# Information Needed for Architecture Decision Makin

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## ABSTRACT

This paper describes the results of the interviews with managers and architects in Philips Healthcare to identify which information is needed to support architecture decision making in practice. The findings will be used to describe possible future trends to improve architecture decision making in the complex organization and business context.

## 1. INTRODUCTION

Architecture decision making aims at improving product quality (evolvability, usability, and reliability) and process quality attributes (time-to-market and cost) that have been eroding under technology and market changes over time. In this paper we refer to architecture decisions making as a process of deciding on (1) one of multiple architecture scenarios or (2) investing in the architecture improvements or keeping with the existing architecture. In such a decision process architects and managers consider the business aspect of architecture improvements to make the investment decision.

The architecture of the product line serves the needs of not only one but potentially many different products []. Investing in an entirely new architecture in practice is avoided due to an enormous amount of work and risk involved. Therefore, architecture investments in product lines usually involve merging, splitting, or modifying the existing product lines that might be considered from different organizations. In such a complex business landscape making business decision is difficult. Although the importance of analyzing the implications of architecture decisions on an organization and business has been recognized, very little attention is spent on training and education of architects to support this duty [1].

The literature refers to a business case analysis as one of the key elements for supporting value-based decision making in software engineering [2].

The simplest form of the business case is *return on investment* (ROI) to determine the relative financial costs, benefits across a system's life cycle as ROI = (Benefits-Costs)/Costs.

ROI has been used by the SPL community to support investments to migrate to software product line development [3-8]. The main benefits are development cost savings which will depend on the portfolio size estimated by the cost models [].

The Cost Benefit Analysis Method (CBAM) provides a sound guidance to evaluate architecture scenarios by trading-off quality attributes considering risk and investments. The CABM decision rule is also based on the ROI analysis. However, benefits expressed in non-monetary utility functions make CBAM difficult to use as the business case []. Although CBAM and alike-approaches are favored by architects it is not clear whether such a process can be used by managers and architects in the organization and business context.

Together, the existing approaches for architecture decision making use quality attribute trade-offs, development cost, portfolio size, risk, and investments as main information for decision making. However, benefits of the customer value of quality attributes improvements such as usability or performance or the internal value of flexibility improvement to be quicker to the market are neglected in the existing analysis. The value of architecture flexibility to react under market uncertainty by creating an option was recognized by several papers [] but there is no evidence of their use in industrial practice.

The question is which information is acutely needed by architects and managers for architecture decision making.

## 2. STUDY DESIGN

### 2.1 Context

This study is a part of a large-scale study[1] with the aim *to improve architecture decision making by linking architecture improvements explicitly to the business strategy in industrial practice*. The research is conducted in MRI business of Philips Healthcare in the Netherlands. MRI is one of the top-five businesses in Philips Healthcare [9] with a primarily focus on developing software intensive imaging systems for diagnostics and treatment. The product portfolio consists of diverse product lines which share several million lines of code and multiple software releases per year.

We investigate how to improve architecture decision making adopting the decision-making model based on three elements [10]:

- *Objective.* Why to invest in architecture?
- *Information.* Which information is used in the decision-making process to evaluate the expected consequences of possible architecture alternatives?
- *Decision rules.* How to generate a decision to invest in architecture alternative from the objective and information used?

In this paper we will investigate the second element, *Information needed for architecture decision making*. Following Yin [11] the

[1]This work has been carried out as a part of the Darwin project at Philips Healthcare under the responsibility of the Embedded Systems Institute. This project is partially supported by the Dutch Ministry of Economic Affairs under the BSIK program.

case study design is suitable for investigating contemporary phenomena (architecture decision making) within its real-life context (the MRI business context). The interviews will be the main source of evidence.

The aim of this study *to discover and describe information needed for architecture decision making by architects and managers* within a broader context of improving architecture decision making in industrial practice.

## 2.2 A step-by-step approach

The research design is presented step-by-step in Figure 1. First, we conducted pilot interviews to identify and define information needed for architecture decision making. Second, we conducted interviews in Philips Healthcare to verify the identified information from the pilot interviews and quantity the frequency of the information used by managers and architects for architecture decision making. Finally, we discuss how the results of the interviews contribute to the improvement of architecture decision making in industrial practice to set up the new trend in developing architecture decision making. The steps are presented in Figure 1 that will be described in the following sections respectively.

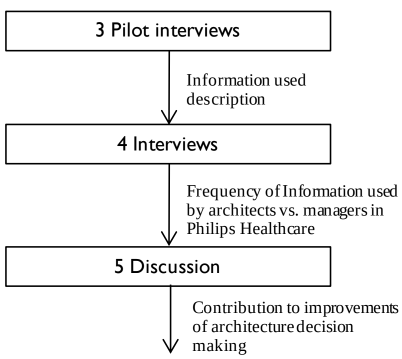


**Figure 1 Study design**

# 3. PILOT INTERVIEWS

## 3.1 Interview design

**Interviewees.**

We interviewed two system architects and one program manager to gain insights about information needed for architecture decision making.

We selected two system architects working in Philips Research having 10 and 15 years of architecting experience in different domains including the healthcare domain. Their role can be described as an in-house consultant working in architecture projects together with architects and managers from Philips Healthcare. Furthermore, the system architects have been actively involved in the architecting research community with a strong interest in the architecture decision making topic. To gain insights about information need from the manager's perspective we selected to interview the program manager of Philips Healthcare. He has been responsible for developing roadmaps for multiple product lines across the organization. In the time of this assignment he was actively involved in architecture decisions making by merging two product lines. The interviewees were aware of our investigation in the Darwin project and introduced to our study design.

**Interview format.**

The interview was conducted in an open-end form for an hour spent per each interviewee. We asked the interviewee to select the most typical architecture cases from his experience and to describe us decision rules and which information have been used for architecture decision making. The information identified in all three interviews was not shared between the interviewees. At the end we merged information identified for architecture decision making in the interviews in the list shown in Table 1.

## 3.2 Results

Based on the context of the decision making cases we defined descriptions of information that closely represent what interviewee meant by the information, see Table 1.

**Table 1 Information needed for architecture decision making**

| Information | Description |
|---|---|
| Investment | The money needed to implement architecture |
| Cash flow | The generated cash because of architecture changes |
| Sales | Volume of product shipments |
| Market uncertainty | Probability of changes in the market that may influence cash flow |
| Customer segment benefits | The distribution of customers that will benefit and how much because of architecture changes |
| Time-to-market | Time to release the product to the market on the new architecture |
| Upside potential | The potential for the business growth enabled by the architecture changes |
| Customer satisfaction | The extent to which the product is perceived as successful by customers |
| Quality attribute trade-offs | Exchange of benefits of one quality attribute in return for another in the architecture design process |
| Future proof | Ability to accommodate technological changes in the future |
| Downside effect | Negative consequences if the architecture would not be modified |
| Resources | Development effort needed for architecture implementation |
| Technology risk | Probability of deviation from the intended results to implement the architecture |
| Cost savings | Savings in a bill of material and development effort because of architecture improvements |
| Capabilities | The organization competence to make architecture changes |

We noticed that the program manager added information that was not used by the architects such as *Customer satisfaction*, *Market uncertainty*, and *Downside effect*. This can be explained by the fact that Philips Healthcare plays an important role in the realization of Philips' strategy to create a customer-centric and market-driven company [9] and managers' decision making has to be aligned accordingly. Since architects had a more supportive role in the organization this information was not explicitly used. In contrast to the architects, the program manager did not use *Customer segment benefits*, *Quality attribute trade-offs*, *Cost*

*savings*, *Resources*, and *Capability*. This can be explained by the manager's role in the organization in which the resources and architecture design are not the primary responsibility of the program manager.
Additionally there are dependences between information used for architecture decision making, i.e. sales contribute directly to cash flow analysis. Nevertheless, we decided to keep the whole list of information for the next interviews as the information is information perceived by decision makers without establishing the decision rules.

# 4. INTERVIEWS

To obtain more quantitative results about frequency of information used by architects and managers we conducted interviews with 19 interviewees, whose responsibility involves architecture decision making in different roles.

## 4.1 Interview design

**Interviewees.**
The interviewees were suggested by the lead architect of the MRI organization and some of them we already got to know supporting them in architecture decision making. They were each invited to an interview meeting of an hour. Out of 22 invitations sent, 19 invitations were accepted. We interviewed nine managers and ten architects closely involved in architecture decision making in Philips Healthcare. The architects had the role of software and system architect while the mangers had the role of department, product, program, and project manager.

**Interview format.**
We conducted semi-structured interviews with an open framework consisting of three parts: *Introduction*, *Open questions*, and *Structured matrix.* The introduction consists of (1) presenting the objectives of the study and the interview structure to the interviewee and (2) asking the interviewees general questions related to *Name*, *Domain knowledge*, *Experience*, and *Role* in the organization. In open questions we asked an interviewee to choose his typical architecture decision in practice and explain the way of reasoning about architecture decisions. At the end, we guided the interviewee to select the information they have used for decision making in the structured matrix given in Table 2.

## 4.2 Results

We present the final result of the interviews in Table 2. The first two columns of results in the table demonstrate the frequency of information used by the architects and managers for architecture decision making. The last four columns are used to help our analysis with evaluation criteria given in the Legend of Table 2.

**Table 2 Diversity in information needed for architecture decision making by managers and architects**


| Icon | ○ | ◔ | ◑ | ◕ | ● |
|---|---|---|---|---|---|
| When value is | <=20 % | 20-40 % | 40-60 % | 60-80 % | =>80% |

| | Description |
|---|---|
| A | Frequency of information used by architects |
| M | Frequency of information used by managers |
| Max(A,M) | Needed. Maximal frequency of information used by architects or managers<br>MAX(A,M) |
| A+M | Agreeability. Architects and managers agree about the need the information in more than 60% of answers<br>=IF (A>0.6 AND M>0.6), 1, 0) |
| A-M | Architects need the information that the architects do not<br>IF(A-M>0, A-M, 0) |
| M-A | Managers need the information that the architects do not<br>IF(M-A>0, M-A, 0) |

# 5. DISSCUSSION

## 5.1 Information needed vs. Information used

## 5.2 Future trends for the new approaches for architecture decision making

## 5.3 Threats to validity

Someone can agree that the information identified is not complete.

# 6. CONCLUSION

We realized, from this study, that information needed for architecture decision making is far richer than just using investments, development effort savings, portfolio size, and time-to-market, in the existing business cases. And so we also realized that different use of information by managers (cash flow, uncertainty) and architects (future proof, quality attribute trade-offs) for architecture decision making are significant for the success of the architecture decision making process.
We envision that further improvements in approaches for architecture decision making can only be achieved if we provide an approach to link explicitly the information used by managers and architects in the architecture decision making process. In the future work we will investigate how to improve architecture decision making by establishing a decision rules to link the identified information to the business strategy.

## 7. ACKNOWLEDGEMENTS
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## REFERENCES

1. Clements, P., et al. *The Duties, Skills, and Knowledge of Software Architects*. in *Proceedings of the Sixth Working IEEE/IFIP Conference on Software Architecture (WICSA'07)* 2007.
2. Boehm, B., *Value-Based Software Engineering: Seven Key Elements and Ethical Consideration* in *Value-Based Software Engineering*, S. Biffl, et al., Editors. 2006.
3. Böckle, G., et al., *Calculating ROI for Software Product Lines.* IEEE Software, 2004. **21**(3).
4. Clements, P., J.D. McGregor, and S.G. Cohen, *The Structured Intuitive Model for Product Line Economics (SIMPLE)*. 2005, Product Line Practice Initiative, Software Engineering Institute.
5. Ganesan, D., D. Muthig, and K. Yoshimura. *Predicting Return-on-Investment for Product Line Generations*. in *10th International Software Product Line Conference*. 2006.
6. In, B.H.P., et al., *A Quality-based Cost Estimation Model for the Product Line Life Cycle.* Communications of the ACM, 2006. **49**(12).
7. Kotler, P. and K. Keller, *Marketing Management* 13 ed. 2008: Prentice Hall.
8. Schmid, K., *A Quantitative Model of the Value of Architecture in Product Line Adoption*, in *5th International Wokshop on Product-Family Engineering*. 2003, Springer.
9. *Philips Healthcare*. 2009 [cited; Available from: http://www.philips.com/about/company/businesses/healthcarehighlights/index.page.
10. Carroll, J.S. and E.J. Johnson, *Decision Research: A Field Guide.* Journal of the Operational Research Society 1992. **43**: p. 71-72.
11. Yin, R.K., *Case study research: design and methods.* Applied Social Research Methods Series. Vol. 5. 2003: SAGE Publications.