

Eliciting end users requirements of a supportive system for tacit knowledge management processes in value networks

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Eliciting End Users Requirements Of A Supportive System For Tacit Knowledge Management Processes In Value Networks: A Delphi Study

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Abstract— Co-creation value with the aim of enhancing customer experience—through providing integrated solutions—relies on networked collaborations of multiple service providers and customers within value network (VN) settings. The customer-centric view of such collaborations highlights the importance of understanding and addressing customer needs in which customer knowledge is essential. Accordingly, managing customer knowledge within VN facilitates providing integrated solutions, and in turn enhances customer experience. In this regard, in previous work we have developed a process-based framework on customer knowledge management within VN settings (VN-CKM). This framework covers processes in relation to both tacit and explicit customer knowledge.

In general, there is extensive literature on IT-based systems in supporting knowledge management processes. However, there is a dearth of research on developing such systems to facilitate VN-CKM processes in the context of VN. In this regard, this study aims at eliciting end users requirements of systems needed to support VN-CKM processes. Regarding the predominant role of tacit knowledge in providing solutions, we focus on the tacit-related processes of our VN-CKM framework. Therefore, in this study these tacit-related processes are used as a basis in the requirement elicitation process. To do this, within a single VN, a two-round Delphi study is conducted to elicit the requirements from different actors of the VN. In total 144 requirements have been identified. Subsequently, by applying a structured classification approach they are classified into a set of 14 requirement types. Finally, a description for each requirement type is provided.

This study, by following a well-structured research process from tacit-related VN-CKM processes to a coherent set of requirement types, provides a clear understanding on linking requirements to the original tacit-related VN-CKM processes. The resulting list of requirement types can be served as a baseline for defining and specifying the supportive system functionalities for tacit-related VN-CKM processes in the VN settings.

Keywords— *Customer knowledge management process; tacit knowledge; value network; requirement elicitation; Delphi study; Metaplan*

I. INTRODUCTION

This paper is about supportive IT-based systems in relation to customer knowledge management in the value network (VN) setting. We look at the topic from the end users' requirements elicitation process, because the success of such a system depends on how well it fits with the needs of end users. Understanding these needs through the participation of end users in the elicitation process is the first step toward developing a beneficial system [1-3]. The elicitation process consists of a set of communicative activities between end users and system analysts to gather the requirements from an end user perspective [1, 4, 5].

Compared to the requirement elicitation process in a single organization, this process is more challenging and complex in the VN settings due to the dynamic, distributed, and a multi-actor nature of the customer-centric networked collaboration. A customer-centric view refers to understanding and addressing customer problems through close interaction and collaboration in providing integrated solutions (i.e. a bundle of products and services) with the ultimate aim of enhancing customer experience. For such an understanding, on the one hand, a networked collaboration of multiple actors (i.e. service providers and customers) within a context of VN is required [6-8]. The VN actors are distributed across different time zones and locations and dynamically collaborate to serve customers [9, 10]. Consequently, including multiple actors with different perspectives and expectations—as the end users group in requirement elicitation processes—makes communication among VN actors and system analysts even more difficult and demands more attention. On the other hand, customer knowledge is imperative for understanding customer needs, as customer understanding is the first step of integrated solutions provision process [11, 12]. Therefore, to co-create customer knowledge which is accessible and useable by VN actors, effective management of customer knowledge is required in VN settings [12].

In the generic research field of knowledge management, it has been widely recognized that the success of any knowledge

management initiative depends on people, processes, and IT-based supportive systems (i.e. *knowledge management systems; KMS*) [12-14]. Regarding the process aspect of customer knowledge management within a VN (VN-CKM), in previous work we developed a process-based framework of VN-CKM.

In this study, we address the IT-based supportive functional aspects of VN-CKM. More specifically, the end users requirements of KMS in relation to tacit-related processes of the VN-CKM framework will be investigated. The reasons for our focus on the tacit-related VN-CKM processes are: 1) the predominant role of tacit knowledge and the operant resource in general—in providing integrated solutions—has been emphasized in the servitization and VN literature [15-17]. 2) While the literature acknowledges the role of KMS in facilitating *knowledge management process in general* [18], there is lack of research on developing systems to facilitate tacit knowledge processes, especially in the context of VN [12, 19].

Accordingly, in this study we seek to elicit the end users requirements of KMS in supporting the tacit-related VN-CKM processes within a VN setting. More specifically, the end users’ requirements in supporting three attributes of each tacit-related VN-CKM processes (i.e. activity, control, and outcome) will be identified. The end users in our study are VN actors. As different actors with diverse perspectives collaborate in providing integrated solutions, the desired KMS must meet their different requirements. To structure the elicitation process, the tacit-related processes of the VN-CKM framework will serve as a guideline to enable the elicitation of the requirements from a well-defined basis. After the requirements have been elicited from the VN actors, they will be consolidated into a single set of requirements to provide a more coherent view of the requirements. This study answers to the research question: *What are the VN actors’ requirements*

of a desired KMS, to support the tacit-related customer knowledge management processes in VN settings? Why?

This study contributes to knowledge management within VN literature: it takes a VN-CKM framework as a basis and follows a systematic process to elicit and classify VN actors’ requirements. Therefore, it presents a coherent set of requirements of a desired KMS in relation to the attributes of tacit-related processes of our VN-CKM framework.

The outline of the paper is as follows. Section II provides an overview on the research background. The research methodology is discussed in section III. Section IV presents the results and some discussion. Finally conclusion and future work are presented in section V.

II. RESEARCH BACKGROUND

Within the context of VN, in spite of the fact that the importance of tacit customer knowledge types (e.g. experience, feedback, and skills) in understanding customer problems has been acknowledged [8, 15, 16, 20], there is a dearth of research on studying the tacit-related customer knowledge management processes and their supportive KMS [11, 12]. To at least partially close this gap, in a previous study we developed a framework of VN-CKM processes [11]. By taking into consideration both tacit and explicit customer knowledge, this framework described the main processes of managing customer knowledge within VN settings in a systematic way. According to this VN-CKM framework, tacit knowledge processes refer to inter-organizational collaborative processes of creation, storage/retrieval, and transfer of tacit customer knowledge among VN actors through interpersonal communication and interaction. The VN-CKM framework describes each tacit process through a set of sub processes and their accompanied attributes of activity, control, and outcome (Table I).

Table I. Tacit-related processes of VN-CKM framework (adapted from [11])

P	Sub-p	Attributes			
		Activities	Control		Outcome
			Formal	Informal	
C	<i>T-T</i>	Contextual understanding of customer experience and problems, through observation, empathic methods, and ethnographic research techniques, customers explained challenges, socializing in relaxed environments	-	Briefing sessions, frequent, collective and reciprocal interactions, interview, dialogues	Mutual understanding of customer problems in the context of usage, increasing social cohesion in a network
	<i>T-E</i>	Explicitly describing customer experiences and problems by storytelling and visualization; analyzing and interpreting customer problems; ideation and conceptualization of initial solutions, mapping out the solution process by using mapping techniques(e.g. encounter mapping, service-blueprinting); formalization of solution processes and reporting structure; clarifying roles and responsibilities	Rules and guidelines.	Workshop, forum, brainstorm sessions, dialogue	Eliciting customer experiences and problems (e.g. structuring problems); directing and structuring the solution processes; providing user-centered perspectives on solution offerings; ensuring that customer problems are defined, discussed, and supported accurately; creating a common understanding of the content of the solutions (i.e. design features); structuring customer contracts
	<i>E-T</i>	Providing knowledge to customers at deployment phases, learning by doing	Network routines,	Trainings	Enhancing the value which customers derive from solutions.
S/R	<i>T-E</i>	Documenting and organizing past experiences of both solution providers and customers. Tacit CK mapping and auditing among actors	Documentation	Interviews	Ensuring the efficient preservation of and access to stored tacit CK across a network.

T	T-T	Establishing learning environments, sharing knowledge of the customer's problems, needs, and value expectations, identifying the customer's preference for centralized or de-centralized knowledge flows among partners and customers.	-	Frequent communication, dialogues, shared values, mutual norms, trust, joint training programs	Reciprocal learning during solution processes; sharing timely, accurate, reliable tacit CK across a network.
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(P: process, Sub-p: sub-process, C: creation, S/R: storage/retrieval, T: transfer, T-T: tacit to tacit, T-E: tacit to explicit, E-T: explicit to tacit)

Regarding the supportive KMS, this refers to a class of IT-based systems utilized to facilitate management of organizational knowledge [18, 21]. In current KMS literature, most of the studies are primarily limited to developing systems for explicit knowledge [22, 23]. In this regard, different systems and tools have been developed, in which database management systems, data warehouses, and data mining tools are some examples among a large list of existing systems [24]. In contrast, research on supporting systems, related to tacit knowledge processes, is underdeveloped [12, 19, 22]. To position our study in this literature, summaries of the results of selected studies are addressed.

Existing research on KMS pertaining to tacit knowledge process can be classified into two broad categories: research providing a general overview about what such systems look like; and research offering a number of end user requirements of a desired system. In the first type of study, through presenting recommendations, researchers indicate some desired properties of the systems. For instance, Ahn, et al. [24] recommend using contextual information in designing KM systems, as contextual information is a crucial component for a better understanding of tacit knowledge. In this respect, Ahn, et al. [24] presents a knowledge contextual model to facilitate the use of contextual information. In another study, Huysman and Wulf [22] suggest that requirement analysis processes need to take into account the social capital of members of the network. This reflects the social and informal nature of tacit knowledge transfer in the context of networked organizations. Therefore, in designing supportive systems for tacit knowledge transfer, besides technical requirements, social requirement analysis needs to be included.

In the second type of research, attempts have been made to provide a set of end user requirements. For instance, Ale, et al. [21] by analyzing several knowledge management models, identified seven requirements. The study proposed a model that met all of these requirements. They then used this model as a reference framework for developing system architecture in relation to the storage/retrieval process of tacit knowledge. In another study, Nevo and Chan [25] conducted a Delphi study to identify desired KMS functionalities which resulted in a list of 17 desired functionality types. In a third study, Butler, et al. [14] developed a conceptual framework which was used to develop a list of functionalities of IT-based KMS. Although Butler, et al. [14] mapped these functionalities to the KM process, the process of how they developed both the conceptual framework and the desired functionalities is unclear. In a fourth study, Pirkkalainen and Pawlowski [26] used a well-founded conceptual framework of knowledge management barriers as a guideline to extract a set of six requirements.

The analysis of the literature leads to the following conclusions:

- The representative studies partially cover the subject of our study. More often their focus is on a single process e.g. [21, 22], and not the whole set of tacit-related processes;
- In some studies a conceptual framework is used as a basis for the requirements engineering process, but only a limited number of requirements is offered [26]. Thus, the opportunity to identify a more extended list of requirements and to classify them into a coherent list is still missing;
- None of the studies are specifically written for the purpose of our study.

Consequently, an approach with a concrete conceptual basis is necessary to elicit and classify requirements in relation to tacit processes of a VN-CKM in a structured way.

III. METHODOLOGY

A. Research Design

This study focuses on eliciting and classifying the VN actors' (i.e. end users) requirements of KMS in supporting tacit-related VN-CKM processes in a systematic way. To this end, four design decisions were made by the research team. The first design decision was using the tacit-related processes part of VN-CKM framework as a reference model in requirement elicitation process. This decision was made in order to structure and guide conversation between VN actors and the researchers during the elicitation process. Using a reference model—in the sense of conceptual framework as defined by Thomas [27]—for supporting and structuring the requirement elicitation process is a widely accepted approach in the requirement engineering literature [26, 28-32]. In this respect, some evidence from the literature is presented. Osterwalder, et al. [28] state that rigorously defined business models in the form of conceptual models, meta-models, and reference models can facilitate requirements engineering. A reference model facilitates more effective communication and shared understanding among end users and system analysts because to extract reliable requirements, effective communication and shared understanding among involved people is required [29, 30, 33, 34]. A shared understanding is required to minimize the risk of user dissatisfaction and to enhance the likelihood of a successful system development project [29]. Similarly, Cheng and Atlee [1] contend that during the elicitation process, reference models can be used to catalyze discussion and to explore the users' needs. Alcazar and Monzón [31] highlight the importance of using a conceptual model to create common understanding of the end users' issues, to have a reference model, and to situate the issues in the context. Daclin and Mallek [32] contend that using a conceptual framework enables capturing and structuring requirements from a well-defined basis. In addition,

reference models can speed up the development process of information systems and reduce the associated costs [33]. Therefore, in this study, the VN-CKM framework was applied as reference model to structure the elicitation process and also to create a shared view on the tacit-related processes among the participants and the researchers.

The second design decision was selecting an exploratory single case study approach. The reasons for this selection were: 1) regarding the exploratory nature of this study—a requirements elicitation—a case study is an appropriate research approach [35, 36]. 2) For elicitation process, a contextual consideration is necessary to better understand the requirements and to ensure the relevancy of requirements for the specific context [4, 5, 37]. A case study is a favorable approach for contextual consideration [35, 38, 39]. Hence, by specifying the VN context, the VN actors expressed their requirements in their actual work setting. 3) As this study aimed at providing a consistent and comparable set of requirements, the VN actors must be selected from the same VN. Hence, a single case study offers an appropriate empirical ground for this purpose.

For the purpose of this study, one VN was selected with care based on four selection criteria defined by the research team: 1) the selected VN must have experience in providing integrated solutions. 2) In the selected VN the customer is actively involved in the solution provision process. 3) Regarding the building blocks of the VN [40], at least three actors (two service providers and the customer) must collaborate in the VN setting. 4) To include heterogeneous perspectives of different actors in the resulting list of requirements, all of the VN actors must be willing to partake in the study. Based on these criteria, one real-life VN active in the financial services sector was selected in which representatives from three actors were considered for data collection.

The third design decision was related to the selection of a requirement elicitation approach. To this end, from different approaches [4, 5, 41-43], a group requirement elicitation approach was selected for two reasons: 1) as the VN consisted of different actors with various perceptions, this approach enabled the capture of diverse viewpoints [5, 41]. 2) In comparison to an individual elicitation approach (e.g. interview), this approach, by transcending from an individual focus, stimulates a more thorough understanding of the end users' needs [5, 41]. A group approach allows for questioning, comparing, reflecting, and justifying information among a group of people, so one participant can be triggered by the statements of others [41]. This, in turn, leads to a richer understanding of the topic under investigation.

The fourth design decision was the selection of a particular method from different methods of group elicitation approaches (e.g. a Delphi method, focus group, brainstorming, and nominal group methods) [44, 45]. For the purpose of this study the Delphi method was selected. The Delphi method is based on a structured process with flexible iteration rounds aimed at obtaining reliable judgments and opinions of a group of participants anonymously [46, 47]. The main reasons for this selection were:

- The VN actors are geographically distributed. A Delphi method facilitates distributed requirement elicitation [48, 49]. Since there are no time and geographical limitations, each representative of the VN actors can participate in the study independently from the other actors.
- A Delphi method eliminates undesirable group effects, such as destructive dominance of a more powerful and influential participant, and conformance pressure within the peer-group [44, 50]. The anonymity feature of the Delphi method allows participants to express their ideas unbiased from peer-group pressure [46, 48].
- The structured process of iteration and controlled feedback of the Delphi method contributes to greater objectivity, refinement, richer data, and more extensive consideration of ideas [46, 48].

However, the Delphi method has also some drawbacks. The four main weaknesses of the Delphi method are presented here and the tactics used in this study to overcome them are explained.

- 1) There is a participant drop-out issue in subsequent rounds [49, 51]. This can occur, for instance, when a large number of questions are asked, or when in the first round a large number of experts' ideas are generated. To deal with this issue we first—to reduce the number of questions—focused on only the tacit-related VN-CKM processes of the framework. Second, to keep the participants motivated, each round was conducted within an hour and the same questions were asked for each of the tacit-related VN-CKM processes.
- 2) Inefficient application of the Delphi method, such as a lack of explanation to the participants [46]. To overcome this issue, at the beginning of each Delphi round, a brief introduction of the Delphi method was given to the participants. Moreover, at the beginning of the first round, a theoretical description of the tacit-related VN-CKM processes was given, to keep the focus of the conversation on the subject of this study.
- 3) Questions are poorly formulated [46]. To address this issue the questions were structurally defined in accordance with the tacit-related processes of the VN-CKM framework. Additionally, the questions were examined in a pilot study which resulted in some modifications.
- 4) Results are insufficiently analyzed [46]. To address this issue, data analysis was conducted in a structured way (see Section 3-3). In addition, to classify the large list of requirements—as suggested by the VN actors—the results were structurally classified by using a Metaplan approach (see Section III-C).

B. Data Collection

In the context of a single VN, a two-round Delphi study was conducted for data collection from representatives of the VN actors. According to the structure of a Delphi study, the first step for data collection was selecting eligible participants

[47, 48, 52]. This selection is regarded as a cornerstone of the Delphi method [46, 48]. It should be based on a structured selection process with specific selection criteria rather than be based on a random sample selection [50]. Therefore, based on a purposive sampling approach [47, 53], the following criteria were defined by the research team to select the qualified participants.

- 1) To ensure that the Delphi study would lead to comparable sets of requirements, all participants were representatives of the actors of the same VN. Belonging to the same VN enabled the inclusion of the context in which the desired KMS might be used.
- 2) Organizational roles of knowledge experts, IT experts, and integrated solution process experts were considered in selecting participants. People in these roles were assumed to have knowledge of integrated solution processes and customer knowledge. In case these roles were not specifically determined in the VN, related persons had to be found to cover the multiple perspectives.
- 3) To provide accurate answers to the 'why' questions, i.e. as a rationale for suggested requirements, participants needed to have a background or be involved in projects on knowledge management.
- 4) Participants needed to understand the inter-firm collaborative processes of VN-CKM. To facilitate this understanding, participants needed to be directly involved in inter-firm collaborative activities in which frequent interactions with customers and partners were possible. Through such interactions, participants gained a better understanding of the VN-CKM processes.
- 5) A participant needed to understand the concepts of a VN and integrated solutions. To this end, the participant was required to have at least one year of experience in working in VN settings. Although more years of experience might have been desirable, given the fact that VN is a relatively new phenomenon, increasing the number of experience years would have made it too hard to find enough suitable participants for this study.

Based on these criteria, a group of eight participants from three actors of the studied VN were selected for each round of the Delphi study. Therefore within the studied VN, by including participants from different actors and different organizational roles, the heterogeneous group of participants was selected. The focus of this Delphi study was on collecting different opinions (i.e. a divergent set of ideas), so using the heterogeneous group of participants enhanced this diversity. Regarding the required number of participants to take part anonymously in each Delphi round, this number of participants was in line with the recommendations of [52]: between eight and 16 participants.

After participants were selected, the data was collected in a four-step process. First, for data collection a two-round Delphi study was designed. While the first round was used for generating independently the experts' ideas (i.e. individual brainstorming), the second round was used for a verification

of the results of the first round, and for justification of the expert's opinion based on a controlled feedback [46, 51, 53]. Second, for each round, a set of questions was defined in a Delphi protocol. As this study looked for requirements in relation to the attributes of the tacit-related VN-CKM processes (i.e. the activity, control, and outcome attribute), the structure of the questions corresponds with these attributes of the VN-CKM framework. Accordingly, in the protocol of the first round, for each tacit-related process it was asked whether an IT-based system can support its attributes. If so, then for each attribute it was asked from what kind of IT functionalities could be supported from the particular perspective of the participant. Whenever a participant proposed a requirement, the argument for the proposal was asked (the 'why' question). Asking this 'why' question encouraged participants to give their opinions more precisely. It also enabled a better understanding of the differences in the perceptions among participants. To ensure that the questions were formulated appropriately, the protocol was examined in a pilot interview. As a result, the protocol was modified (e.g. some of the questions were reformulated for the purpose of clarity). The final protocol was then used in the actual Delphi study. Regarding the protocol of the second round, for each attribute of the tacit-related VN-CKM processes, a summary of all suggested requirements with their rationales given by the eight participants (i.e. the results of the first round) were put into the protocol. The participants were asked whether they recognized their own inputs to check the quality of our interpretation. After that it was asked which of the requirements suggested by other participants were useful in the context of the VN. Subsequently, the participants were asked for additional requirements, because they saw the feedback of others and could be triggered by the other suggestions and rationales. Third, the participants' requirements were collected through face-to-face semi-structured interviews in which the Delphi protocols were used to facilitate the discussions. The face-to-face interview, in comparison with sending questionnaires via email/post, enabled the participants to answer at greater length. It also enabled both the interviewer and participants to ask for clarifications and to correct misunderstandings when needed. The interviewer served as a neutral facilitator to guide the group of participants in these rounds towards exploration and rationalization [44]. Fourth, all interviews were recorded, transcribed, and preserved in the research database. This process led to a total of 15 interviews (one of the participants could not take part in the second round despite rescheduling several times). The average duration of the interviews was one hour. The two-round Delphi study was conducted over a period of two months in 2016.

C. Data Analysis

As the data from both Delphi rounds were qualitative, they were analyzed on the basis of a content analysis approach [53]. In order to structure the analysis process, for each Delphi round a specific data extraction form was designed. The tacit-related part of the VN-CKM framework was chosen as the basis for the design. As this study focused on requirements in relation to the attributes of the tacit-related VN-CKM processes, the structure of the forms corresponds to these

attributes. Regarding the data extraction form of the first Delphi round, two extra columns were added. These two columns were for requirements and for rationales. For each interview, the data analysis started with completing the extraction form by using the relevant part of the transcript. Recognizing the relevant part of the transcript to the particular attribute would be easy, because each Delphi round was guided by the protocol which was designed in accordance with

the attributes of the tacit-related VN-CKM process. A quote was considered as relevant if it pointed to requirements for a desired KMS based on a participant perception and the rationale. Whenever a participant proposed a requirement, his quote was positioned in the requirements column of the extraction form (see Table II). Subsequently, the accompanying rationales were positioned in the rationale column (see Table II).

Table II. Example of data extraction form in the Delphi first round

1. General information			
Name of interviewee:		Date of interview:	
Name of interviewer:		Date of data extraction:	
2. Detailed information			
Requirement			Rationale
C, T-T	Informal control	Enable writing down issues and related requirements from the customer's point of view (to be backtracked easily).	Standardization
		Enable automatic categorization and prioritization based on a SLA, (subsequently rules are connected to it).	Automation, standardization

For Delphi round one, following this process resulted in eight data extraction forms. The form was completed by the researcher who conducted the Delphi study. To address reliability, a random set of quotes were positioned into the form by the other members of the research team. There was high consistency between the researchers. In a few cases of different opinions, there was a research group discussion until a consensus was reached.

After data analysis of the first round, participants were mailed a summary of their proposed requirements, corresponding with each of the VN-CKM attributes. The rationales were also provided, and participants were asked to review and confirm. This was done to ensure that participants' statements had been correctly interpreted and positioned. This

was done before their suggestions were shared with other participants used in the second Delphi round.

For the second Delphi round, a data extraction form was designed of which the structure corresponded to the tacit-related VN-CKM attributes. This was similar to the first round. As mentioned before, participants were asked to recognize their own suggestions from the first Delphi round ('own column' in Table 3), to label the requirements proposed by others as useful or not ('others useful' column in Table 3), and to propose new requirement if any were triggered by the feedback ('new suggestions' column in Table III). This structured extraction form enabled us to keep a track of each requirement in relation to each attribute across a group of eight participants, which in turn enhanced the transparency of the analysis process.

Table III. Example of data extraction form in the second Delphi round

Creation process		Participant 1			Participant 2		
Sub-process	Attribute	Own	Others useful	New suggestions	Own	Others useful	New suggestions
T-T	Activity	4, 7	yes	Data analysis; dig deeper in the customer's real problem	8,9	Yes	
	Control	2,5,6,7	yes, except 1, 2 (assumed they are at an individual level)		10	Yes	
	Outcome	1, 8	Yes		8,11	yes, except 7 needs to be collective	

The two-round Delphi study resulted in a diverse list of requirements with many similarities between them. This implied that there were a number of requirements that covered multiple attributes of the tacit VN-CKM processes. Hence, to structure this large list and provide a more coherent set of requirements, a group of experts with a more thorough understanding of IT (i.e. the research team) got together and classified the requirements. As a result, proposed requirements were clustered into a smaller set of requirements types at a higher abstraction level. To accomplish this, a structured classification approach called Metaplan was applied. The Metaplan approach uses a structured classification process through a group discussion [54]. Accordingly, three Metaplan

sessions were held by the research team. During the first session, based on the principles of inductive content analysis [55], the requirement types emerged from the initial set of proposed requirements. In the second session, some modifications were carried out (e.g. some requirement types were merged) and the classification was finalized through the research team discussion. After that, based on the essential aspect of the range of requirements under each requirement type, a description was provided. In the third and final session all of the requirement types with their descriptions were discussed with the other members of the research team to reach a final agreement.

D. Quality Assessment of the Research

To address the reliability of the research, a clear description was provided and documented for 1) the context of this study; 2) the selection criteria for participants; 3) the data collection; and 4) the data analysis process.

To address the construct validity of the research, the protocols of both Delphi rounds were carefully designed through several research team discussions and tested in the pilot study (as suggested by [48]). Furthermore, the tacit-related part of the VN-CKM framework was used as a basis to design the protocol in a systematic way and to create a shared understanding among the group of participants and the research team.

To address the internal validity of the research, after the first round each participants were mailed their proposed requirements with their rationales—corresponding to the tacit-related VN-CKM process attributes—to review and check the quality of our interpretations. To allow another chance for checking, participants were also asked to recognize their own input at the beginning of round two. Results from the second round were also mailed to participants for the same purpose. Additionally, participants often found the requirements suggested by others useful, according to the results of the second round.

To address the external validity of the research, participants were selected on the basis of predefined criteria. Therefore, their responses to the ‘why’ question—i.e. rationales for the suggested requirements—provided the research team with a deeper understanding of the desired KMS functionalities and more precise explanations of the study outcomes. This made it easier to generalize our findings to similar VN contexts [48]. In addition, a well-structured list of requirement types, i.e. the results of the Metaplan sessions, provided us with a more generic set of requirements.

IV. RESULTS AND DISCUSSION

To achieve the research objective of this study—eliciting requirements from representatives of VN actors and

classifying them into a coherent set—a systematic research process was followed. A summary of the research findings with a brief discussion is presented below.

- Using the tacit-related part of the VN-CKM framework as a reference model creates a shared understanding among participants and the research team. It also structured the data collection and data analysis process.
- All participants were from the same VN. Using the single VN as a research context enabled us to attain coherent and consistent responses from participants. This contextual consideration ensures the relevance of the identified requirements. Such a coherent set of requirements might then be used by actors as a basis for developing KMS for this context.
- Participants of the Delphi study were selected on the basis of a predefined set of criteria. Defining and applying these selection criteria led to a proper identification of the wide range of the VN actors’ opinions.
- During the first Delphi round, participants were asked to give their rationales for their suggested requirements. This ensured that suggestions were objective because they were based on arguments and logical reasoning.
- During the first round, without any restrictions or suggestions posed by the researchers, it was difficult for participants to come up with a lot of suggestions. Each of them offered only two or three requirements.
- The first Delphi round resulted in a total of 144 requirements in relation to the 18 tacit-related attributes. To provide an overview on attributes and the requirements, for each attributes of tacit-related VN-CKM processes, all of the proposed requirements and rationales of all participants are summarized in a dedicated table and preserved in the research database (see samples in Table IV).

Table IV. Mapping the requirements to the activity attribute of knowledge creation, T-T

Attribute ID	Requirement	Rational	Participant ID
C1	Visualization (Visio, PowerPoint, short video clips)	To support discussion and to make things clear when talking about challenges.	7
C2	Enable direct and fast interaction, and discussion, and short communication lines (i.e. Skype, conference call, WebEx)	When the parties are not in the same room (7). In order to get all information out of the customer (2). To explain challenges directly (5).	7,2,5
C3	Enable quick sharing of ideas to generate a pool of ideas (forum-like)	Resulting in new projects	3
C4	Support of in-depth problem explanation and exploration	To gain a deep understanding of the needs	8
C5	Online mind-map tool to interactively connect keywords related to customer’s challenges	To work together interactively in gaining a joint understanding	4
C6	Look over the shoulder’: to be able to take over the other’s screen	An image says more than a thousand words	5
C7	A supporting structure, or checklist, that guides the process	Capture the whole creative process and not only the end	6

- All of the eight participants, except one, took part in the second round. This is a low dropout rate.
- During the second Delphi round, all participants recognized their own input meaning that their quotes

were positioned and interpreted properly. In addition, participants often found the requirements proposed by others useful. However, participants were not triggered very often by others’ suggestions. A total 10

requirements were suggested in round two, but none of them were new. Therefore, they were not included in the final set of requirements. One possible reason for this finding is that the list from the first round was already quite extensive.

- Regarding the classification of the Delphi study results, the research group discussions in three Metaplan sessions led to classifying 144 requirements into a set of 13 requirements types at a higher abstraction level. The requirements types are further classified into four main groups: 1) knowledge storage, 2) E-learning, 3) communication, and 4) solution delivery process. The

requirements types and their descriptions are presented in Table V.

- During the classification process, besides requirement types related to the different attributes of tacit-related processes, one distinct group emerged. This group covers a requirements type related to solution delivery processes meaning that customer knowledge management processes and solution delivery processes are interconnected concepts. This in turn reflects the fact that managing customer knowledge in VN settings is important.

Table V. Definition of requirements type (results of Metaplan sessions)

Requirement type	Description	Included requirements
Knowledge storage		
Support management of stored knowledge	<i>Less structured data</i>	FAQ and experience database that is continuously being developed and updated.
	<i>Structured data</i>	<ul style="list-style-type: none"> • Continuous monitoring and providing insights of the customer's system. • Providing logs of the customer's system at any time. • Providing easy references to find knowledge.
Support knowledge Storage/retrieval process	<i>Knowledge storage by actors and knowledge moderator</i>	<ul style="list-style-type: none"> • Documentation and archive function in order to provide a knowledge base and stores experiences and discussions through for instance: writing down issues, making minutes and agreements, and forming dossiers. • Developing templates. • Allowing for a check of the entered knowledge and easily backtracing.
	<i>Automated knowledge storage</i>	<ul style="list-style-type: none"> • Automatically generating the tracking of history of past-issues through automatic monitoring. • Enabling automatic categorization and prioritization issues based on the SLA, then connect rules to it.
	<i>Data access</i>	<ul style="list-style-type: none"> • Searching. • Uniformity in noting down experiences with certain standards. • Easy accessible with different access levels. • Quick iterations and maintainability. • Visual interface and interactive environment. • Categorization of experiences. • Sharing of periodic progress reports.
E-learning		
Support online courses, E-training	An interactive and attractive online training with movies, cases, tables of content (offering facilities such as search, test, and certificates).	
Communication		
Support real time communication	Digital means (e.g. Skype, conference call, WebEx, interactive video call) to support direct, fast, and informal interaction, and to enable face-to-face effective collaboration and learning amongst partners.	
Support forum functionality	Online open forum to share issues and ideas to generate a pool of ideas	
Solution delivery process		
Support process design	<ul style="list-style-type: none"> • Structured work-flow among all actors, and process mapping. • Supporting and guiding processes from idea towards final solutions. • Supporting making network routines available and continuously updating. • Supporting development of rules, guideline, structure, and checklists. • Support steering and measuring. • Standard exchange of results. 	
Support idea generation	<ul style="list-style-type: none"> • Communication of the whole user story with some checks. • Writing down issues and related requirements from the customer's point of view. 	
Support demonstration & explanation process	<ul style="list-style-type: none"> • Showing the solution in the customer context and demonstrate how the product works, through: <ul style="list-style-type: none"> ◦ Recording (audio/video, movie clip). ◦ Using demos and interactive webinars to show what the solutions look like. • Showing products remotely, screen sharing. • Support drawing, visualizing, sketching, and storing visualization by using presentation tools (e.g. beamer, PowerPoint, Smartboard, videoconferencing, whiteboards). • Standardization of the visualization of the solution. 	
Support testing process	Support a sandbox and playground for testing	
Support back-end process	<ul style="list-style-type: none"> • Enable monitoring and surveillance of the solution processes. • Support compact and complete stories about the delivered solution. 	

- | | | |
|--|--|--|
| | <ul style="list-style-type: none"> • Provide interactive environments in order to provide updated information about solutions, with the possibility of asking questions about solutions. • Keeping the user active by sending automated questionnaires, at particular points in time during service utilization. | |
|--|--|--|

V. CONCLUSION AND FUTURE WORK

Regarding the identification of supportive functional aspects of managing customer knowledge within a VN setting, this study focuses on the requirements elicitation process. Given the importance of managing tacit knowledge in the context of a VN, this study also focuses on the tacit-related processes of a VN-CKM framework and uses them as a reference model to facilitate the elicitation process. In order to elicit the requirements from different actors of the studied VN, a two-round Delphi study was conducted. Thus, rather than eliciting VN actors' requirements separately from the context, we positioned the elicitation process in a real-life situation of a VN and integrated it into the VN-CKM processes. Accordingly, from a Delphi study a set of 144 requirements from the perspectives of eight representatives of the VN actors were identified. In order to classify the large list of proposed requirements into a more coherent and smaller list, three Metaplan sessions were conducted by the research team. These sessions led to a final set of 13 requirement types under four main groups. In summary, following a well-structured research approach in eliciting and classifying the VN actors requirements has lead us to conclude that the proposed set of requirement types are relevant for a VN setting. Regarding generalizability of the resulting requirements list, the rationales of participants for their proposed requirements enabled us to come up with a more generic set of requirements. However, the research is limited to the single case and could be complemented by future cross-sector analyses. Replicating the study in other VNs active in different industrial sectors could enhance the external validity of our research findings. The proposed list of requirement types cover the wide perspective of multiple actors from the studied VN, providing a structured and precise baseline for other activities of requirement engineering process such as specification, verification, and system development. Based on the input from this study, these other requirement engineering activities need to be investigated further in future research. In addition, we recommended that a similar study be conducted for eliciting VN actors' requirements in relation to explicit-related VN-CKM processes. By combining the results of both studies, a more complete set of requirements of KMS for VN-CKM can be provided.

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