

Requirements Prioritization Challenges in Practice

Laura Lehtola, Marjo Kauppinen, and Sari Kujala

Helsinki University of Technology, Software Business and Engineering Institute,
P.O. Box 9210, FIN-02015 HUT, Finland
(Laura.Lehtola, Marjo.Kauppinen, Sari.Kujala)@hut.fi

Abstract. Requirements prioritization is recognized as an important activity in product development. In this paper, we describe the current state of requirements prioritization practices in two case companies and present the practical challenges involved. Our study showed that requirements prioritization is an ambiguous concept and current practices in the companies are informal. Requirements prioritization requires complex context-specific decision-making and must be performed iteratively in many phases during development work. Practitioners are seeking more systematic ways to prioritize requirements but they find it difficult to pay attention to all the relevant factors that have an effect on priorities and explicitly to draw different stakeholder views together. In addition, practitioners need more information about real customer preferences.

1 Introduction

Prioritizing requirements is an important activity in product development [1, 2, 3, 4]. When customer expectations are high, timelines short, and resources limited, the product must deliver the most essential functionality as early as possible [5] and the scope of each release must be limited [1]. Many projects face the fact that not all the requirements can be implemented because of limited time and resource constraints. That means that it has to be decided which of the requirements can be removed from the next release. According to Wiegers [5] information about priorities is needed, not just so as to be able to ignore the least important requirements but also to help the project manager to resolve conflicts, plan for staged deliveries, and make the necessary trade-offs. Harwel et al. [6] describe a priority as being a characteristic of a requirement that can be used for different purposes, depending on program and company needs.

However, requirements prioritization is also recognized as a very challenging activity. For example, Lubars et al. [7] report that none of the companies in their study really knew how to assign and modify priorities or how to communicate those priorities effectively to project members. Furthermore, Karlsson et al. [2] argue that despite the recent rapid and welcome growth in requirements engineering (RE) research, managers still do not have simple, effective, and industrially proven techniques for prioritizing requirements.

Some findings concerning the challenges in requirements prioritization can be found in the literature. Aurum et al. [8] describe the RE process, in essence, a complex communication and negotiation process involving many stakeholders. They argue that it includes a great deal of invisible decision-making [8]. For example, Wiegers [5] argues that customers might not want to prioritize their requirements, because they are afraid of having just the most important ones done and developers do not want to admit that they are not able to implement all the requirements. Political issues are discussed by other authors [9], too. The interdependencies between requirements are another topic that is discussed [10].

The articles written about requirements prioritization issues can be roughly divided into three categories. The first category involves those papers that describe the current state of RE processes in the industry (for example [7] [1]). These studies provide the information that requirements prioritization is an important and challenging issue. Other authors (for example [8] [11]) discuss decision making in the context of the whole RE process. These studies provide a basis for decision-making in the development context. A few authors introduce their own approach to requirements prioritization (for example [2] [4]) and evaluate it with a specific set of requirements, either with industrial partners or without them. On the basis of these studies, it seems that more information about the current state of requirements prioritization practices is needed.

The high-level goal of this study is to clarify the field of requirements prioritization. In this paper, we assess current requirements prioritization practices in industry by describing the state of the art in two organizations in which they had used different kinds of free-form requirements prioritization practices.

This paper is structured as follows: the case organizations and research methods used are described in Section 2; Section 3 provides an overview of the lessons learned from this study, and finally, Section 4 concludes the paper.

2 Research design

The experience drawn on in this research comes from work with two industrial partners of the Qure¹ project. The research goal of the Qure project was to investigate how organizations can develop products that better satisfy user and customer needs. This research was part of a subproject investigating how user and customer needs and requirements should be prioritized. The research work was carried out in the product development units of two Finnish companies. The companies (introduced in Table 1) represent two different kinds of application domains.

In order to clarify the current practice in the requirements prioritization area we carried out a focus group study and two in-depth interviews. In addition, we observed real requirements prioritization work in different phases of product development.

¹ The Qure (Quality through Requirements) project was research project at the Helsinki University of Technology (HUT).

Table 1. Case companies and their application domains and product types

Company	Number of employees	Application domain	Product type
A	500	Information management systems for building public infra and energy distribution designers	Software systems
B	1100	Measurement systems for meteorology, environmental sciences and traffic safety	Interactive systems

The goal of the focus group session was to find out how and in which phases of the development work companies prioritize requirements in practice. We also clarified which factors have an effect on priorities and from which sources the practitioners gather the information on which they base their priority decisions. In addition, we inspected the problems the developers felt they had with their current requirements prioritization practices. In our case, the focus group consisted of four representatives from the two case companies. The participants and their relationship to requirements prioritization are introduced in Table 2.

Table 2. Focus group participants and their relation to requirements prioritization

Company	Description of participant's work and his relation to prioritization
A	Product manager. Main task is to elicit and prioritize requirements.
A	Leader of the R&D unit. Substantial experience of mutual prioritization of requirements.
B	Project manager. Collects information about markets and writes requirements documents. Substantial experience of mutual prioritization of requirements.
B	Product development process engineer. Main task is to implement a requirement management tool to the organization. Knows basics of requirements prioritization.

Rather than providing quantifiable responses to a specific question obtained from a large sampling of the population, focus group participants provide a flow of input and interaction related to the topic [12]. In our case, while we wanted to gain fresh insights regarding the issue [12] and the problem area was not strictly bounded, we thought that four people participating in a semi-formal discussion together would provide more intimate information of requirements prioritization than would be obtained by inter-views or questionnaires. For example, Templeton [13] supports our point of view by describing focus groups as small, temporary communities, formed for the purpose of the collaborative enterprise of discovery.

The assembly is based on some interest shared by the panel members, and the effort is reinforced because the panelists are paid for the work [13]. We did not pay cash for the work, but panel members had an incentive to participate because of benchmarking.

The discussions were semiformal. This meant that a researcher worked as the facilitator of the session by giving the participants five discussion topics (introduced in Table 3) and by leading the discussion. Each session (1/2 hour each) was started in such a way that participants wrote their thoughts and key words about the topic on post-it notes. After that, the post-it notes were gathered and organized on a white board using the affinity grouping technique [14]. The post-it notes were used as a basis for the discussions. All the discussions were recorded and analyzed later by reorganizing comments into topic tables according to similarity between them.

Table 3. Focus group discussion topics

Number	Topic
1	Current requirements prioritization practices in the companies
2	Problems that companies have with their current practices
3	Factors that have, or should have, an effect on priority decisions
4	Sources for priority information
5	Development phases in which requirements are prioritized

As mentioned earlier, we also carried out semi-structured, in-depth interviews by interviewing two project managers, one in each company. The goal of these was to have more detailed information about current practices and to understand better the project point of view in requirements prioritization. The questions covered prioritization practices used and challenges involved. We also focused on clarifying what kind of priority information they needed in the beginning of project. Both of the interviews were audio recorded. The two interviewees are presented in Table 4. In addition, we observed real prioritization work in one case company. The goal of the observation was to focus not only on what practitioners say they do but also on what they actually do.

Table 4. Interviewees

Company	Description of participant's work and his relation to prioritization
A	Project manager. Responsible for a modeling team. Prioritized requirements by negotiating informally.
B	Project manager. Responsible for releasing a second version of a product. Prioritized requirements by negotiating informally.

3 Results

Five main findings were identified that describe the current practice in requirements prioritization in the two case companies. The lessons learned from the companies, summarized in bullet points below and described in Sections 3.1 - 3.5, are:

- Requirements prioritization is an ambiguous concept
- Prioritization practices are informal and dependent on individuals
- Requirements are prioritized in many phases
- Developers do not know enough about customer preferences
- The priority of a requirement is based on many factors

3.1 Requirements prioritization is an ambiguous concept

Although it is essential that people have a common understanding about the terms they use and activities they perform in product development, the terms “requirements prioritization” and “priority” have several different meanings in practice. This causes confusion and misunderstandings among product development personnel. The terms are not uniformly defined in organizations, so in spoken language different activities with different purposes are referred to by the same terms. This happens without the awareness of the practitioners.

The activity called “requirements prioritization” had many meanings in the case companies. Occasionally, the term was used with the meaning “How do we decide which requirements are the most important ones for the company in the long run?”; sometimes it meant “How do we decide, which requirements we have to implement right away in the next product release?” or “How do we select the requirements that will be implemented first in this project?”, or “Which of the requirements describe the system in high-level terms?”.

A “priority” is an attribute of a requirement which should be the result of the activity called requirements prioritization. In the case companies, there were ambiguities in the usage of the term “priority”, as well. In some cases the term was used as a quantity meaning “the importance of a requirement to the customer” and in other cases it described how soon the requirement would be implemented. In some cases these two scales, the importance scale and the time scale, were equal to each other. However, in release planning other things than importance to the customer, for example interdependencies of the requirements can have a greater effect on implementation decisions and their schedule.

Not only were there ambiguities with the usage of terms, but also with the usage of prioritization scales (introduced in Section 3.2). The categories high, medium and low were experienced as being ambiguous. For example, one of the interviewees mentioned that “We needed a lot of discussion about the meanings of each priority level with the project group when we set priorities. I was surprised how different the meanings we had in our minds were.”

3.2 Prioritization practices are informal and dependent on individuals

There are no commonly agreed ways to perform requirements prioritization in the companies. Requirements are prioritized mostly on the basis of experience of development personnel. The factors one should take into account when deciding priorities are not commonly explicated. Roughly speaking, individuals make prioritization decisions mostly on the basis of their tacit knowledge or feelings.

No explicit requirements prioritization methods were in use in the companies. The development personnel tried to make a rough guess which requirements were the most important ones to customers and users, how profitable requirements were to their own company, and how all this cohered with the strategy of the company, but there were no systematic practices for these analyses. Contracts made with customers and promises given to them in informal discussions played a major role when priorities were being set. An interesting point we found was that often the companies descend into a situation where they try to avoid the biggest “breach of contract” -payment. “First we promise to implement something and then we try to pin down how much it will cost if we do not implement it.” complained one project manager.

Table 5. Requirements prioritization practices and related problems

Practices companies use	Comments that describe related problems
Assessing requirements value for customers and its development costs	“We try to judge costs in the early phases of development. We have no formal method for that.”
Priority lists of local areas	“Our local areas have the same problem as we have. How to know what is truly important to customers?”
Prioritization scales	“I have no idea how we divide the requirements into categories. The process is very mutual.”
Negotiation in project meetings	“We have a person who knows what it takes in the way of resources to implement the requirement and a person who knows how much effect it has on business. It is just a mutual discussion.”

The participants mentioned that in practice there is no time to figure out all the relevant information as a basis for priority decisions. The development personnel had for example difficulties in analyzing all the raw requirements they gathered from customers. “There is no time to analyze thousands of wishes. Much of the work is done intuitively” said one of the interviewees. In most cases the requirements specification is written only by one person. That leads to situations

in which the writer of the specification thinks that there is no need to prioritize the requirements any more. One of the interviewees complained that “The writer does not want to drop anything. The first version is, in a way, prioritized in his head.”

The practices companies currently use for prioritizing requirements are listed in Table 5. In the early phases of development the companies try to analyze the costs and value of the requirements. These analyzes are very informal and there is usually no documentation about these decisions and their rationale. In the other company the product managers also try to prioritize raw requirements according to priority lists drawn up locally, but they find it quite difficult to truly combine the information from different sources. In product development projects, requirements are mutually grouped into three categories using prioritization scales. This is usually done by product managers. Negotiation in project meetings is used especially in those situations where the project group is not able to implement all the requirements in the given time. These discussions are informal. The project group just makes the decision if there is or is not time to implement a requirement in this particular release.

3.3 Requirements are prioritized in many phases

Decisions about which requirements can be included in the next version of the product and which can be postponed are needed in many phases of product development. Requirements definition is a process during which priority decisions have to be made iteratively. Requirement priorities are needed, not only for making decisions as to which requirements to leave out, but also for analysis purposes after the release and in order to help the communication within the organization and with the customers.

Product management needs high-level information about customer preferences, markets and the company’s own strategy and resources when they decide which requirements will constitute the basis of the product or release. This information is also needed to decide which of the raw requirements or user needs gathered should be evolved further. Participants felt that they need more systematic ways to work out this “high-level priority view” and common ways to link it to lower level-requirements.

Personnel working at the customer interface felt that they need information about priorities for communication purposes. They want to have a big picture of how they have managed to serve different market segments with their product. The other case organization wanted to know how much value they had produced for each customer segment with their current release. They felt that the priorities that customers give to their own raw requirements and change requests can be a key for managing customer satisfaction. In addition to this, they want to know better in advance how much value different requirements combinations would produce for different customers and market segments.

Product development projects need more, and better-documented, information about which requirements are important according to earlier phases of development. They also need to know the rationales for these decisions. This in-

formation is wanted in order to help them to decide which requirements they can leave out if there is no time to implement all that was planned. Participants mentioned that they needed priority information in order to make the kick-off of the implementation work easier. They would have liked to know which of the requirements constitute the basis of the product.

3.4 Developers do not know enough about customer preferences

The product development personnel would like to know why a requirement is important to users or customers. Usually they have no idea because people are working separately in the product development; product development personnel do not have direct contacts with users and customers. In addition to this, there are no common practices to communicate customer and user information through the product development process.

Particularly in small projects, contact with customers and users was felt to be too narrow. A great deal of important information was gathered from users by the help desk calls they made. In addition to this, product development staff communicated with vendors and gathered information in this manner. In the case companies, product managers created the first requirements specification on the grounds of discussions they had had with customers. They had an idea which requirements were important to customers and placed requirements into priority categories.

There were no generally agreed ways to transfer priority information to the project group and usually the original reason for requirements being considered important failed to reach as far as to the project manager and other project group. One participant complained that “Usually there is no clear explanation besides requirement or need, why it is important or wanted. A person who does not know anything about this particular requirement from the customer point of view does the prioritization.”

3.5 The priority of a requirement is based on many factors

The requirement’s importance to a customer is an important, but usually not the only, factor that has an effect to a requirement’s priority. There are many difficulties in defining which factors should be taken into account when setting the priorities. Getting the right information for to use as the basis for prioritization decisions is not always easy.

Our study indicates that there are three main points of view which are more or less explicitly taken into account when setting priorities. These three points of view, introduced in Figure 1, seem to encapsulate the other factors. For a company it is a lifeline to profit, so issues like customer relationships, competitors, and the importance of the requirement’s source for the company have to be taken into account. An other point of view is that of customers and users. The development organization must know which of the requirements are most important to them. A third point of view is implementation. The resources of the

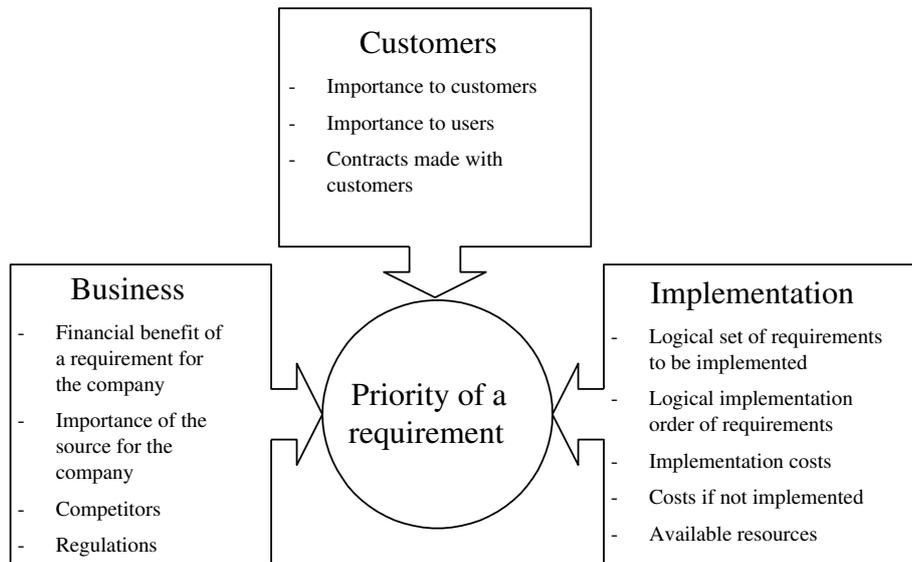


Fig. 1. Three points of views having an effect to requirement's priority

company and the manufacturing situation, as well as the logical implementation order, have an effect on which requirements should be implemented first.

Developers can gain information about factors that have an effect on priority from many sources or stakeholders. The participants mentioned that one of the most used source for getting information concerning the basis of priority decisions is discussions with key customers and their representatives. In one of the companies the customer representatives in different geographical areas made their own priority lists, which were integrated into a world-wide priority list in the main company.

It is not always easy to decide which factors and stakeholders should be taken into account when deciding priorities, getting the right information about them, and combining information from different sources. These problems are examined more carefully in Table 6.

Table 6. Challenge, description and related comments

Challenge	Description	Related comments
How to know which are the relevant factors?	The priority of a requirement is based on many factors. It is not clear which points of views should be taken into account, when deciding priorities.	"Priorities are dynamic. There is different criteria for priorities in different phases."
How to get correct information?	Priority information can be skewed or even wrong. Companies lack ways to communicate priority information further.	"They (the local areas) have the same problem as we have. How to know what is truly important to customers?"
How to combine information from different sources?	Companies do not know how to combine different market and customer preferences systematically.	"There are requirements from this customer and that customer. There are Japanese requirements and requirements from the U.S.A" "Now we are in a situation where the customers who complain most get most."

4 Conclusion

This work aimed to clarify the field of requirements prioritization. In this paper, we have described current requirements prioritization practices in the two case companies and highlighted the practical challenges involved. The main contribution of the paper is that it describes the nature of prioritization problem and why its solution is so hard. By addressing the prioritization challenges, researchers and practitioners may better be able to tackle them.

Our study indicates that requirements prioritization practices are informal and dependent on individuals. Individual practitioners prioritize requirements on the basis of their experience and tacit knowledge. Even the meaning of the term "requirements prioritization" depends on individuals. This causes misunderstandings. Lubars et al. [7] also found in their study that companies do not know how to set and modify priorities.

According to our research, having systematic requirements prioritization practices is a challenge because requirements prioritization requires a great deal of non-trivial decision making. Also, Yeh [15] reports that requirements prioritization is one of the most crucial and at the same time difficult tasks that faces the decision makers. Our study indicates that the priority of a requirement is based

on many factors such as financial benefit of the requirement for the company, requirement's importance to users, and implementation costs. These factors can be grouped into three main points of views: business, customers, and implementation.

Requirements prioritization is usually described as a part of the requirements analysis phase [16]. Our study indicates that instead of being just one-off activity, requirements prioritization is needed in many phases of the development work. The importance of different viewpoints depends on the development phase. For example, in the early phases of development work business issues seem to have more influence on priorities than implementation issues. Other authors also discuss the importance of different viewpoints in requirements prioritization. For example, Moisiadis [17] argues that prioritizing requirements should involve representatives from each group of stakeholders with a vested interest in the success of the development project.

In practice, it is difficult to get all the important information about factors that influence the priorities of requirements and explicitly draw different points of views together. Practitioners make decisions about priorities without explicitly being aware which factors they take into account and to what extent. Developers also feel that they do not have enough information about real customer preferences.

The lessons described in this study were gained from two Finnish organizations and therefore there might be issues that may not be appropriate to all organizations. However, as other authors have reported similar kinds of challenges [7] [15] we think that our findings are also valid for many other organizations. This study identifies important research challenges which should be investigated further. One of the research challenges in the future is to help organizations define which points of views have an effect on requirements priorities in different phases of development and in what extent. Another important challenge is to investigate how to combine different points of views in requirements prioritization.

5 Acknowledgments

The authors would like to thank the industrial partners of the Qure project for participating in the research and Dr. Jyrki Kontio, Dr. Pekka Abrahamsson, and Mr. Jarno Vähäniitty for their considerable effort in commenting on this paper. Additional thanks are due to Mr. Jouko Koski for his technical advice.

References

- [1] Siddiqi, J., Shekaran, M.: Requirements engineering: The emerging wisdom. *IEEE Software* **2** (1996) 15–19
- [2] Karlsson, J., Ryan, K.: A cost-value approach for prioritizing requirements. *IEEE Software* **14** (1997) 67–74
- [3] Karlsson, J., Wohlin, C., Regnell, B.: An evaluation of methods for prioritizing software requirements. *Information and Software Technology* **39** (1998) 939–947

- [4] Regnell, B., Höst, M., Natt och Dag, J., Beremark, P., Hjelm, T.: An industrial case study on distributed prioritisation in market-driven requirements engineering for packaged software. *Requirements Engineering* **6** (2001) 51–62
- [5] Wiegers, K.E.: *Software Requirements*. Microsoft Press, Redmont, Washington (1999)
- [6] Harwell, R., Aslaksen, E., Hooks, I., Mengot, R., Ptack, K.: What is a requirement? In: *Proceedings of the Third International Symposium of the NCOSE*. (1993) 17–24
- [7] Lubars, M., Potts, C., Richter, C.: A review of the state of the practice in requirements modelling. In: *Proceedings of IEEE Symposium on Requirements Engineering (RE'93)*, IEEE Computer Society Press (1993)
- [8] Aurum, A., Wohlin, C.: The fundamental nature of requirements engineering activities as a decision-making process. *Information and Software Technology* **45** (2003) 945–954
- [9] Andriole, S.: The politics of requirements management. *IEEE Software* **15** (1998) 82–84
- [10] Carlshamre, P., Sandahl, K., Lindvall, M., Regnell, B., Natt och Dag, J.: An industrial survey of requirements interdependencies in software product release planning. In: *Proceedings of the Fifth IEEE International Symposium on Requirements Engineering (RE'01)*. (2001) 84–91
- [11] Regnell, B., Paech, B., Aurum, A., Wohlin, C., Dutoit, A., Natt och Dag, J.: Requirements mean decisions! - research issues for understanding and supporting decision-making in requirements engineering. In: *Proceedings of the First Swedish conference on Software Engineering Research and Practice (SERP'01)*, Ronneby, Sweden (2001) 49–52
- [12] Edmunds, H.: *The Focus Group Research Handbook*. NTC Business Books in conjunction with the American Marketing Association, Lincolnwood (Chicago), Illinois (1999)
- [13] Templeton, J.F.: *The Focus Group - A Strategic Guide to Organizing, Conducting and Analyzing the Focus Group Interview*. Revised edn. Mc Graw Hill, New York (1994)
- [14] Oddo, F., ed.: *Coach's Guide to the Memory Jogger II*. GOAL/QPC, Methuen, MA (1995)
- [15] Yeh, A.C.: Requirements engineering support technique (request) a market driven requirements management process. In: *Proceedings of the Second Symposium of Quality Software Development Tools*, New Orleans, USA (1992) 211–223
- [16] Sommerville, I.: *Software Engineering*. 5 edn. Addison-Wesley, Wokingham, England (1996)
- [17] Moisiadis, F.: The fundamentals of prioritising requirements. In: (Web) *Proceedings of Systems Engineering/Test and Evaluation conference (SETE2002)*. (2002) <http://www.seecforum.unisa.edu.au/Sete2002/ProceedingsDocs/>.