Improving Requirements Engineering Communication in Multi-Project Contexts

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Abstract

In complex multi-project contexts communication is the key to a successful requirements engineering process. In this article we present the notion of an information model which captures the documents and the responsibilities of the stakeholders during requirements engineering. The responsibilities determine authorship, review, approval and the propagation of change of and within the documents. The information model is an effective and practical means to ensure that stakeholders of dependent projects are mutually aware of their most critical communication needs. As an example we present the information model developed at Nokia STP and show how it was defined in a two-day workshop.

Keywords: Requirements process, software engineering process definition

Introduction

Many software experts argue that process improvement should be based on process models with explicit activities and work products handled in these activities [1][2]. This focus on activities has lead to several best practice collections, see e.g. [3] for a requirements engineering best practice guide. However, before one can focus on specific practices it is important to create a common understanding of who needs the output of which activity why and who provides which input to which activity. This is especially important in *complex multi-project contexts* where work products evolve in several projects concurrently and have to be synchronized. Nokia Smart Traffic Products (STP) is an example for such a context. At Nokia STP customer projects build innovative, customer-specific products. Within these projects, technological and user issues are negotiated. The main focus of these projects is customer satisfaction. Platform projects build assets that are reusable in several projects. As Nokia STP is going into the direction of product lines [4][5], ideally, all the general product features are developed as reusable assets. However, in practice, sometimes customer projects need to develop such general features before the platform project can take over. The goal of the platform project is effort and cost reduction through reuse. To get a maximum benefit from this reuse, it is important to make sure that the platform project is synchronized with all customer projects.

In such a context, it is difficult to achieve a common understanding of the activities and the work products for two reasons: (i) there is a high number of stakeholders involved throughout the concurrent projects; (ii) it is almost impossible and to some extent not even desirable to define a fixed number and fixed schedule of activities and work product flow because of the complexity of the factors and issues evolving during multi-project execution.

To alleviate these difficulties we propose to focus requirements engineering process improvement first on the information flow by creating an *information model* instead of a process model. The information model captures the information, in terms of documents, created and needed by the stakeholders, as well as the responsibilities for information exchange. This article describes a case study where we developed the requirements engineering information model for a complex multi-project context at Nokia STP during a two-day workshop.

Information Model

The information model characterizes a set of requirements documents evolving in a company in different, but interdependent projects, as well as the responsibilities of the stakeholders for the documents. It answers the following questions:

- Which viewpoints are captured in which documents
- Who creates which requirements document and for which audience
- Who approves the documents
- Who reviews the documents
- Who is responsible for consistency
- Who is responsible for approving and propagating change

The information model consists of several sub-models, namely document matrix, document details, role details, and change process flow. Figure 1 shows an abstract example of a *document matrix:*
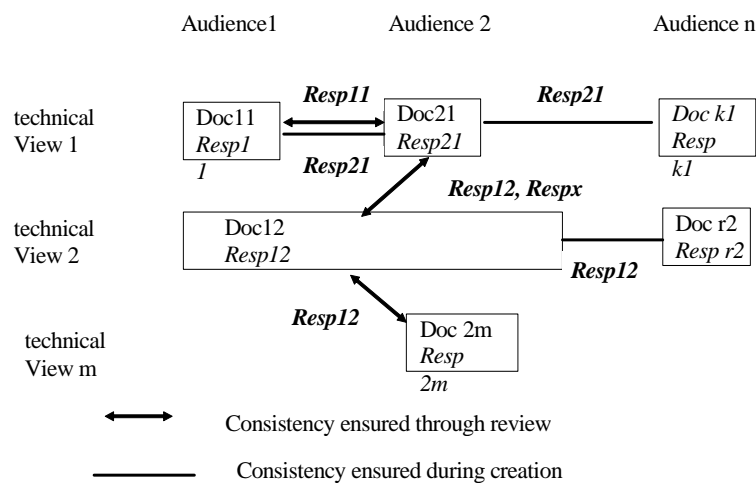
Figure 1: Abstract document matrix

The boxes represent documents from various projects and contain the names of the document and the authors. The rows and the columns characterize the viewpoints, namely the level of technical detail and the audience, the documents are intended for. The audience and authors can be stakeholder roles within one or across several projects. Note that not each viewpoint for each audience must be captured in a document. Note also that one document (e.g., Doc12) can be aimed at several audiences. For one audience one viewpoint is at most captured by one document. Note that the documents package the information needed by the audiences. Thus, information may be duplicated between documents. The arrows describe the responsibilities for consistency (the names along the lines indicate the responsible person). As there are several documents evolving in parallel, someone has to ensure consistency between the documents. This can be performed either during the creation of the document or through explicit review after the creation. In the first case, the author of the document is responsible for consistency. In the second case, other roles who need not be involved in document creation can take the responsibility for consistency review. Even though the reviewers' main goal is to check the consistency of the document with some other document, they can, in addition, check the document for other criteria like completeness or feasibility. Further details of the information flow, e.g. the review concerns or the responsibilities in case of change are captured in other sub-models (see the following case study for examples).

Improvement Workshop

As process stakeholders barely can afford the effort for process improvement, one of the main advantages of the information model is that it can be developed in a two-day workshop with many stakeholders. Another half day of each stakeholder is needed for company internal preparation. We conducted a workshop at Nokia STP with 20

participants from marketing, sales, system design, software design, project management and multi-project management (also called program manager, where one program comprises a set of products). We used t he following workshop scheme:

Preparation (as input to the moderator of the workshop)
- Identification and basic description of the typical roles and documents in the project
- Preliminary identification of problems with the current process

Day One
- Introduction of participants and their expectations of the workshop
- Introduction of RE terminology and basics through the moderator
- Collection of problems with the as-is RE process
- Derivation of a first, basic document matrix (who defines requirements with which viewpoint)
- Teamwork: Discussion of document matrix (groups with a maximum of 10 members)

Day Two
- Presentation of the teamwork results and consolidation as an improved basis for the to-be information model
- Teamwork: Determination of the consistency and review responsibilities; determination of the change responsibilities
- Wrap-up and determination of the next steps to ensure that the to-be information model will be incorporated in the company's every day life.

Workshop Preparation

Nokia sent typical documents used in the RE process to the workshop moderator. Before the workshop, the Nokia participants filled in a questionnaire (available from [6]) in groups (sales, development, marketing) . This helped the moderator to gather information about their current situation and problems and triggered discussions within the groups. In addition, the questionnaire made the participants sensitive for the topics addressed in the workshop. Another input to the workshop was a matrix, created by the Nokia experts before the workshop, which shows which stakeholder role creates or uses which requirements documents. The reason for such a matrix is twofold: First, this matrix can be seen as an initial step towards the information model, as documents and stakeholders are related. Second, the creation of such a matrix in a company creates a common ground: It gives each stakeholder a good overview of who is involved in the RE processes, especially in multi-project environments. Additionally, each stakeholder gets an overview of the involved requirements documents. Often, members of the customer projects are not aware of all documents and stakeholders of the platform development and vice versa.

First Day of the Improvement Workshop: Characterization and Common Ground

The first day of the workshop revealed that requirements have to be defined considering the following views:
- Marketing: general customer needs and innovative technologies
- User: specific user needs, namely the usage of the product
- System: behavior and quality constraints of the system (HW, mechanical parts and SW)
- Detailed System: details of the functionality and the constraints (as far as needed to distribute responsibilities between hardware, software and mechanics).
- Software: behavior and quality constraints of the software

Figure 2 shows the to-be-document matrix that emerged during the workshop. On the first day only the documents were determined. Table 1 and

Table 2 explain the acronyms used.
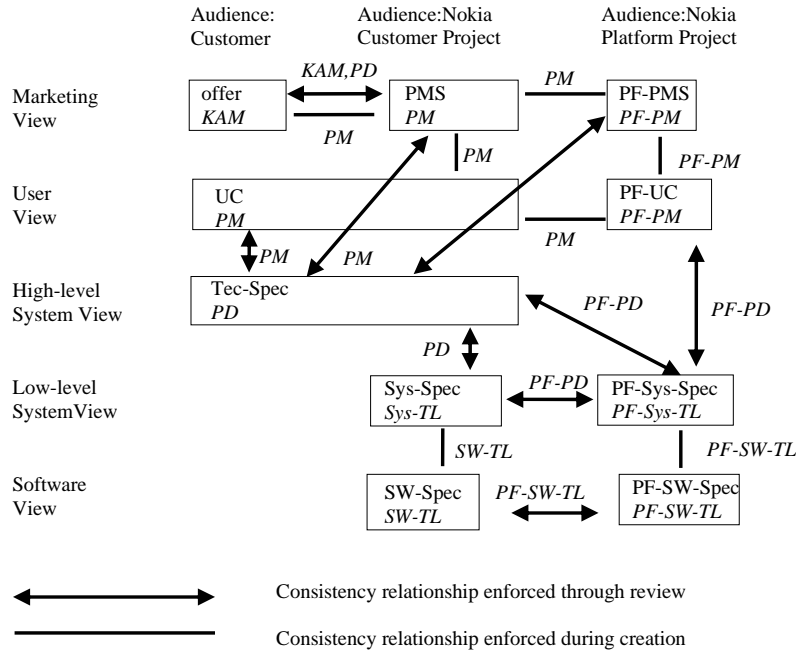
Figure 2: To-Be-Document Matrix

Table 1: Document explanation

Acronym	Document name	Explanation
	offer	Product characteristics on the marketing level for the customer
PMS	product marketing specification	Product characteristics identified by the market strategy as input to product development in customer projects
PF-PMS	platform PMS	Roadmap for the platform development
UC	use case	Intended usage of the product features
PF-UC	platform UC	Intended usage of the platform product features
Tec-Spec	technical specification	System behavior and quality constraints for the customer
Sys-Spec	low-level system specification	System details for customer and platform system developers, not given to the customer.
PF-Sys-Spec	low-level platform system specification	Platform system details for customer and platform system developers, not given to the customer.
Soft-Spec	software specification	Software details for customer and platform software developers, not given to the customer.
PF-Soft-Spec	platform software specification	Platform software details for customer and platform software developers, not given to the customer.

Table 2: Role explanation

Acronym	Role name	Explanation
KAM	key account manager	responsible for the customer relationship
PM	product marketing manager	responsible for the marketing of a certain product and its features
PD	product development manager	responsible for one single product to be developed in a customer development project
Sys-TL	system team leader	leads the development of the system, including software, hardware, and mechanical parts
Soft-TL	software team leader	leads the development of the software
PPM	product program manager	responsible for a group of products
PF-PM	Platform product marketing manager	responsible for the marketing of the platform product features
PF-Sys-TL	Platform system team leader	leads the development of the platform system, including software, hardware, and mechanical parts
PF-Soft-TL	Platform software team leader	leads the development of the platform software

We only distinguished between three different audiences: Customer, Customer Projects at Nokia STP and the Platform Project at Nokia STP. These three audiences typically consist of different development roles, namely developer, tester, maintainer, and project manager. There are, of course, other technical roles involved such as hardware development, but in the workshop, we focused on software.

The first day of the workshop ends with group discussions about the information model. In the Nokia workshop, we built two moderated groups that discussed the accuracy of the model and the pros and cons of the documents as well as the authoring responsibilities determined so far. These discussions together with the information from the workshop preparation lead to a list of potential improvements for the RE process at Nokia. In short, Nokia already uses many good practices in their RE process. Still, the information model revealed a number of potential improvements:

1. The current RE process (handling of documents, information exchange) is more complex than necessary.
2. The RE processes and documents are not transparent to the different roles.
3. Not all documentation responsibilities, especially in the area of customer contact and quality assurance of the documents, are clearly defined.
4. The documents are not tailored to the information needs of the stakeholders. On the one hand, the documents contain unnecessary information. On the other hand, important information is scattered across several documents.
5. The documents do not follow a documentation standard. Templates are only used for parts of the documentation. The needed content (kind of information) for the documents is unclear. This leads to an incomplete set of requirements.
6. Change management procedures are installed for written change requests from the customer, but do not work well for internal change requests and customer change requests issued verbally to various team members.

Second Day of the Improvement Workshop: Innovation

During the second day we completed the to-be information model with the main consistency relationships and roles that are responsible for these consistency relationships.

The document matrix: Figure 2 shows that the Tec-Spec serves as a central document. It was agreed to use it as a kind of master document (e.g., it serves as an entry point for change requests). Several people at Nokia STP were not aware of this central role. The consistency relationships give hints on which kinds of information should be included in the documents. Furthermore, the document matrix shows the importance of the integration of PF-

development and customer projects. PF-development is very important to synchronize the different customer projects and to save effort and time through reuse.

In addition to the consistency responsibilities in the document matrix, we captured the details of the document and role responsibilities in tables, and the change process in a simple document flow diagram.

The document details: We express the document details by a table that lists for each document:
- Its main contents
- The authors (the responsible person is underlined)
- The reviewers and their main concern during the review (the person who finally approves the document is underlined)
- Comments that highlight important considerations (e.g., what should be taken into account during creation/review/approval).

Table 3: Document Details

Document	Content	Authors (Responsible)	Review (Viewpoint) (Approval)	Comments
Tec-Spec	high-level system view, features, quality requirements, interfaces, architecture, additional internal requirements, test requirements	PD Sys-TL, Supply Chain	PPM PM (consistency with PMS and UC) PF-PD (consistency with PF-Sys-Spec) Customer (approval, mediated through KAM)	Should be updated at each milestone After each update: review should be repeated

Table 3 shows an excerpt of the document details. The authors' column specifies the roles involved in the requirements engineering process: the Sys-TL, PD and supply chain are involved in the Tec-Spec. The PD is underlined, which means s/he is responsible for the creation. The review column shows the roles involved in the review and consistency checking. The PPM, PM and the PF-PD, are involved in the review process. The PPM and the PF-PD roles review the Tec-Spec with a multi-project view. As the review by the PF-PD and PM are consistency checks, they are shown in the document matrix. The review of the PPM is a review for approval and, therefore, it is not included in the document matrix.

The document details are important to get complete and consistent documents. Furthermore, the intertwining of the platform development and the customer development project is implemented through the documentation and review responsibilities.

As the documents focus on different audiences, clearly important requirements knowledge may be duplicated between the documents. Thus, this is part of the consistency issue. To support the responsible stakeholders traceability tools should be used [7]. In the document details table important traceability relationships between different documents can be mentioned in the comments section. The definition of detailed traceability links is not part of the information model, the same holds true for the detailed review criteria. These details cannot be fixed within a two-day workshop.

The role details: We express the role details by a table that lists the documents responsibilities of each role.

Table 4: Role details

Role	Responsibility
KAM	The offer is created by the KAM. The KAM needs to get the approval of the customer for the offer. In addition, the KAM is responsible for all oral communication to the customer, e.g. wrt. the UCs, the Tec-Spec and changes. This requires close communication with PM and PPM.

Table 4 shows an excerpt of the role details of the KAM. The main purpose of this table is to collect all responsibilities of one role and thus to detect bottlenecks. In the workshop, the role of the PPM was discussed several times. At first, it seemed that s/he had to approve each and every document. By the careful use of review and co-authoring responsibilities and by distributing the PPM concerns to other roles, it was possible to drastically reduce this workload.

The change process: Basically, there are two ways how change requests arrive at Nokia STP. First, written change requests are issued by the customer and, second, verbal change requests issued informally by the customer arrive at several points during a development project. The verbal change requests were much more problematic, as there was no common process for handling these kinds of change requests. The participants agreed upon the fact that verbal change requests cannot be avoided. In addition to the external change requests from the customer there are

- Internal change requests that are visible to the customer
- Internal change requests that are not visible to the customer

During the workshop, change processes were sketched for all kinds of requests.
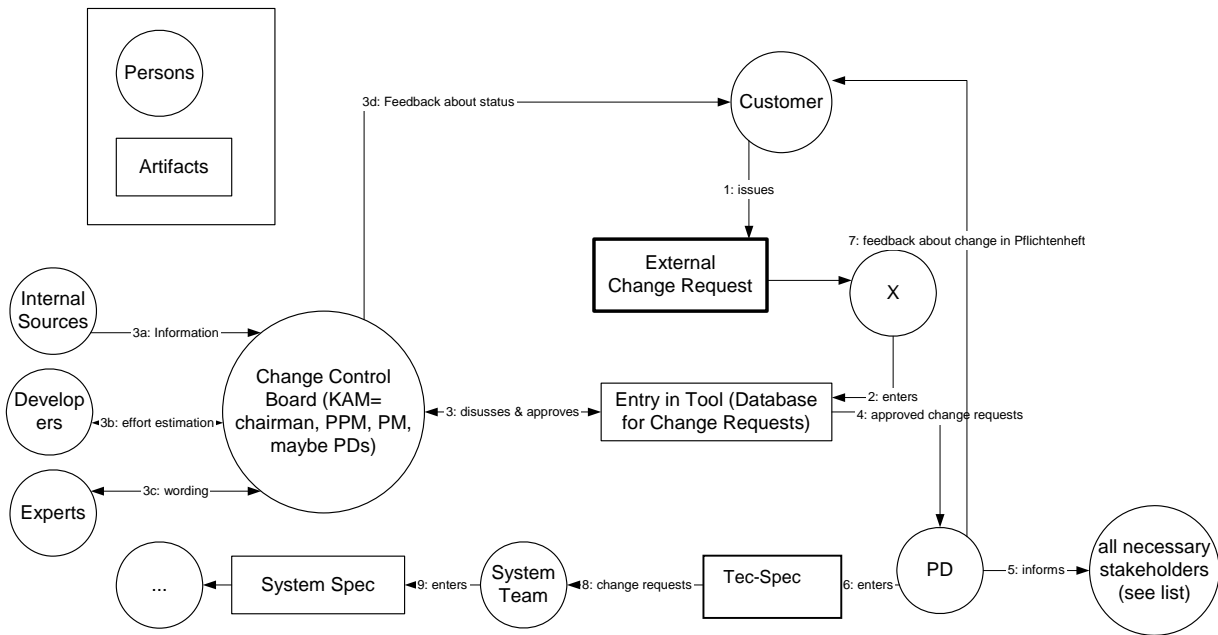
Figure 3: Change process flow for customer change requests

Change processes are part of the information model. Figure 3 shows an excerpt of the change process for customer change requests. Because of its central role, change requests affect the Tec-Spec first and are then propagated to other documents. A change request from the customer arrives at any team member of the customer development project (marked as "X").

The workshop participants agreed that a dedicated contact person for change requests would be beneficial, but it would not be possible in their current projects. The change process was designed to handle this situation, i.e., the change request is entered by the team member "X" into a tool already used at Nokia. The change control board scrutinizes the requests and gathers information from various team members and experts. The review, approval and consistency responsibilities (including important traceability relationships) from the document and/or role details give valuable support in defining the change process, as they show who has to be involved in the decision and negotiation processes. Once a decision is made, the customer is informed on whether the change request is accepted or not. The change control board approves the request. The PD, as responsible author of the Tec-Spec, informs all relevant stakeholders who need to know about the change and incorporates the change into the technical specification. The PD, as responsible person for the consistency check between Tec-Spec and Sys-Spec (see Figure 2), informs the system team about the change. The Sys-TL as responsible author of the Sys-Spec incorporates the change into the Sys-Spec and so on. From this description, one can see that the various responsibilities defined in the role details efficiently support the definition of the change process. Furthermore, the list of team members to be informed in case of a change to the Tec-Spec (step five in Figure 3) can also be derived from the authoring and review responsibilities.

During the second-day also solutions to the improvement issues (revealed during the first day) evolved together with the information model:

1. An information model with explicit responsibilities and a focus on the most important documents as a kind of master document reduces the complexity of the RE process.
2. The missing transparency was tackled by the explicit modeling of the documents, audiences, technical views, and responsibilities in the information model.
3. Similarly, the missing responsibilities are defined by the information model.
4. The information model makes it easier to tailor the RE documents, as the audience and the technical level of the documents are clearly defined. Furthermore, the document details (see Table 3) show which content a document should have. By having explicit reviewers, it is assured that this content is in the appropriate document.
5. The missing documentation standard is solved by using templates for the whole documents. The templates are not part of the information model, but the information model provides hints on which kinds of requirements should be addressed by the template.
6. The information model also tackles the change management procedures, as a change process definition is part of the information model.

The sidebar shows how the results of the workshop are currently transferred into every day life at Nokia STP.

Transitioning the workshop results into practice

The workshop was an organization-wide eye opener about what Requirement Engineering means. Therefore, improving (or even establishing) RE processes found support in all relevant departments. Product Marketing took the first step by creating a feature list template for STP products. In order to use the Technical Specification as the central requirements document, we designed a unique template here as well. This process, however, is not yet completed. The reason is that this document should have a similar format as the customer requirements document so that it can be used for the documentation of negotiation results. The requirements documents created by various customers, however, are very different in format and granularity. The change process defined in the workshop is used for internal and external change requests already in one of the new projects and will be introduced to all projects. We established a new RE process in System Design and Software Development, using a company-wide available, proprietary RE tool. Next steps will be (a) the expansion of this process to the rest of the organization and (b) the evaluation of commercial RE tools as a potential replacement for the proprietary tool.

Lessons Learnede

The information model was the key to improve RE communication in the multi-project context of Nokia STP. We recommend other companies to develop such a model in a similar improvement workshop. Of course, there are many different ways how such a workshop could be organized. In the following we list some guidelines based on the lessons learned during the workshop:

- Filling in the preparation questionnaire in groups requires a certain maturity of the participants, as the group discussions can dominate the individual opinions. Thus, these opinions might not surface in the questionnaire. Therefore, one has to trade-off this risk of loosing individual opinions against the benefit of the initial group discussions.

- In the preparation and during the collection of the problems with the as-is RE process it is important to check whether all mentioned issues can be handled with the information model. There will always be additional issues as e.g. tooling issues. These additional issues should be kept in a separate list and discussed during the workshop wrap up to define when they can be tackled.

- The choice on the level of detail of the audience in the document matrix has to be made based on the company's major need for RE process improvement. For the purpose of the workshop, documents of the same view can be handled as one document, if there are no major problems within the audience.

- During the definition of the first document matrix, the identification of the views is very important. It makes explicit that there are several equally important ways to define the system. Typically, the stakeholders are not aware about these views.

- The detailed review and consistency checking responsibilities should not be discussed in a group with more than 10 people as a specific relationship is only interesting for a small subset of roles. During our workshop we therefore switched from a plenary session to group work. This required synchronization of the results the next day, but it turned out that the group worked was instrumental for the participants to identify with the concept of the information model. So the time was worthwhile.

- Do not worry that the information model leaves more details open than a process model, e.g., it does not fix the point in time when a document is created. So, for instance in Figure 2, the offer could even be created after the Tec-Spec. While this seems strange for an individual project, this is very well possible in a multi-project context where the Tec-Spec is taken from one customer project to another one and then the offer highlights important aspects for the new customer. Similarly, a customer project specification could be created before the platform project specification, because a product feature is first developed in a customer project. The order of document creation differs from project to project. Thus, the omission of scheduling and timing relationships in the document matrix helps to avoid unnecessary discussions.

- Similarly, it is not possible to define all details of the change process (e.g. traceability) in two days. However, it is important to discuss change on the basis of the information model, as change is essentially a cooperative decision process. The document matrix helps to keep the description of the change process simple.

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We are convinced that such a workshop will also be useful in multi-project contexts of other companies. In addition, we recommend that individual projects at project start spend half-a-day to make their information model explicit (skipping the collection of problems and the group work). The information model is a good way to quickly ensure a common understanding of the whole project team about the individual information needs and responsibilities.

References

[1] B. Curtis, M. I. Kellner, J. Over, "Process Modeling", *Communication of the ACM*, vol. 35, no. 9, September 1992, pp. 75-90

[2] R. Conradi, A. Fugetta, "Improving Software Process Improvement, *IEEE Software*, July/August 2002, pp. 92-99

[3] Sawyer, P., Sommerville, I., Viller, St., "Capturing the benefits of requirements engineering", IEEE Software, March/April, 1999

[4] P. Clements, L. Northrop, *Software Product Lines: Practices and Patterns*, Addison-Wesley, 2001

[5] A. Birk, G. Heller, I. John, K. Schmid, Th. Von der Maßen, K. Müller, "Product Line Engineering: The State of the Practice", *IEEE Software*, November/December 2003, pp. 52-60

[6] Requirements Engineering Health Check (Questionnaire); http://www.iese.fraunhofer.de/re-checkup/

[7] B. Ramesh, M. Jarke, "Towards Reference Models for Requirements Traceability", *IEEE Transactions on Software Engineering*, vol. 27, no.1, 2001

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