A Portal for Cross-Administrative Acquisition and Specification of Software Requirements

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Abstract: For the development of software requirements within a team, efficient communication and a systematic approach are necessary. Because of the complexity of the task, the need for software support seems obvious. A requirements portal is an Internet based software application, which provides all parties involved with the current discussion status of the requirements including preliminary versions and open questions. This article shows how such a portal for the support of a process based on the V-model XT is designed in order to improve the cooperation between authorities and local government in the requirements engineering process.

1 Introduction

Internet based technologies have found their way into politics and administration, allowing them to remain connected to the social environment with the fast dissemination of the information and communication technologies (ICT) [BB02]. Electronic Government (E-Government) describes a technically oriented administration reform that in Germany has not been completed yet and faces permanent new challenges [Ab06]. E-Government refers not only to the interfaces to external communication partners such as citizens or private companies, but is also internally directed, in order to organize and improve internal processes with the help of ICT. It therefore questions the traditional administration practice with its specific processes [Tr99] and the complex relations in organizational entities of public administration [KW04, Wir99].

An important prerequisite for the implementation of E-Government projects is the development and the choice of appropriate software. Requirements engineering (RE) is

the first part of the software development process. It consists of several phases, in which different stakeholders deal with the problem of setting up a requirements specification[1] documenting the requirements to the future system as precisely as possible [Pa98, RR06, So07]. This phase is often regarded as the most critical in the software development process [Ma01, Pa98, So07]. Errors in this phase can cost a hundred times more than programming errors [KS98] and misidentified requirements are the main cause of customer dissatisfaction with the finished system [Ma96].

A single person does not generate software requirements. They necessitate the work and competence of several employees of different departments, including technical and professional experts as well as project managers, developers and end users [KS98]. This is important in public administration as well, since, in times of financial shortage, inter-municipal cooperation offers an interesting possibility to save resources for a better citizens' service for instance [HW06, Re06]. Since there are many similar processes in government agencies and municipalities, synergetic effects can be used to save costs, avoid work redundancies, share risks and increase productivity [Hu05]. This can also be put to use in the RE process, by reusing requirements[2] already specified by other government agencies or municipalities on the one hand, and developing the requirements document together on the other. Based on this document, municipalities can generate a public call for bids when required.

An efficient communication and a systematic approach are necessary in order to facilitate RE within and across government agencies. This is especially important in a distributed environment, when personal meetings are rarely or not at all possible [ES05, Il07]. This distribution is actually beneficial for the requirements specification process, since the group can perform the task in a focused and more objective manner [He00]. Because of the complexity of RE, a document based requirements specification has some disadvantages (cp. e.g. [Wi99]). This calls for the use of Internet based software that facilitates work in the virtual team.

In this article we describe the design and implementation of a so-called requirements portal. This was performed with the cooperation of and primarily for the City of Mannheim. However the possibility of a future use by other cities is also to be considered, thus it was decided that the portal should support a process based on the V-model XT (cp. [Ko07]). The portal provides all parties involved with the current discussion status of the requirements including preliminary versions and open questions. A distributed and asynchronous use is possible, decreasing meeting time and potential travels. Additionally all considerations can be documented and retraced in the system. The data in the system can be used as a requirements specification, and thus as the basis for public calls for bids, if required.

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[1] A.k.a. requirements document, specification sheet, functional requirements [Pa98].
[2] According to [KS98], up to 50% of requirements can be reused in systems from the same field of application.

2 Preliminary Analyses

For the design and implementation of the portal, the application context had to be clarified first, and an actual analysis of the software bidding process of the City of Mannheim performed. Afterwards, the first requirements were elicited in order to determine the basic technology for the portal.

2.1 Application Context and Current Situation

The Department for Information Technology of the City of Mannheim has 60 employees in three sub-departments. It is responsible for the infrastructure management (e.g. telecommunication, server operations) and application management (software implementation and maintenance). For the implementation of a software application, an agency must make a request. The RE is then performed in a project with the cooperation of the Department for Information Technology and the respective agency, generating a vast amount of information in the form of concepts, protocols and emails. This is stored in a data system assigned to the project. IT support of the RE process is currently not available. Therefore, it is decided to design and implement a prototypical requirements portal to support the RE process.

2.2 Initial Requirements Elicitation

At first, the stakeholders of the future system are identified, resulting in two groups of users: employees of the IT department and employees of other offices. The different level of IT know-how within the two groups has to be taken into consideration. Whereas employees of the IT department possess a high technical know-how and command of programming languages, this cannot be expected of employees in other offices. This has an important effect on the design of the portal, as it will be shown later.

Additionally, the following requirements are elicited: The basic technology should be license-free or better open source and platform independent. Furthermore, the portal should be web based and operated by a web browser. The most complex requirement to the portal is, as already mentioned, that it should support a development project performed according to the V-model XT. This means on the one hand that the basic technology has to be as flexible as possible, to allow an easy customization during *Tailoring*, i.e. the project specific customization of the V-model XT. On the other hand, the portal had to be basically configured to support V-model XT activities. It is decided that the portal should cover almost the complete product group *Requirements and Analyses* of the V-model XT. The focus is especially, but not exclusively on the client. The initial requirements are summarized in Figure 1.

Functionality	Support of a generic RE process
Operability	Operated by web browser
License	Free and open source
Platform	Platform independent
Standards	Support of a development project performed according to the V-model XT

Figure 1: Initial requirements for the portal

2.3 Evaluation of potential basic technologies

Due to the suitability of wiki systems for RE purposes (cp. [Ge07]), they are used as a basic technology. As opposed to traditional, commercially available RE tools that are not designed for Internet based use[3], the portal is meant as a flexible, light, cross-organizational approach.

Since the decision for a wiki system has been taken, further system requirements have to be specified in order to perform a reasonable evaluation. Because the portal should also be used outside the IT department, it is decided that the special wiki syntax has to be replaced by a WYSIWYG-editor[4]. Extensibility of the system through plug-ins, scripts, templates[5], interfaces etc., to allow a better adjustment to the needs of the government agencies, is also added to the initial requirements. A community as large as possible and a good documentation should also be available, which help clarify questions that may arise during development and future use.

After that an evaluation of wiki systems is performed. Since there are over 200 wiki systems available on the market[6], a preselection is necessary before a detailed evaluation is possible. It turns out that the requirement *WYSIWYG-Editor* reduces the number of eligible wiki systems the most. After the first step of the evaluation only 19 wiki systems with WYSIWYG support are left. These 19 wiki systems are now evaluated with respect to the other requirements. Surprisingly enough, only four wiki systems can provide a good integration of a WYSIWYG editor. In all the others the integration is still in beta status, which causes problems with plug-ins, data storage or access rights. These problems are mostly caused by the fact that external editors have to be integrated, which do not yet interact properly with the wiki system. It turns out that TWiki[7] can best meet

[3] An overview and evaluation of various RE tools is available in [GHR06].
[4] "What You See Is What You Get"-editor. An editor that allows text formatting similar to Microsoft Word.
[5] In wikis templates can be used to create new pages and are a good way of customizing the system.
[6] For an overview see e.g. www.wikimatrix.org or www.c2.com/cgi/wiki?WikiEngines.
[7] It needs mentioning that the concept can also be applied on other wiki systems.

the requirements. Moreover TWiki distinguishes itself by providing a workflow plug-in, which is generally not available in wiki systems.

3 Concept and Implementation

After completing the technology evaluation, a general concept with regard to the chosen wiki system is developed. After that the concept for a single module is specified, validated on site and then prototypically implemented. The implementation is then presented on site. New requirements that arise then are recorded and implemented in the next iteration.

3.1 General Concept

In the V-model XT the final or intermediary results to be developed are called *products*. *Product groups* sum up related products and allow for a hierarchical structure. A complex product can be made up of several *themes*. Similarly every product in a V-model project is completed by one *activity*. Activities can be subdivided into *sub activities* to be performed together, which process one or more themes [Ko07].

The portal basically maps the activities group *Requirements and Analyses* of the V-model XT. This means that a user who is familiar with the V-model XT in this area will immediately recognize it in the portal (see Figure 2). Furthermore, all data needed for products in the product group *Requirements and Analyses* can be stored and managed in the portal. The portal processes the data in such a way that the products requested by the V-model XT can be directly displayed through the portal. The usability is increased by menu navigation, direct links and a sensible father-child topic[8] structure. The portal basically supports a generic RE process and all its phases: requirements elicitation, specification, validation and management.

[8] In TWiki a wiki page is called a “topic”.

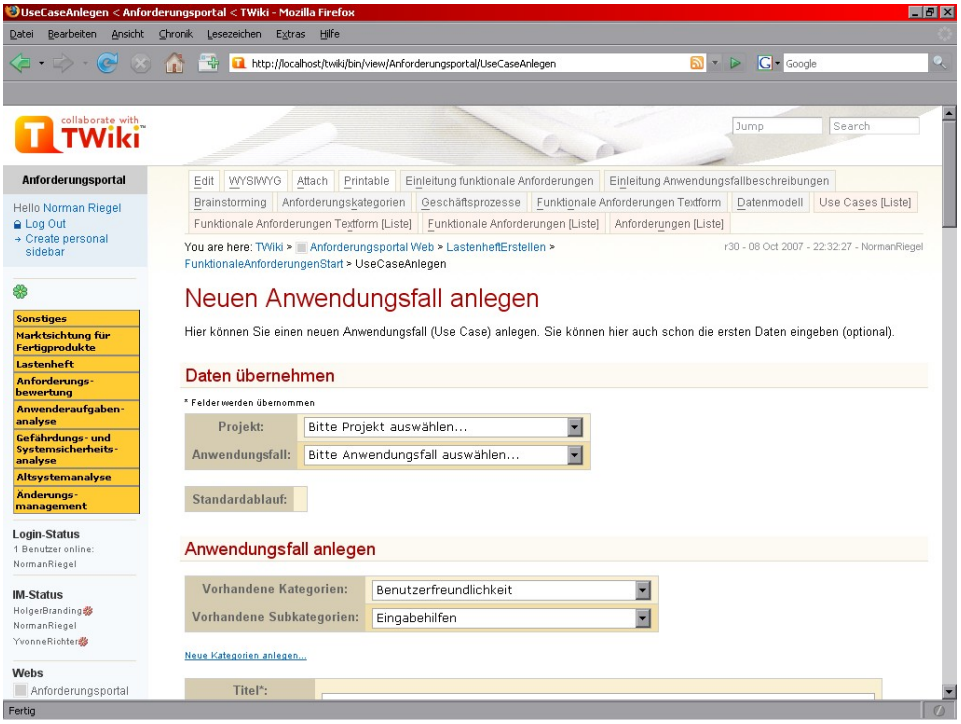

Figure 2: The requirements portal with its V-model XT-like menu

Through the elicited requirements it was determined that only the use through WYSIWYG-editors should be possible. This has to be taken into consideration in the concept, since pages are not allowed to contain any wiki-specific syntax. The solution to this problem is a breakdown into three topic types: form based input topics, data topics and output topics.

Aside from the data topics themselves, special input topics can be used for data acquisition in the portal. They serve the sole purpose of setting up data topics with the help of forms. These input topics are by default closed for editing with a WYSIWYG-editor. This makes sure that no user can inadvertently change the page and that he never gets in touch with special wiki syntax or form code, unless he wishes so.

For data storage, the portal contains two types of data topics that after set-up can be edited through the respective input topic. These are on the one hand topics that can be edited[9] with a WYSIWYG-editor, and on the other hand form-based data topics, that allow data input in HTML-forms. These form topics are closed for editing with a

[9] These correspond to a normal wiki page without editing limitations.

WYSIWYG-editor as well, and data entered through the forms is saved internally in the wiki as meta-data.

The form-based storage has another purpose apart from the structured displaying: data can be read out individually when needed. For data topics that can be edited with a WYSIWYG-editor, that is generally not possible[10]. This means that an exact analysis should be made as to which data topics should contain forms and which shouldn't. The stored data can then be read out internally such that only information relevant to one particular product can be extracted. There is therefore one type of output topic that represents one particular product of the V-model XT. The portal assembles this product automatically from the saved data. List topics are another output topic type. They allow an overview of the data topics. The advantage is obvious: lists or documents can be created without any programming knowledge, which can be put together with the wiki syntax available alone.

Through the use of the wiki, a versioning of the data is given. Beside a unique ID, other information is stored, such as author, editor and editing time. For a good traceability, additional interdependencies among requirements can be defined. Change requests are also supported. The portal offers a workflow support seldom met in a wiki system, which controls the editing of any page in the portal, allowing an unrestricted workflow definition. Hence for pages with a certain status, access for users is either free or restricted. Different overview lists contain the current processing status of certain pages and the name of the person they are currently assigned to. Interdependencies among requirements can also be represented this way. To support baseline functionality, dynamically generated products can also be stored in the portal.

Comments can be added in every wiki page as a means of communication. An overview of the user online status is also available. The Instant Messenger status of a user is also shown on demand, to facilitate direct contact. In addition the portal allows two types of surveys that can be used for polling processes for instance. Users can choose between a selection survey and a scale survey. In the case of the former, the user can name several options, which survey participants can pick from. The portal automatically generates the poll result. In a scale survey, users can choose a value on a scale. The portal also generates the result.

3.2 The Product Requirements Specification

The portal offers several options for requirements elicitation and specification of the product *Requirements Specification* of the V-model XT. If no requirements exist yet, initial ideas can be generated with the help of an implemented distributed brainstorming. An individual page will be set up for every user. Through the workflow mechanism this is cleared for editing by one single user. Afterwards the page can be cleared for the next

[10] With the use of regular expressions extracting certain data would also be possible by adequate markings, but a user could delete these markings by mistake or on purpose. Checking the input would also be more difficult. This method should be applied in wiki systems that do not offer a function for storing structured data.

user. An overview shows which page is currently edited by whom. This way each user can edit each page exactly once. Results can then be gathered on the main page of the brainstorming round.

The portal offers two types of templates for functional requirements elicitation and specification: a template for use cases and one for normal text requirements. The latter is also suited for initial requirements elicitation that can be better specified in use cases. Upload and integration of diagrams for example is also possible, as well as data transfer from other projects. The integrated survey mechanism can also be used for requirements elicitation. A template for non-functional requirements is also available. Additionally, ready-made two-step categories are available in the portal, which facilitate the elicitation of non-functional requirements.

The other parts of the product R*equirements Specification*, such as the topic *Initial Situation and Objectives*, can also be created and edited in the portal and are automatically integrated into the product.

The requirements document is then dynamically generated from this data into a separate wiki page, formatted according to the product templates of the V-model XT (see Figure 3). On demand it can be exported to HTML or PDF, or copied and pasted into a Microsoft Word document without format loss.

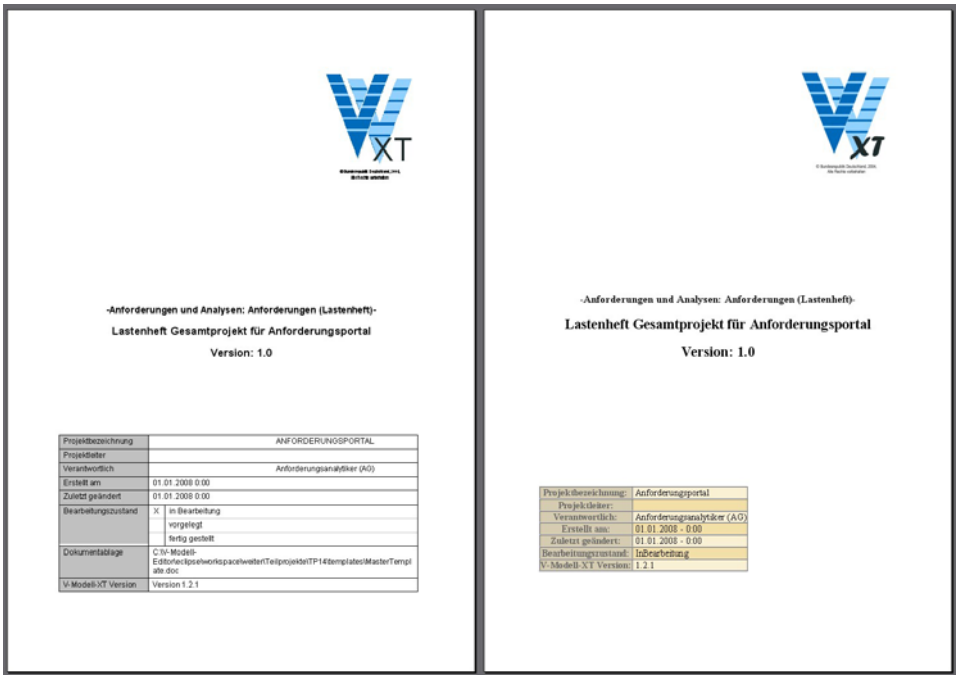

Figure 3: The Requirements Specification of the V-model XT (left) and its counterpart generated by the requirements portal

3.3 The Product Requirements Evaluation

A form is attached to each requirement in the portal, which covers all quality criteria proposed for requirements in the V-model XT. Consequently, the editor has a checklist he needs to go through step by step. In case problems may arise, they can also be noted on this list. A linking mechanism is available in case of conflicting requirements. An individual list of evaluation criteria can also be created.

The requirements categories that can also be created and assigned to functional requirements are needed for the prioritization algorithm implemented in the portal. This algorithm can perform a requirements prioritization according to the hierarchical prioritization approach *Hierarchical Cumulative Voting (HCV)* (cp. [BJ06]). After a user has evaluated categories, subcategories and requirements, the portal generates a benefit value for each requirement. If requirements costs are also entered, the portal will display a table of the cost-benefit ratio of each requirement. Hence a ranking of the requirements can easily be generated.

The requirements evaluation, like the requirements document, is displayed on a separate wiki page. This is possible for all products of the V-model XT supported by the portal.

3.4 Other Products

In addition to generating other products from *Requirements and Analyses*, such as a system security analysis, the portal supports the *Market Survey for Off-the-Shelf Products*. Descriptions for off-the-shelf products can be added, and their level of compliance to each requirement. The portal then performs a utility value analysis and generates the total utility of each off-the-shelf product from their compliance levels.

3.5 Implementation

The functionality of over 15 TWiki plug-ins is used in the implementation, where three of them are self-developed. They mainly perform the requirement prioritization and utility value analysis described before. Parts of an already existing plug-in are used in the development of a plug-in for distributed brainstorming.

To increase usability, JavaScript is used for menu navigation and form control and, where needed, AJAX for data storage and loading.

4 Evaluation

The goal of this evaluation is to prove that, with the technical support of V-model XT, processes especially in activities of the activities group *Requirements and Analyses*, advantages in terms of quantity at least, but also quality, can be achieved.

Advantages in terms of quantity refer on the one hand to the processing time of the RE phase, which should be substantially reduced by the process support. Reducing the idle time of documents alone would bring a substantial economy, as assumed before starting the portal conception. On the other hand a reduction of man-days is expected. This can be achieved especially by the reduction of the number of meetings, better coordination of subtasks to be performed and a wide accessibility of information. Advantages in terms of quality are seen in the forced formalization of communication and the consistent writing with its increased binding character.

A proof of the quantitative and perhaps qualitative improvement of the process execution requires a comparison between the execution of the RE with and without wiki technology support. For that, a RE project for the selection of a new resident registering procedure of the City of Mannheim is chosen for evaluation. This project is complex enough, lasts for several weeks and results in a performance catalogue with approximately 150 criteria as basis for a product selection. For the evaluation, the product selection process from awarding the project contract to generating the performance catalogue and an evaluation matrix using wiki technology is evaluated and compared with the process already executed.

Communication between project participants is traced in order to determine the reduction in the resources processing time and employed man-days. Training costs for the technology are not taken into account. For the processing time, a reduction of at least 15% is achieved. The resulting increase in efficiency is mainly due to the support of an asynchronous communication between project participants, the increased degree of communication formalization, the IT-supported consolidation of work results and the openness of information generated in processes. The reduction of man-days is mainly due to the reduction of project meetings and the cutback in personnel resources necessary for communication organization and maintenance. In this case, a 7% reduction of the total expenditure is achieved by the cutback of group meetings. For project bureau activities, a cutback of 4% is ensued. Getting a precise mean value for different-sized project classes would require several parallel analyses, which would be too complex for current possibilities. The results show a clear advantage of wiki technology use for software selection processes and creating requirements documents. The degree of cost reduction is not identically transferable to each project. The easy adaptability of the used technology to the requirements of a project however is especially important. The cutback in resources depends on the quality of adaptation and can therefore be shaped as desired.

5 Conclusion and Outlook

Over the past years, the V-model-97 was largely used in public administration. After its replacement with the V-model XT in 2005, an improved flexibility allowed an enlarged scope of application. Particularly the hereby introduced model-inherent *tailoring*, i.e. the project-specific process adaptation between client and contractor, requires a technology suitable for this flexible area. This article has shown how a requirements portal for the support of a development project in accordance to the V-model XT was conceived and implemented based on a wiki system.

For this purpose an analysis of the current situation of the software bidding process and an evaluation of wiki systems have been performed in cooperation with the City of Mannheim. Finally, the portal was developed by a suitable configuration and customization of the selected wiki system.

An evaluation of the portal based on a past project has shown that its use yields considerable resource cutbacks. The lack of structure that wiki systems are often said to possess was also proven to be avoidable by a suitable conceptual design. Especially the possibility of quickly adjusting the system without any programming knowledge is of great importance. Usability can also be improved by the use of a WYSIWYG-editor or AJAX, but the decision to do so is left to each organization.

Through the use of such a platform independent portal with its generic design based on the V-model XT, another step is made towards cooperation across administration and local authorities. Because of its generic design it is not only suitable for authorities, but also represents a good basis for use in companies.

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