customers. This is most probably due to the fact that there is more variance in technical knowledge among the customers. How the vendor prioritized components can be seen in Figure 3.

Fig.2. Average priorities for components including all interviewed customers (AV=average, C=customer)

Fig.3. Average priorities for components including all interviewed vendors (AV=average, V=vendor)

One conclusion of discussions was that worth and cost allocations for all components were seen as relevant for both sides, even if only stated as percentages. According to customer they also had their own idea about the actual costs of production, and since they knew the worth they were satisfied for the situation. Figure 4 presents the average worth and cost for components.

On the whole, the experiences of using prioritization in ranking components were positive. Even more interest was seen in the analysis of worth and cost for each component, and especially in the differences identified.
between customer and vendor, as well as between technical- and user-oriented personnel.

3.4 Creativity

In accordance with the agreement between the customer and the vendor, only the vendor participated in the phases from creativity to presentation. The first step in the creativity phase was to allocate costs to all components. According to the vendor it was easy to allocate costs to the components. General costs were perhaps the most difficult costs to allocate. This was because costs such as the project manager’s salary usually cannot be allocated directly to any particular component.

The project team decided that for the purposes of this assessment it was satisfactory for only project-level costs to be allocated to components. Business unit- and company-level general costs were not allocated to components. Hence, from a value index point of view, the results are more optimistic than they should be. However, because the project personnel saw that they could not influence these costs at the project level, they should not have an effect on “project-level” value improving figures either. Naturally, if this assessment had included business unit- and company-level functions, these costs should have been taken into account too.

After cost allocations had been completed, the project team started brainstorming. The vendors evaluated priority lists, figures, and worth and cost calculations for all components. All personnel were encouraged to explain how they would improve value at component levels. According to their comments, clear figures helped a lot in understanding where the most significant differences in value existed.

Based on the figures it was noted that certain components did not create good value. After discussion of this, the project members shared the opinion that this was because of the unfinished architectural plan. This had an influence on the planning and design of these items and thus they had been delayed, and created significantly higher costs. In general, it seemed as though the components that should have been implemented first suffered the most from this situation. Designing was problematic and time-consuming, and code implementation often had to be paused. This took a lot of time, and people often had to wait for updates in design and architecture before they could start coding again. The problem was significantly smaller at the end of the project when the architectural plan was stable and clear design plans also existed.

Project members could also see from the charts presented how time-consuming it was to start using new technical environments, without good planning. The new technical environment delayed the implementation of certain components significantly.

New technical challenges, such as developing software for multiprocessor environments, were also named as one reason for the problems encountered.
for delays. This was because project personnel did not have sufficient training in working in the multiprocessor environment.

All the project members also felt that estimates for work times were not realistic. As a result of all the problems mentioned, working hours were about 20% higher than expected, and three components were not implemented at all.

![Fig.6. Value indexes for fully-implemented components including all interviewees](image)

In Figure 6, the real value of these components are also extremely high, because in real cost accounting costs are not allocated to these targets at all. This is due to the fact that the planned components (sending, activities, and surveillance) were not implemented as planned, or were not implemented at all. Therefore, when calculating value indexes and forming estimates, it might be helpful to use relative percentages based on interviews, as in this assessment. By looking at Figures 5 and 6, we can see more clearly what kind of value the fully-implemented components had. By comparing value indexes (interview and real), we can also see how greatly the estimated calculations differ from the real situation. In practice this is due to production costs, because worth was calculated based on product price that was know from sales agreement.

3.5 Evaluation
At the beginning of the evaluation phase the project team discussed criteria for the evaluation of improvement ideas. The criteria decided on were system stability, safety, optimized functioning, ease of use, maintainability, and profitability. First, all the project team members were asked to give a relative percentage (max 100%) for how important each criterion was for their project. Secondly, project personnel calculated averages for all the criteria. The calculated averages were as follows: system stability 25%, safety 20%, optimized functioning 7.5%, ease of use 20%, maintainability 15%, and profitability 12.5%.

After thus defining the weightings of the criteria, the project personnel gave points to each improvement proposal on a scale of one to six, where six indicated maximum points and one, minimum. The points allocated were multiplied by the calculated weighting percentages. The project team discussed these results. The most surprising result was that the importance of the technical environment was as high as third place. Problems in design and architectural planning were expected, as were problems related to project management. Estimation and multiprocessing got the least points, so their importance to the project was not considered to be as high. However, it was noted that if the project would have been more business critical this would not have been the case. The more business critical the project would have been the more weighting the profitability criterion would have got.

3.6 Development
In the development phase, the improvement ideas were separately developed further, in order to examine their practical implications. Each idea developed included issues such as description, positive consequences, negative consequences and potential cost savings.

Architectural plan and design plans
The project personnel stated: “It has been difficult to get the necessary working resources for small projects.” The architecture and design phases have perhaps suffered from this the most. There had not been enough time to review these phases, which can be seen in the presence of incomplete plans. Both plans had been updated several times during the writing of code, which had sometimes stopped coding for several days.
One proposed change was that the number of reviews for the architectural and design plans had to be increased. Project personnel also identified a clear need to develop criteria for these review rounds. A clear criteria stating what kind of characteristics are the most relevant in a new project was seen to help significantly to evaluation of architectural and design plans too.

The advantages of the proposed change are numerous. If all the project members work together to form success criteria for the project, and review plans using these criteria, no one person has to foresee all the forthcoming problems himself and take full responsibility for the technical environment and the quality of plans. Project members did not see any disadvantages to the proposal. They calculated that if there had been support resources for making more comprehensive plans and reviewing them, the project would have been 640 working hours shorter. The potential cost savings would have been about 46 000 €.

**Technical environment**

At the moment, the ability to use the existing characteristics of technical tools is weak. The use of pre-existing components is also rather poor. The result is that code has to be written from start to finish each time. Up to this point, training in using the new technical environments has not been satisfactory.

The change proposal is that there should be component libraries at company-level, categorized into classes to indicate how the component in question could be used. When starting a project, there should also be an evaluation of the needed technologies, and project members’ skills, so that the lack of training could be compensated for. The advantage of the proposal is that it probably provides cost savings at the company-level too, but the disadvantage is that there are perhaps no effective methods for handling the component libraries. The project group evaluated that if basic components for development work had existed, 100 fewer working hours would have been required. If there had been sufficient technical training concerning the new environments (dotNET and ATL 7) for key personnel, 350 fewer working hours would have been required. In total, the potential cost savings would have been approximately 19 000 €.

**Project management**

From a project management point of view, it is problematic that all the employees are always assigned one hundred percent to a given project. As a consequence, there is not enough support available if needed, and “the wheel is invented several times in different projects.” At the company level, there is a competence center, but these personnel are also assigned to projects.

The proposed change is that the competence center activities are developed in order to be usable regularly for all projects. This could be done so that competence center resources are allocated to projects at only a 70% level. In addition, it was proposed that the competence center develops its activities so that it is able to reply to technological questionnaires from different projects within two weeks. Typically, these answers would contain a short description stating what needs to be known if new technology is to be used, and giving an estimate of the number of working hours needed when using it for the first time.

It is a clear advantage in setting up new projects if there are sufficient resources for evaluating the risks involved in using new technologies. This way, projects would not all have to reinvent the wheel, but would learn from previous mistakes. The project team evaluated that with satisfactory support in evaluating the architectural plan, the design plans, and the extra need for time in starting to use new technologies, 200 fewer working hours would have been required. In financial terms, this would have meant a saving of about 12 000 €.

### 3.7 Presentation

The results of the product value assessment were presented phase by phase to the high-level management. The project team supported the presentation by giving brief comments. In the presentation, a clear emphasis was placed on presenting customer needs and wants, and the corresponding costs to the company. The value indexes were used to outline the existing value-increasing opportunities. The potential cost saving proposed was approximately 26% of product price.
After the presentation had ended, the management wanted to discuss the value improvement opportunities presented with the project personnel. Some improvement ideas were implemented and some were developed further; others were postponed due to lack of resources. As a whole, the assessment strongly emphasized collaboration between the customer and the vendor, and all the improvement proposals were in line with the customer’s interests as well. All customer and vendor representatives considered product-focused assessment an interesting method for the development of product quality and value, and process capability. As well it was considered to improve efficient allocation of development resources.

4 Conclusion
The purpose of this study was to collect experiences of using value assessment for product architecture in an industrial case. In more detail the purpose was to answer to following questions:
- How the proposed value assessment for product architecture works in practice
- The strengths and weaknesses of value assessment for product architecture
- Whether the company assessed sees the value assessment for product architecture useful

This product assessment for architecture worked very well in practice. All participants agreed that the value assessment process was clear and practical. Vendor saw it important that the customer was involved to the assessment as it increased the efficient use of resources and brought more business point of view to the assessment, which was considered to be extremely important.

The product assessment for architecture had several strengths. Compared to all process assessments it was seen to give more customer-oriented improvement proposals than process assessments. Product assessment also involved the customer in the decision process so that designed architecture was in a more solid basis to be implemented. Vendor considered it important that when the assessment is undertaken together with the customer, it can keep the customer more satisfied, which is a good basis for business. All participants also emphasized that if value assessment is done in the planning phase of a product, it is cheaper for any company than making changes after several months of development work.

There were also weaknesses in the proposed value assessment for architecture. First, the empirical findings of this study are rather limited as this study bases on one industrial case. Cost accounting was also rather challenging to be implemented in component level and finally, some costs had to be estimated instead of having calculated actual costs.

Generally, all the assessment results in this assessment are reliable. The reliability of the results was also improved significantly because the assessor interviewed several people and went through the same questions with all of them. The interview results were also compared to existing written material to check that they matched.

References: