Assessing Value of Software Architecture: a Case Study

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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. It outlines also existing possibilities for implementing value assessments. 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 process and product improvement, Architecture, Assessment, Value, Worth, Cost and Value engineering.

1 Introduction

The objective of the value-based approach [8, 9] 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 [6]. Value-based approach uses economic-driven tools, which are based on economic studies including, for example, the areas of cost estimation [about cost estimation see 1, 2], 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 [5, 12]. 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

Nowadays, VE methodology is widely known and accepted in the industry. It is an organized process with a history of improving value and quality. The VE process identifies areas in which unnecessary costs can be removed, while assuring that quality, reliability, capability, and other critical factors will meet or exceed the customer’s expectations.

All published VE processes usually begin by describing the research topic in functions, and analyzing these functions. Creativity is necessary in order to generate new ideas for the possible replacement of some of the functions used. Evaluation addresses these new ideas, and development forms new function structures by replacing old functions with new ones. If the quality, cost levels and customer requirements defined and needed are still fulfilled, and unnecessary costs have been cut, value has been increased.

In practice, the improvements developed are the result of recommendations made by a multidisciplinary team representing all the parties involved in the subject studied, and led by a facilitator. Development ideas are systematic efforts to improve the value and optimize the life cycle cost of a function or facility. It is vitally important that the VE team has technical as well as cost-accounting knowledge. A wide range of companies and establishments have used VE effectively, to achieve their continuous goal of improvement in the decision-making process.

So even though there are several definitions in the literature for the VE process, they all have similarities. Generally, they 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. These phases are also considered appropriate since they constitute independent areas of VE, emphasizing the preparation aspect, the independent study aspect and the post-study aspect performed after the other phases.

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 [10] 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):

$$Value = \frac{Worth}{Cost} \qquad (1)$$

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 least 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).

When emphasizing the characteristics of Worth, the most common definition used has perhaps been following (2) [3, 4, 7, 8, 10]:

$$Value = \frac{Function + Quality}{Cost} \qquad (2)$$

where:

Function = The specific work that a design/item (product, service or process) must perform.

Quality = The owner’s or user’s needs, desires, and expectations.

Cost = The life cycle cost of the product, service or process

In this formula (2) Value is the most cost-effective way to reliably accomplish a function that will meet the user’s needs, desires, and expectations. Function represents the work that should be done, and Quality represents the needs, desires and expectations for how this should be done. In other words, Function + Quality defines the Worth to the customer of the item in question. If the customer has higher expectations, the Worth is higher to him and if he has lower expectations the Worth is lower. As well as an increase in Quality causing an increase in Worth, increases in Functions have similar effects, because if the customer wants to list more work to be done with the product, the amount of Functions rise, which leads to an increase in Worth as well.

This also applies to the manufacturer’s software processes. If the specific work that the process must perform increases, there are more functions and, therefore Worth increases. On the other hand, if the manufacturer’s desires and needs for processes are at a higher “capability level”, that process is of better quality, worth also increases. The increased functionality is same as increased amount of process practices, which are defining functionality for processes. In practice, if process model is used these practices are defined in the process model and if process model is not used, generally in each process description. (About process models see appendixes).

In practice, the customer (individual) is not necessarily interested in software processes and therefore it is not often worth examining the value of processes from an individual customer’s point of view. However, if the customer is, for example, inside the same company or business group (internal customer) or is another external company, the interest in the value of processes is higher. This is simply because within the company several different units can offer services or products to each other (internal customers) having at the same time strict business goals and different processes. One unit can design a product, another one can produce it and the last unit in the division can test it. It is even possible that a unit from another division may buy this product for use as a component in its own product. It is also possible that the customer (external company) may be buying for example, testing services and therefore has a strong interest in the capability and value of the vendor's testing process. One example of customers demanding a certain capability level and low costs from a vendor's processes are public sector customers in the USA

In general, a product is often seen as an output of the use of processes. Therefore, it is possible to claim that it is not enough merely to assess processes; products should be assessed as well. This means that value should be examined from both points of view – especially from the product point of view, because this viewpoint is interesting to both the customer and the manufacturer.

In conclusion, it can be seen that value has a close relationship with cost. This is inevitable, because if more functions are expected to be performed with a single process, and expectations do not become lower, the costs of running the process will be higher. The same logic applies to software products as well. If it is expected that a software process should perform more work, the product costs become higher. If the expectations for functions – how the product should perform – become stricter, again costs will rise.

However, there is one significant difference between assessing processes and assessing products. This is due to the fact that customers tend to have clearer opinions about product worth than about process worth, because they buy products more often than "processes" or process services. However, there seem to be situations where a customer (internal or external) is acting as a buyer of "processes" as well. When this happens the calculation of worth can happen using real worth as defined by the customer (using "wants and needs"), and when it does not happen, the assessed company should use the least cost as customer worth. This is simply because, finally, the customer is always interested in getting the process service as cheaply as possible, and least cost perhaps represents this customer point of view best. However, if worth is defined using least cost, the criticism might be made that the calculated value index is therefore closer to cost index than value index. This is perhaps partially true, but always when calculating the value index, the company should consider customer interest when defining worth, which does not happen if the company defines the "pure least cost" only from its own point of view.

In both products and processes, the value should also be calculated using the same life cycle, the same period of time. For a product it is easier to see the life cycle, which means the entire time that the product is defined, designed, manufactured and used by the customer. Product worth is calculated over the time the customer is using it and the product costs over the time the vendor has costs due to it. However, if it is not possible to calculate worth using customer opinions, the company should use least cost, defined using customer needs for functionality and needed quality level.

For processes, the concept of life cycle is more complex. What is the life cycle of a process? How long the process is used? Naturally, small updates in a process should not mean that the process is completely new and that the life cycle has changed, but if the tools used in the process have changed and the personnel do not know how to use the new defined process, the life cycle has clearly changed. In practice, the assessed company has to define the life cycle for a process based on these assumptions, so that worth and cost can be defined for a process and value can be calculated.

3 Value Assessment for Processes and Products

There are four ways to enhance a standard software process assessment using VE [8]. The first possibility includes an addition of defined VE process into the existing process models of used capability assessment method (for example in CMMI or SPICE).

The second possibility covers Value Assessment for processes defined in used process model. The main idea of this enhancement is to run through all defined VE phases and as part of it calculate costs, worth and value for each assessed process existing in used process model.

The third possibility includes Value Assessment for processes without process model. The purpose of this enhancement is to find out from company's own defined process descriptions all process practices which are then examined from cost, worth and value point of views using VE process.

The fourth possibility includes Value Assessment of a product. This enhancement examines Value of product components and requirements and reveals value improvement possibilities in them.

4 Value Assessment for Product Architecture

4.1 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
- 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
- Services

Together with the requirement and component lists, several other documents were analyzed during the assessment as well. These documents included strategy plans, project plans, process descriptions, selling agreement and different financial statements.

4.2 Information

The product to be assessed was a typical electronic product containing software and hardware. It was developed in collaboration, by the vendor and the customer. The vendor was responsible for developing the product and the customer for defining user requirements for it. The vendor and the customer used project organization for specifying, implementing and testing the product. In practice, both sides nominated project managers to handle all the everyday managerial tasks involved in the project. For example, the vendor's project manager took responsibility for customer negotiations and for the allocation of resources to tasks. The customer's project manager coordinated customer-related tasks such as defining user needs more comprehensively and delivering information about project status to the customer organization. The overall management of the project, including issues that project managers were not able to decide on, was done in a project management group, to which both parties also nominated representatives from higher management.

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.

The implemented product assessment was supported and sponsored by the vendor's and customer high-level management. 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. The vendor also emphasized the importance of the component list and told that all development resources were roadmapped using this list.

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. However, if needed, they would give their comments on any questions that arose. 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.

4.3 Function Analysis

After the initial meeting it was easy to "start the assessment", because the components to be assessed were agreed in the information phase. 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 other ones. 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 (AV=average, C=customer, V=vendor) easy. They found the component lists, which contained technical names (classes, etc.), were not easily understood without explanations.

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.

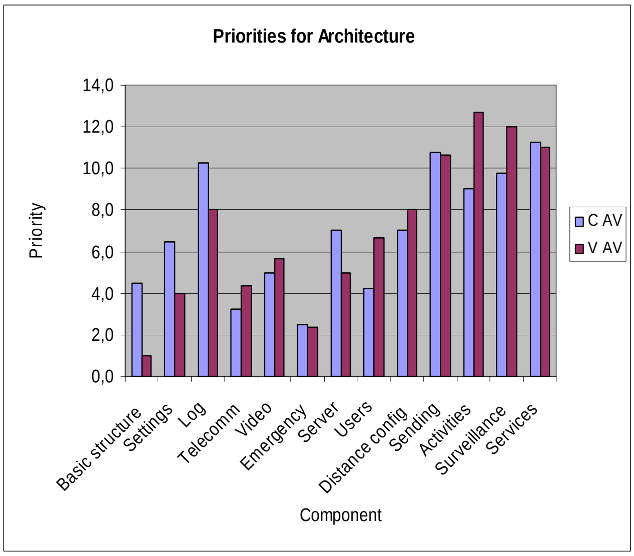


Fig.1. Average priorities for components including all interviewees (AV=average, C=customer, V=vendor)

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.

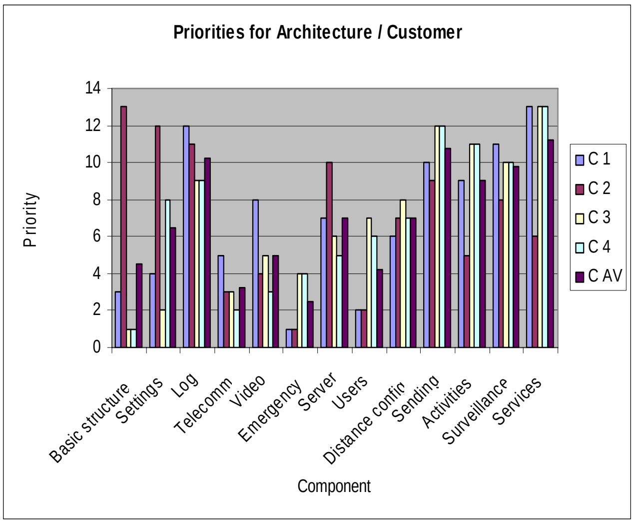


Fig.2. Average priorities for components including all interviewed customers (AV=average, C=customer)

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.

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.

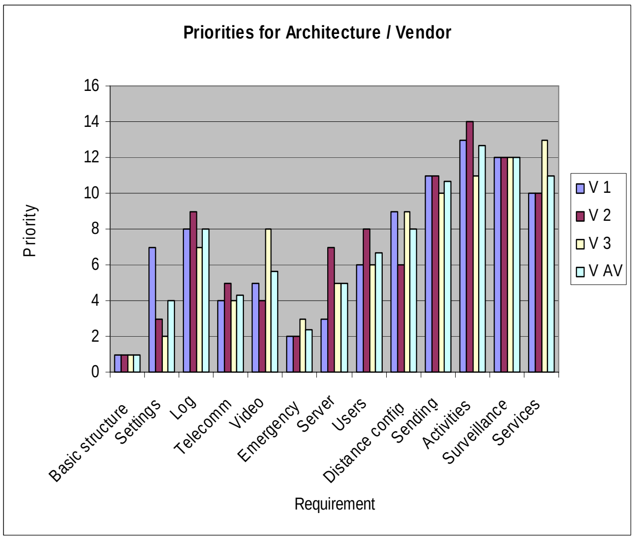


Fig.3. Average priorities for components including all interviewed vendors (AV=average, V=vendor)

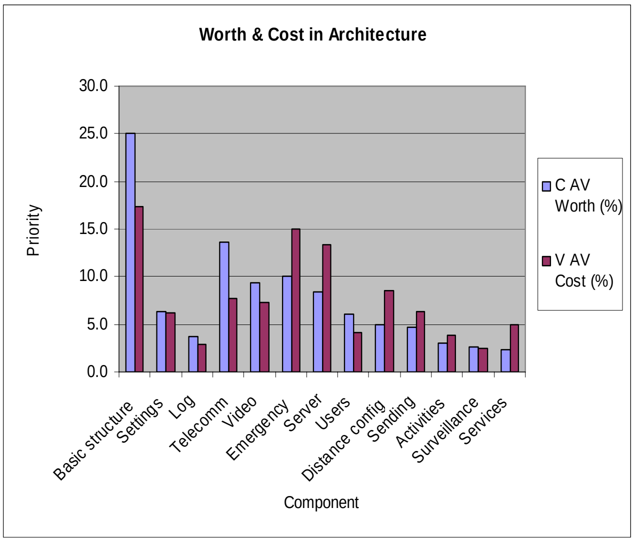


Fig.4. Average worth and cost for components including all interviewees (AV=average, V=vendor)

4.4 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.

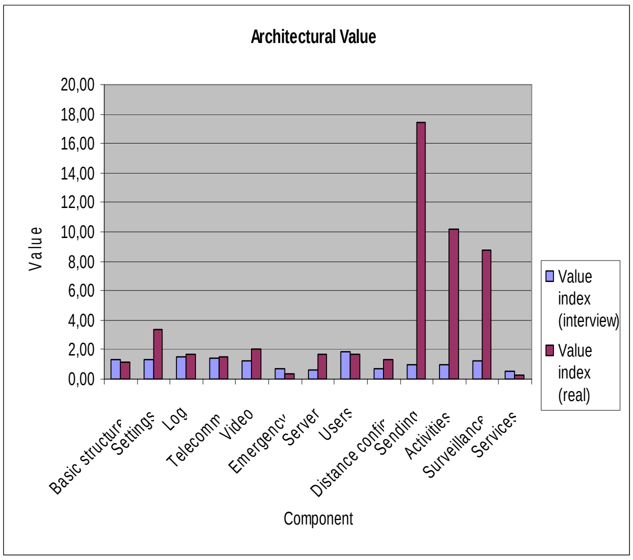


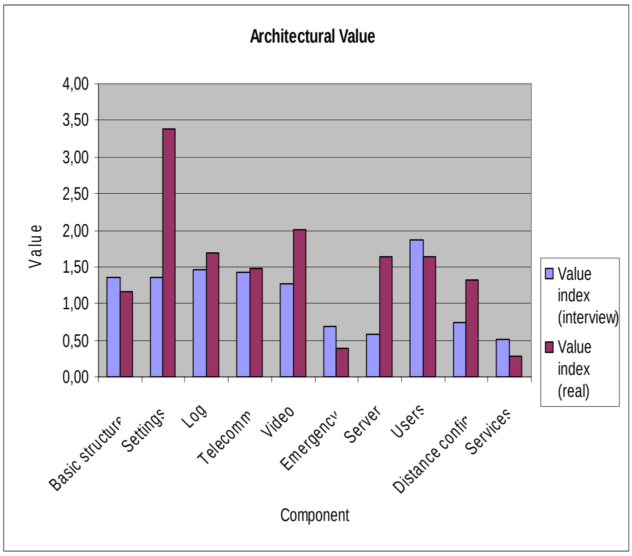
Fig.5. Value indexes for components including all interviewees

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 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

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 25 and 26, 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.

4.5 Evaluation

In terms of the process-related improvement proposals, project managers and the testing manager organized workshops with their teams to discuss the most time-consuming work practices. Based on these workshops it was noted that:

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.

4.6 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. However, setting up an existing competence center might require significant investment at the company level. 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 €.

4.7 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.

5 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. Especially customer saw it important that it has a possibility to participate in decisions about which features would be implemented and which would not. 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. Since the assessor had also passed the Value Analyst exams, he had the necessary skills to interpret the findings.

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