CARES: Requirements Specification with BPMN 2.0 in WTO Procurement

Daniel Hadrian and Florian Evequoz

HES-SO // Valais Wallis
Institute of Business Information Systems
TechnoPôle 3
3960 Sierre
daniel.hadrian@rigertconsulting.ch
florian.evequoz@hevs.ch

Abstract: The WTO procurement procedure for IT infrastructures and services involves the creation of software requirements specifications (RS). This task is challenging for the public administration, as few aids and guidelines are available. But RS is important in the WTO procedure because it serves as a basis for the evaluation of bidders. On the other hand, BPMN is increasingly applied in administrations to document business processes. Taking the situation of the Swiss administration as a reference, we introduce an original methodology to specify requirements from business processes in BPMN 2.0, based on standardized phrase patterns that are attached to BPMN elements. Our methodology also provides a template structure and guidelines for producing RS that can be included in WTO-conform Request for Proposals. Our methodology originates from the situation in Swiss administration, but it is generic enough to be applied in other public administrations as well as in private companies. We also conduct user interviews to identify the actual tasks and challenges faced by users when specifying requirements. Findings from the interviews suggest that communication issues between stakeholders (business users, analysts, IT specialists) are the most pregnant. Based on results and analysis of user interviews, we design a software prototype that aims at solving most problems faced by users when producing requirements specifications. The main advantage of our methodology is that administrations can reuse existing BPMN process documentation as a basis for specifying requirements in the WTO procedure.

1 Introduction

Public procurement of IT infrastructures and services is set by common agreements for countries that are members of the World Trade Organization (WTO). The WTO rules and regulations are meant to promote competition, guarantee the right usage of public funds, and ensure fair and non-discriminatory treatment and equal opportunity between the competing bidders. Above a certain cost threshold in the procurement of IT infrastructures and services, the WTO rules and regulations are applied.

Early in the procurement procedure, the public administration wanting to procure must issue a Request For Proposals (RFP). In Switzerland, the legal basis that governs public procurements [Lo94] gives precise guidelines once the request for proposal has been launched. However, as stated by [Ga07], there is a lack of instructions regarding the form and the content a request for proposal should have. Even HERMES 5, the new version of the official Swiss federal government IT-project methodology (eCH-0054) [Ec13a] does not contain the template of a RFP. Moreover, previous research we conducted by interviewing WTO procurement specialists in Swiss administration tend to confirm this lack of templates, and point out the crucial role of Requirements Specifications within a RFP (as the main basis for the evaluation of the bidders) and the challenges associated with gathering and specifying requirements [Ha11]. Therefore, we believe that a methodology for producing WTO-conform requirement specifications would be a great help for Swiss administrations, but also to other administrations conforming to WTO.

Apart from the procurement theme, public administrations face increasing challenges and opportunities in the E-Government domain, increasing the capabilities but somewhat also modifying the culture of the public sector. In particular, the Swiss Strategy for E-Government recognizes the importance of business processes towards a successful implementation of E-Government [Fi07]. Indeed BPMN 2.0 has been adopted as a national standard for describing business processes (eCH-0140) [Ec13b]. We know that BPMN aims at bridging the gap between business people, business analysts and IT specialists. Those three groups of stakeholders are also key players in the creation of requirements specification. Therefore we think the BPMN knowledge in public administration can be leveraged upon, in order to ease the creation of requirements specifications.

In this article, we introduce a methodology, supported by a software prototype called CARES (Computer Aided Requirements Engineering Software) that eases the creation of requirements specifications based on a BPMN 2.0 documentation of processes. The requirements specification produced can then be used by a public administration as part of a RFP in a public procurement procedure.

In our work, we use the context of the Swiss Government as a reference. In Switzerland, BPMN has been declared a standard for process documentation in public administration [Ec13b], which provides an ideal use case for the methodology we present here. However our findings could be applied to other administrations as well as to the private sector. We also found it most important to primarily target public administrations because of the high regulation in this particular field. The main difference between Switzerland and the EU-member are to be found in the threshold values for public procurement. For EU members, the threshold starts at 134,000 Euros for state administrations and at 207,000 Euros for local and regional authorities and other public sector authorities. In Switzerland the threshold is set at 250,000 Francs (200’000 Euros) for state administrations and is federaly regulated by the cantons.

The article is structured as follows. We first present related work in requirement specifications. Then, we introduce our methodology for requirements specifications

based on BPMN documentation of processes. In section 4, we describe the results of interviews we conducted to enhance our understanding of the tasks and problems users face when specifying requirements, and confronting our methodology to the practice. In section 5, we present the design of a software prototype supporting our methodology and incorporating the main findings from user interviews. We conclude by presenting perspectives and future works envisioned.

2 Related Work

To the knowledge of the authors, existing research to date does not specifically address the use of BPMN in requirements specification. Practitioners in the fiels of requirements engineering that we interviewed as part of preliminary research [Ha11] were also not aware of existing use of BPMN in that context. Specifying requirements from a business point of view is generally part of a Goal-Orientend Requirements Engineering (GORE) approach. Several GORE frameworks for specifying strategic requirements exist. KAOS, i* and B-SCP are probably the most famous. Knowledge Acquisition in autOmated Specification of software systems (KAOS) [La01] enables the computation of requirements from Goal Diagrams. i* (pronounced "i star") or i* framework describes the dependency between actors and their motivations, which is useful for early requirements [Ko06]. B-SCP: Business-Strategy, Context and Processes is based on three different frameworks, namely i*, role activity diagrams and Jackson context diagrams [BK06]. A common feature of those frameworks is that they use their own abstractions for representing the business from which the requirements are derived. They do not rely e.g. on existing process documentation nor do they capitalize an a standard notation as BPMN.. UML Use cases are also used for requirement specifications. In contrast to processes modeled in BPMN, UML provides system use-cases rather than business use-cases.

Best practices for software requirements specification are presented in IEEE-830-1998 [Ie98]. In particular, this document considers three categories of methods, languages and tools for requirements specification ([Ie98] section 4.3.2.3). The process-based approach is one of them. In a process-based approach to requirements specification, requirements are organized „into hierarchies of functions that communicate via data flows“. The approach we present in this article falls in the process-based category.

More specifically, in Switzerland, several guidelines for public procurement also exist [Gu11] [Li12]. Neither provides a template nor guidelines for requirements specifications.

This short survey of the related work shows that no existing approach to date explicitly builds upon a BPMN documentation of business processes to prepare requirements specifications.

3 A BPMN-Based Methodology for Requirements Specification

In this section, we introduce our methodology for requirement specifications based on BPMN documentation of processes. This methodology has three stages. First, process modeling in BPMN, then actual specification of requirements alongside business processes, and finally production of the requirement specification document with the help of a template. We describe the methodology hereafter in a prescriptive fashion.

3.1 Process Modeling

The business processes serve as a basis to specify the actual requirements. Therefore they have to be modeled precisely, using modeling conventions to minimize interpretability bias as well as to maximize coherence. They must stand in the context of the organization in order to show the perimeter of the system that will have to support them. In order to depict the context of the organization and to show the perimeter of the future system, we recommend building up a process architecture (see Figure 1), either top-down or bottom-up by applying the principles explained in the relevant eCH-standards (eCH-0145, eCH-0138, eCH-0139 and eCH-0140, see www.ech.ch).

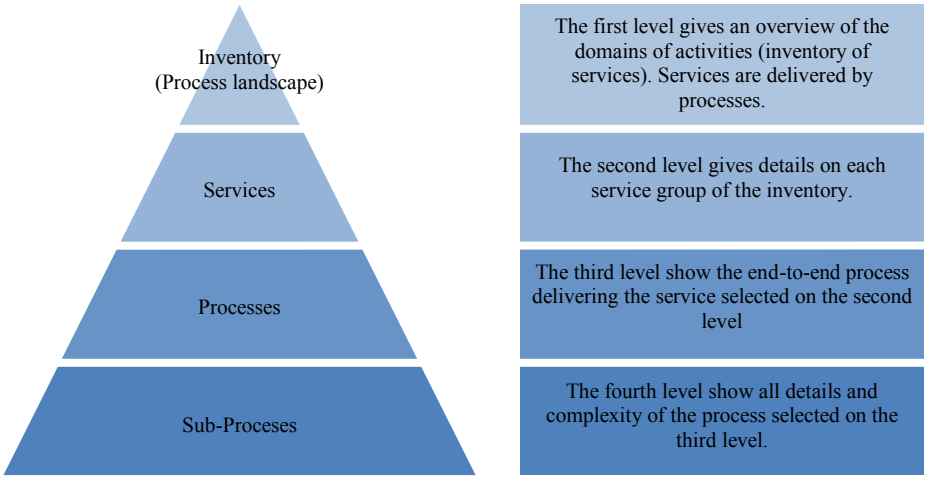

Figure 1 – Levels of process documentation pyramid

The first two levels of the process documentation pyramid in Figure 1 serve only the purpose of putting the processes into context with the whole organization and to show the system perimeter. The third level of the architecture reveals an end-to-end process. The goal of this representation is to show what happens in that process, what are the possible issues and what participants and/or roles are involved. Figure 2 below shows an

example of a process model in BPMN on this level of the pyramid (left) and the detailed business use-case, in form of a BPMN sub-process (right, fourth level).

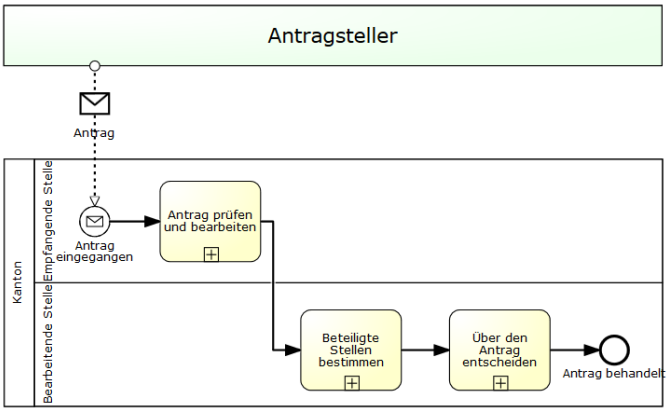

Figure 2 –End-to-end process in BPMN with three business use-cases;

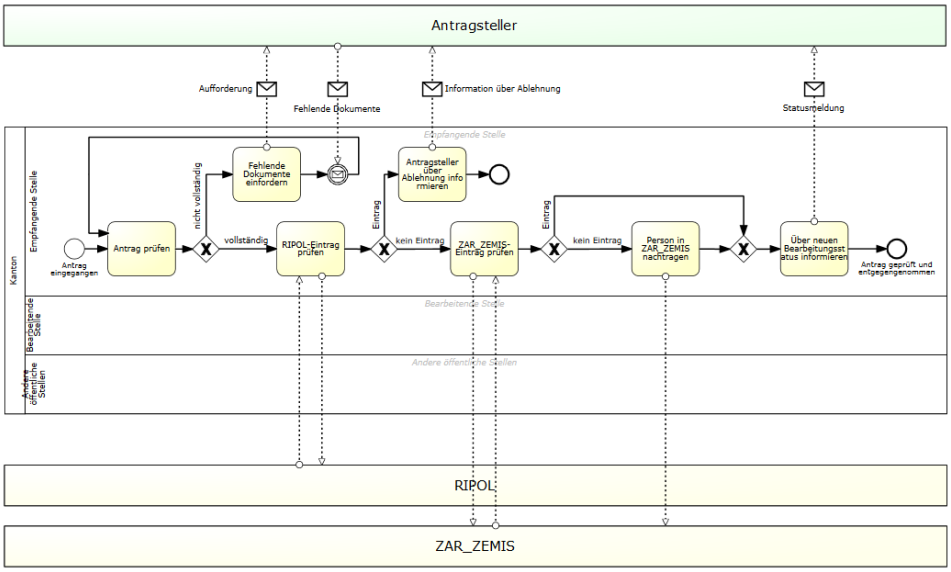

Figure 3 - Detailed use-case "Receive and check enquiry"

3.2 Requirements specification

Requirements are specified on the fourth level of the pyramid, namely the detailed business use-cases. We propose to attach each requirement to an activity, a message flow or a message of the BPMN model at this level (business use-case level). In order to

express the requirement, we use the standardized phrase pattern from [PR11] as shown in Figure 4.

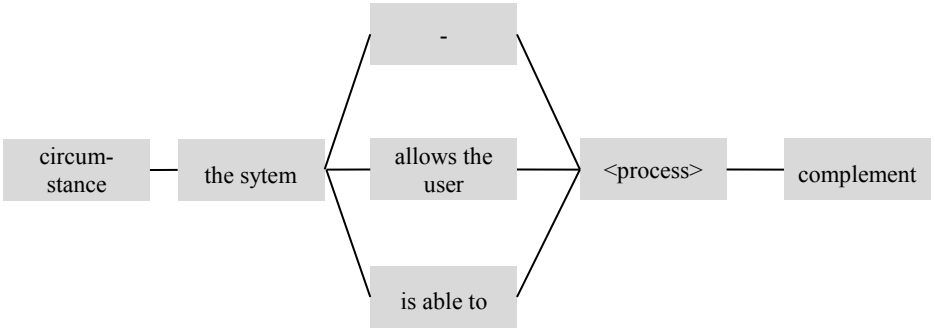

Figure 4 - Standardized phrase pattern

The following table shows a few examples of requirements expressed with the pattern.

Shape name	**Req. ID**	**Specification**
Check inquiry	FRT-001	The system is able to call the business rule relative to the integrity of an inquiry (FRR-001)
	FRT-002	In case the inquiry is incomplete, the system allows the user to send a message to the inquirer containing the list of the missing documents.
Invoice generation	FRT-002	The system is able to check if the inquirer has a record in RIPOL (FRR-002)
	FRR-002	The system is able to call the business rule relative to the RIPOL records

Table 1. Interface specifications of the sub-conversation “communication”

3.3 Requirement Specification Template

Once the requirements have been specified and attached to the business processes in BPMN, they need to be formalized in a requirement specification document. This document will be attached to the RFP of a WTO-conform procurement process. We introduce hereafter a template for this document, inspired by [Ie98] but modified to fit the needs of our original approach. Text in italic font is the chapter structure of the document. We comment chapters directly after they appear, when we propose significant modifications or additions to [Ie98], and provide recommendations for authors.

1. *Introduction*
    1.1. *Purpose*
    1.2. *Scope*
    1.3. *Definitions, acronyms, and abbreviations*
    1.4. *References*
    1.5. *Overview **

This section shall: describe the content of the other section of the RS; explain how the RS is organized; inform how the business processes have been organized and have been modeled; describe the BPMN shapes used, the meaning of the symbols, the modeling conventions used; describe how the requirements' IDs are built and how to do forward and backward tracing of them.

2. *Overall description*
    2.1. *Product perspective**

In addition to what is mentioned in [Ie98] we intent to call this section "system perimeter" as stated in [Eb10] and [PR11]. The "system perimeter" can be depicted by a BPMN 2.0 **conversation diagram** and some additional artifacts that BPMN 2.0 provides. Using conversation diagrams in this situation has been done prior by [Ri11].

    2.2. *Product functions**

"This subsection of the SRS should provide a summary of the major functions that the software will perform. For example, an RS for an accounting program may use this part to address customer account maintenance, customer statement, and invoice preparation without mentioning the vast amount of detail that each of those functions requires." [Ie98]

To achieve this granularity of detail we propose to use a **process landscape or process map** of the business processes the application will have to sustain. In this chapter the process landscape can be detailed to what we will call use-cases later on.

    2.3. *User characteristics*
    2.4. *Constraints*
    2.5. *Assumptions and dependencies*
3. *Specific requirements**

This chapter describes precisely each and every requirement the system will have to fulfill. It is based on the chapter 2.1 that describes the system perimeter or product perspective and on the use-case diagrams from chapter 2.2. Each use-case will be detailed within a **single end-to-end BPMN diagram**. The requirements will be written down and split into two main categories, namely functional requirements (FR) and nonfunctional requirements (NR). The authors of the RS are free to make sub-classes for each FR and NR like for instance requirements related to interfaces, performance, compliance, etc.

The authors will take care of avoiding redundancy among requirements. If for instance the chapter 2.1 of the RS already specifies all the interfaces of the system, they shall not be mentioned in this section any more.

The sections in this chapter can be organized the following way:

3.1. End-to-end process 1 "Name of the Process"
3.1.1. Use-case 1 "Name of the use-case"
3.1.2. Use-case 2 "Name of the use-case"
3.2. End-to-end process 2 "Name of the Process"
3.2.1. Use-case 1 "Name of the use-case"
3.2.2. Use-case 2 "Name of the use-case"
3.3. etc

4 Users' Point of View in Requirements Specification

In order to enhance the methodology presented above and design a tool supporting it, we wanted to complete our understanding of the actual tasks and problems of users when preparing requirement specifications. Therefore we conducted interviews with selected professionals active in Requirements Engineering in the public sector. This type of professionals would be the target user group of our methodology.

4.1 Methodology for User Interviews

We interviewed five people working both in the private and the public sectors across Switzerland. These interviews were done as contextual inquiries, where participants shared information about their work, roles and tasks, being conducted in a semi-structured way by the interviewer [BH97] [Sa13]. All the interviews were recorded. There were five participants: two Requirement and Process engineers from public administration who were involved in WTO procurement, two business analyst from an IT company who acts as a vendor for the public administration, one participant was the CEO of a startup company involved in business consultancy for WTO procurement. Our areas of interest in the interviews were:

- Work and Roles of the user
- Requirement specification and Request for proposal document
- Weighting of the requirements
- Collaboration between different stakeholders or people involved
- Use of BPMN and other modeling languages

Having defined our methodology prior to the interviews, we were explicitly interested in confronting it with real users' workflows and problems when specifying requirements. Therefore, we classified the statements of our participants into three broad categories:

- Problems,

- General important statements
- Process- or work-related terminologies

The different statements gathered from the recording were analyzed in a brainstorming session, with the help of an affinity diagram [BH97]. In particular, we discussed the user problems in details and generated solutions wherever possible. We present below the main problems reported and other findings useful in the context of our methodology, that we extracted from the affinity diagram.

4.2 Main Problems in Requirements Specifications

We summarize here the pain points our participants reported most often in the process of producing a requirements specification. Although the number of participants in our contextual inquiries was low, we believe these problems may inform further research.

Communication issues. Extracting actual requirements from interviews conducted with business people is seen as the biggest challenge. Several participants reported that business specialists have a hard time describing exactly the processes they follow and expressing precisely what they would need (i.e. the requirements). Also, attaching requirements to specific parts in a process can be difficult. Software vendors might also face difficulties when trying to understand requirements stated in RFP.

Requirements gathering, in relation with communication issues above, is perceived as a time-consuming task, accounting for more than 50% of the work towards producing the RS.

Expressing requirements in a standardized form. For one participant, requirements expressed in free text are hard to manage, especially if the list is long. Standardization (e.g. using phrase patterns) would be appreciated. However, another participant pointed out a weakness of standardized form for requirements: business specialists need to be educated to use them correctly.

Tracing requirements coming from different sources is an important challenge noted by several participants. In particular, merging requirements in a later phase should leave the initial requirements accessible. There should therefore be a way to trace back to the original requirements.

Weighting requirements often involves negotiation between stakeholders, many approvals and manual tasks, as it directly influences on the evaluation of the bids later in the procurement process. Therefore, it is a difficult and time-consuming task.

4.3 Other Findings Relevant to our Methodology

The results of the affinity diagram also gave valuable indications on how to enhance our methodology to accommodate the users needs. Among these indications we can mention:

- There are overall requirements that are valid for the whole project before we get to functional and nonfunctional requirements
- All the requirements must be framed as questions or declarations allowing a YES/NO answer by the bidders.
- Requirements have to be expressed directly by the end-users of the IT service or good being procured, before they are refined into WTO-proof requirements. The refinement must be backwards traceable for the end-user so he knows where his initial requirement was incorporated.
- Besides functional and non-functional requirements, interface-related requirements shall have their own category
- Requirements have to be weighted and the user must be able to set the weighting scale according to his needs
- The normalized phrase pattern by [PR11] is suitable for WTO requests for proposal but other phrase patterns might be relevant like agile phrase patterns for SCRUM or Xtreme Programming (e.g. user stories)

5 CARES Software Prototype

Based on our methodology and incorporating the lessons we learned from user interviews, we designed a tool to support the methodology and implemented it as a prototype. This tool was coined "CARES" for 'Computer Aided Requirements Engineering Software'. We wanted this software to be able to reuse existing BPMN 2.0 business processes and attach functional and nonfunctional requirements to process elements. Moreover, it must offer features to administrate, trace, weight and export the requirements in order to incorporate them into a consistent request for proposal. We stated our own initial requirements for CARES that would support our methodology as follows:

- CARES is meant to be a requirements specification tool only (i.e. not a modeling tool)
- CARES has export functions to Microsoft Excel and Word (Requirements Specifications document in Word, and Requirements List in Excel)
- CARES is able to access and re-use existing BPMN 2.0 diagrams from an existing business process management system (BPMS)
- CARES shall be web-based (SaaS)

5.1 Designing CARES

Based on the affinity analysis, we consolidated all problems-solutions pairs into categories and functions, and we derived the information architecture from them. This architecture is depicted hereafter in three different tree structures; each tree showing one of the main functions: project management, requirements management, collaboration.

5.2 Information architecture – Projects

Doing requirements specification for a request for proposal is a long lasting activity and must therefore be handled as a project. CARES must be able to handle different projects for different requests for proposal. Furthermore a project is composed of files (protocols, pictures, etc.), process models, requirements (in the form of BPMN shape attributes). These will be organized through folders (Figure 5)

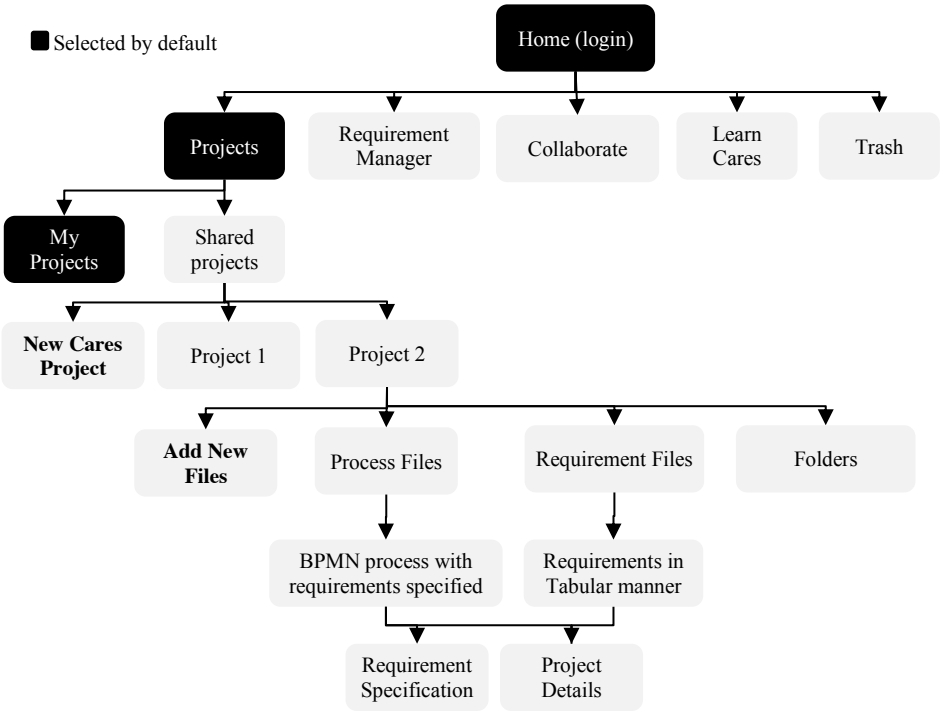

Figure 5 - Information architecture of CARES - projects

5.3 Information architecture – Requirements manager

As stated earlier in the findings for CARES, requirements must be expressed by the user, before they are refined into WTO-proof requirements. The requirements manager function is tailored to respond to this need. Through a tabular view, the requirements engineer can filter, add, delete, search, edit, save, print and export the requirements. Moreover, our interviews have shown that users face difficulty while working with large set of requirements. The requirements manager aims at easing this aspect (Figure 6).

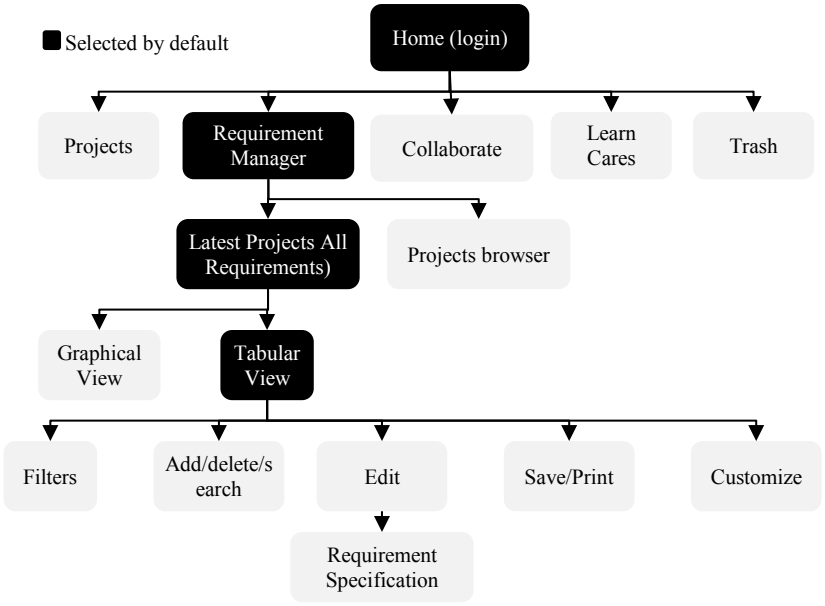

Figure 6 - Information architecture of CARES - Requirements manager

5.4 Information architecture – Collaboration

The collaboration function is targeted at ubiquity. The requirements specification project could be led by the requirements engineer or project manager and collaborators could share their thoughts, approve or comment requirements and participate in live discussions via the web application. Figure 7 depicts the information architecture for the collaboration function.

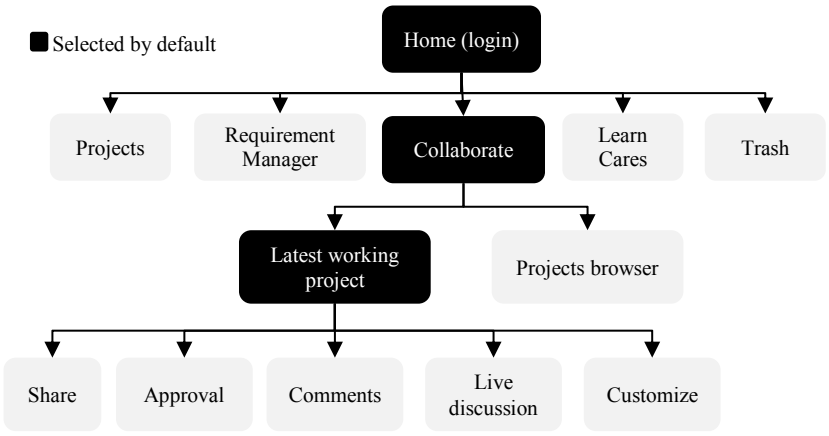

Figure 7 Information architecture CARES – Collaboration

5.5 CARES Prototype

As we already knew, there was no business process related notation specifically tailored for RS. Chances were little that we would find an existing tool that would do what we wanted with few adjustments. Nevertheless we conducted a comparative analysis of the Requirements Engineering tools we were able to find on the market to see if they fitted our requirements. We compared Sparx Enterprise Architect, the ARIS Platform, Visual Paradigm for UML along with Agilian Enterprise Architecture and Visure Requirements. The comparative tool analysis turned out that none of these tools were either simple to use nor did they feature the required flexibility to accommodate our methodology easily. Therefore we chose to implement our own SaaS solution to support our methodology. Our solution builds upon the BPM modeling tool of Signavio (www.signavio.com). It uses its REST and Mashup APIs to access the underlying process repository of Signavio. We added a layer of interface dedicated to the Requirements Specification functionalities that were implemented as described above in Section 5. Screenshots from the prototype are presented in Figure 8.

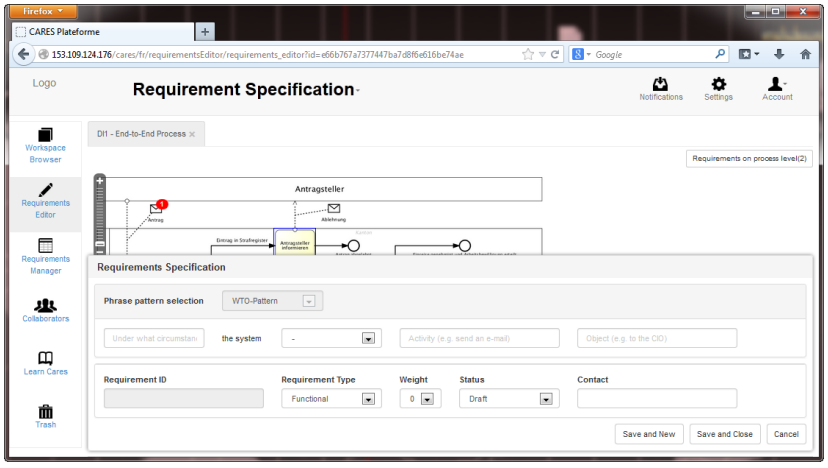

Figure 8 Screenshot of CARES prototype: specifications of requirements on a BPMN diagram with phrase patterns

6 Conclusion and Perspectives

In this article we presented an original methodology to specify requirements from business processes in BPMN 2.0, based on standardized phrase patterns that are attached to BPMN elements. Our methodology also provides a template structure and guidelines for producing requirement specifications that can be included in WTO-conform Request for Proposals. The main advantage of our methodology in the context of WTO

procurement procedure is that administrations can reuse existing BPMN process documentation as a basis for specifying requirements. Moreover, although our methodology originated from the needs and situation of the Swiss public administration, it can be applied for specifying requirements based on BPMN in other countries' public administration as well as in private companies.

We also conducted user interviews to identify the actual tasks and challenges faced by users when specifying requirements. Findings from this interviews suggest communication issues between stakeholders (business users, analysts, IT specialists) are the most pregnant in requirements specifications. Our approach using BPMN and standardized phrase patterns aims at lowering those issues. Based on results and analysis of user interviews, we designed a software prototype that aims at solving the most important problems faced by users.

Future works include evaluation and testing of the prototype with users. Perspectives for future development of CARES include:

- Evaluation of the proposals submit by the vendors
- Extensive collaborative features in CARES
- Graphical/Tree view of the requirements within the requirements manager
- Merge function to merge similar requirements during the refinement phase
- Requirement Specification for agile project management

Acknowledgements

The research was funded by RCSO-ISNet. The authors wish to thank Vikas Luthra, Simon Martin and Alain Duc who were involved in the user research, design and implementation of the prototype, as well as the participants in our user interviews. Sections 4 and 5 of this article are partially taken from an internal unpublished report written by Vikas Luthra in the framework of this project.

References

[BH97] Beyer, H., & Holtzblatt, K.: Contextual design: defining customer-centered systems. Elsevier 1997.

[BK06] Bleistein, Steven, K. C.: B-SCP: a requirements analysis framework for validating strategic alignment of organizational IT based on strategy, context, and process. Sydney, 2006.

[Br89] Brooks, F.: Mythical man-month: essays on software engineering. Dorset House Publishing, New York 1989.

[Eb10] Ebert, C.: Systematisches Requirements Engineering.dpunkt.verlag, Heidelberg, 2010.

[Ec12] Verein eCH: eCH-0073 Vorgabe zur Beschreibung von Leistungen und Prozessen. Version 2.0, www.ech.ch, 2012.
[Ec13a] Verein eCH: eCH-0054 HERMES Projektmanagement Methode, Version 2.0, Entwurf, www.ech.ch, 2013
[Ec13b] Verein eCH: eCH-0140 Vorgaben zur Beschreibung und Darstellung von Prozessen der öffentlichen Verwaltung der Schweiz. Version 1.0, www.ech.ch, 2013
[De91] US Department of Defense: Software Technology Strategy. Washington, 1991
[Fi07] Federal IT Steering Unit (FITSU): Swiss Strategy on E-Government, Bern, 2007
[Ga07] Galli, P. et al.: Praxis des öffentlichen Beschaffungsrechst (2nd edition Ausg.). Zürich, Basel, Genf: Schulthess, 2007
[Gu11] Conférence Romande des Marchés Publics: Guide Romand pour les marchés publics, Abgerufen am 02. 01 2012 von http://www.vd.ch/fileadmin/user_upload/organisation/dinf/sg-dinf/guide_romand/AA_Pr%C3%A9face_Guide_romand.pdf, 2011
[Ha11] Hadrian D.: Requirements Engineering à l'aide de BPMN 2.0 dans le cadre d'appels d'offres selon l'OMC. Master thesis. HES-SO Master, 2011.
[Ie98] IEEE: IEEE Recommended Practice for Software Requirements Specifications, The Institute of Electrical and Electronics Engineers, Inc., New-York, 1998
[Ko06] Koliadis George, A. V.: Combining i* and BPMN for Business Process Model Lifecycle Managmeent. University of Wollongong (UOW), School of Information Technonolgy and Computer Science (SITACS), 2522Gwynneville NSW, 2006.
[La01] Lamsweerde, v.: Goal-oriented requirements engineering: A guided tour. International Joint Conference on Requirements Engineering (S. 249-263). IEEE Conference, Toronto, 2001.
[Li12] Cantonal Aministration, Bern, Switzerland: LIBIT. Guide sur l'adjudiciton des marchés publics, Abgerufen am 25. 01 2012 von http://www.fin.be.ch/fin/fr/index/informatik/informatik/rechtliche_grundlagen/libit_2.html., Bern, 2011
[Lo94] Swiss Confederation: LMP, Loi sur les marchés publics, LMI, Loi sur les marchés intérieurs, AMP, Accord sur les marchés publics. Berne, 1994.
[PR11] Pohl, K., & Rupp, C.: Basiswissen Requirements Engineering (3. korrigierte Auflage Ausg.), dpunkt.verlag GmbH, Heidelberg, 2011.
[Ri11] Ritter, Daniel, et al.: Building a Business Graph System and Network Integration Model Based on BPMN, in Remco Dijkmann, Jörg Hofstetter et Koehler Jana. Business Process Model and Notation, Third International Workshop on BPMN, Proceedings. Luzern, S. 154-159.Springer, 2011.
[Sa13] Saini, A., Nanchen, B., & Evequoz, F.: Putting the Customer Back in the Center of SOA with Service Design and User-Centered Design. In Service-Oriented and Cloud Computing (pp. 94-103). Springer Berlin Heidelberg, 2013.
[We10] Wesfall, L.: Software Requirements Engineering: What, Why, Who, When, and How. University of Texas, 2010.