THE ROLE OF BROKERING SITUATIONS IN DATA WAREHOUSE DEVELOPMENT: CREATING KNOWLEDGE FIT WITH BROKERS AND BOUNDARY OBJECTS

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Abstract

Due to their complex nature, data warehouse (DWH) development projects often fail or significantly exceed budgets. Prior literature has revealed that achieving common understanding in the requirements elicitation phase is a key factor for the successful knowledge transfer and overall success of information systems (IS) development. To closer observe these phenomena, we conducted in-depth interviews with participants of several DWH projects. We propose the concept of 'brokering situations' to examine social interactions between project stakeholders and we analyze multiple brokering situations in reported DWH projects. Brokering situations help to understand the time-dependent development of brokers, the boundary objects, and their relations with regard to knowledge transfer. We augment Carlile's (2004) classification of the boundary objects according to boundary complexity and development time. We discovered that in case of a low knowledge fit between project participants, involvement of a 'knowledgeable' broker seems important.

Keywords: Data Warehouse, Requirements Engineering, Boundary Spanning, Boundary Objects

Introduction

Requirements elicitation is the single most important and extremely complex phase of information systems (IS) development, having significant impact on data and system quality (Corvera Charaf et al. 2010; Davis et al. 2006; Davis 1982; Hofmann and Lehner 2001; Jarke et al. 2009; Mathiassen et al. 2007). Unlike transaction-oriented application systems, however, *data warehouses* (DWHs) do not implement the data-processing components of operational business transactions, but need to support decision-making by representing a group of very heterogeneous application systems (March and Hevner 2007; Stroh et al. 2011). DWH requirements specify what kind of data has to be provided to whom for what kind of management decision (Watson et al. 2004; Wixom and Watson 2001).

Nevertheless, the IS and DWH literature is replete with examples of users' inability to accurately specify their requirements, and developers are frequently criticized for being unable to elicit requirements from users (e. g., Davis 1982; Hansen and Lyytinen 2010; March and Hevner 2007; Rizzi et al. 2006; Winter and Strauch 2004). Caused by the broad scope of content and users, the large size, heterogeneous application systems, and long life cycles, DWH development fosters complexity (Stroh et al. 2011, p. 40). Moreover, a multitude of different stakeholders is involved in DWH development, for example, DWH experts, operational source system specialists, business (subject matter) experts, or managers and decision-makers. Consequently, next to the acquisition and integration of information from a wide range of sources, DWH development projects also pose challenges not often found in other IS development projects: the elicitation of information needs and requirements of very *different stakeholders* for often *less-structured decisions* (Winter and Strauch 2003), which enable the organization to effectively utilize its core capabilities and gain a competitive advantage (March and Hevner 2007, p. 1034; Watson and Wixom 2007). Each group of these stakeholders forms a distinct *community of practice* (Wenger 1998) that needs to collaborate and share the domain knowledge for requirements elicitation to be successful (Chakraborty et al. 2010, p. 242); each community of practice owns specific knowledge which has to be reflected in DWH specifications (March and Hevner 2007, p. 1035).

In DWH development projects, it is up to DWH professionals as developers and designers to span the boundaries of their community of practice in order to elicit the necessary requirements from other participating communities of practice (Vranesic and Rosenkranz 2010). Many studies of boundary spanning focus on individuals, so-called *boundary spanners*, who perform the knowledge transfer on the borders between different communities within an organization or towards its environment (e. g., Aldrich and Herker 1977; Ancona and Caldwell 1992; Ancona and Caldwell 1998; Tushman 1977). Based on these studies, previous IS research has identified states, transitions, and participant-based enablers and inhibitors for successful requirements elicitation (Chakraborty et al. 2010; Fisk et al. 2010; Levina and Vaast 2005). However, some participants of IS development projects are known to facilitate knowledge flow across *different* communities; these representatives then become more than 'local' boundary spanners by brokering knowledge between different communities, so-called *brokers* (Pawlowski and Robey 2004). Furthermore, given the complex nature of requirements elicitation, other concepts between boundary spanners and brokers are important as well for understanding this process. For example, requirements specifications, data and process models, diagrams, or program code examples are all important in requirements elicitation and are instances of the *boundary objects* discussed in the IS development literature (Bergman et al. 2007; Carlile 2002; Gal et al. 2008; Levina 2005; Nicolini et al. 2011). So far, however, the interplay of brokers and boundary objects during requirements elicitation has scarcely been the focus of researchers (Kimble et al. 2010). As a result, we concentrate on the following research question: "*How important is the interplay between brokers and the boundary objects they use during the requirement elicitation process in DWH development?*"

The remainder of the paper is structured as follows. The next section discusses general and DWH-specific challenges of the requirements elicitation phase in IS development. We also discuss the role of brokers and boundary objects with regard to these challenges. We then present our research approach and the findings of our analysis. We argue that the existence of brokers and adequate boundary objects accelerates the process of requirements elicitation. We discuss our results with regard to the literature. Finally, we summarize our findings, indicate limitations, and conclude with an outlook on further research.

Related Work and Theoretical Background

Several studies have revealed the importance of determining information requirements in DWH development (Watson et al. 2004; Winter and Strauch 2004; Wixom and Watson 2001) and translating those requirements into specifications based on a common vocabulary between IT experts and decision-makers (Rizzi et al. 2006). The resulting “shared” (Hirschheim and Klein 1989), “mutual” (Tan 1994), or “common understanding” (Tiwana and McLean 2003) has been repeatedly identified as a key determinant of the quality of the elicited user requirements that is important for IS development success (Siau et al. 2010). In order to achieve shared meaning, an individual must develop *rapport*, the harmony, accordance, and congruity developed in relationship with another individual (Guinan and Bostrom 1986).

A recent study by Hansen and Lyytinen (2010) summarizes key challenges for design professionals to overcome in IS requirements analysis in order to develop rapport. One of the challenges, the so called “limits of individual cognition” in requirements elicitation, stems from the inability of relevant users to articulate their needs concisely due to differing users’ or developers’ perspectives (Hansen and Lyytinen 2010) or so-called internalized “frames” of experiences (McMaster and Grinder 1980). Therefore, it is up to IS developers to have the communication competence and use effective patterns and behaviors in order to establish rapport with users (Guinan and Bostrom 1986). For example, it is hard to imagine how even the best tool could eliminate the need for a DWH developer to read documentation, ask other developers and end-users how they use the data, or review test runs to check for unexpected results (Bernstein et al. 2004, p. 38). It is the high affiliation between participating communities that is needed so that DWH developers can develop an integrated specification of DWH requirements (March and Hevner 2007).

Boundary Spanners, Brokers, and Boundary Objects

Recent studies argue that one decision appears to be highly relevant in order to establish rapport: which members of the different communities (other than the IS developers’ community) to assign to a project as participants (Chakraborty et al. 2010; Fisk et al. 2010; Ko et al. 2005; Levina 2005; White and Leifer 1986). For example, user representatives who do not only have intricate domain-specific business knowledge, but also have previous experience with technical aspects of IS development, seem to be important for the success of the project. The same holds for developers who possess domain-specific business knowledge and familiarity with the thinking of business people. Business knowledge, good communication proficiency, technical expertise, and analytical expertise seem to be very important individual skills for the success of IS development (Chakraborty et al. 2010; Fisk et al. 2010; White and Leifer 1986).

When they engage in boundary activities, individuals possessing such skills then act as *boundary spanners* (Aldrich and Herker 1977, p. 218). These activities include managing the coordination and knowledge transfer as well as the political maneuvering needed for the information sharing across the borders of an organization (Ancona and Caldwell 1998). Boundary spanning has a rich conceptual and empirical history within the organizational learning and social psychology domain, exploring the nature of organizational boundary spanning roles, facilitators, and constraints on role behavior, and anticipated outcomes associated with such roles for both boundary spanners and their organizations (e. g., Aldrich and Herker 1977; Ancona and Caldwell 1992; Ancona and Caldwell 1998; Tushman 1977).

In IS development, legitimate, peripheral participants who take over the role of boundary spanners and have been assigned to a project by management (delegated boundary spanners) can become a “boundary spanner-in-practice” (Levina and Vaast 2005, p. 352). To become such a participant, a delegated boundary spanner has to exchange the different subspecies of capital (e. g., economic, cultural, social, or symbolic capital) he or she had accumulated in one community for capital accumulated in another community (Levina and Vaast 2005, p. 353).

This is in line with theories of situated learning in communities of practice (Brown and Duguid 1991; Wenger 1998) that, in contrast to intra-organizational boundary spanning theories, have more power to explain the knowledge exchange between participants from different organizations working together on IS development projects (Fleming and Waguespack 2007; Pawlowski and Robey 2004). Key concepts for IS development here are *brokers* and *boundary objects*. Brokers are defined as individuals who participate in the work of *multiple communities* and facilitate the knowledge transfer across the boundaries using boundary objects (Brown and Duguid 1991). In contrast to boundary spanners, who span the communities borders from the inside of their communities, brokers may be weakly linked to several communities at once (and full members of none), strategically positioned to facilitate knowledge flow across communities (Pawlowski and Robey 2004). Boundary objects (BOs), on the other hand, are any "artifacts, documents, terms, concepts, and other forms of reification around which communities of practice can organize their interconnections" (Wenger 1998, p. 107). BOs represent a nexus of perspectives between communities and are "both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (Star and Griesemer 1989, p. 393). BOs can have different meanings in different social contexts; however, their structure is common enough across contexts to make them recognizable (Star and Griesemer 1989). If these objects become both locally useful and provide a common identity across different communities, they can become "boundary objects-in-use" (Levina and Vaast 2005, p. 354).

Brokering Situations in Data Warehouse Development

In DWH development, *DWH professionals* are DWH designers or developers who assume the role of a broker in knowledge exchange on two different borders: IT domain and business domain. On the one hand, eliciting users' requirements in DWH development means for DWH professionals to meet and discuss with users who mostly are *business experts in decision-making field*s (BEDFs). In these meetings, for example, definitions of sample reports are used as examples of required information and act as BOs. Only through the continuous interaction of DWH professionals with users can a full understanding of the requirements be reached (Chakraborty et al. 2010). On the other hand, DWH professionals design the technical extraction, transformation, and loading (ETL) processes (Kimball and Caserta 2004) in interaction with *operative system professionals* (OSPs) who are in charge of source data systems. Only in close cooperation with knowledgeable representatives from the OSP community can DWH professionals extract and interpret operational data so that it matches the users' requirements.

In the IS development literature, "brokering" often refers only to IS developers as potential brokers who manage coordination and knowledge transfer across the borders of their communities (e. g., Pawlowski et al. 2000, p. 335). In contrast to this one-sided definition, we define the concept of a *brokering situation* in DWH development as a knowledge exchange situation with at least two boundary spanners from different communities of practice in which each spanner adopts the role of a broker (Vranesic and Rosenkranz 2010). We argue that in these situations, all involved community representatives, not only DWH professionals as IS developers, can take brokering roles that facilitate knowledge transfer on the border towards neighboring communities. Furthermore, we acknowledge that the exchanged BOs during these brokering situations in DWH development projects (e. g., report print-outs or data models) play a significant role in mediating knowledge transfer between communities of practice. Depending on the type of complexity the boundary faces, BOs need not only to facilitate the representation of the knowledge but also its potential translation and transformation (Carlile and Rebentisch 2003). That is to say, BOs with different capacities are required (Carlile 2002).

Carlile (2004) scaled the relative complexity of the circumstances at the boundary using Shanon and Weaver's (1949) three levels of communication complexity: *syntactic*, *semantic*, and *pragmatic*. In order to describe the complexity, Carlile (2004) further identified three different properties of knowledge at a boundary: difference, dependence, and novelty. *Difference* refers to a difference in the amount of knowledge accumulated (e. g., novice-expert distinction). If knowledge is different in kind, and not just in degree, managing *dependence* among them is also needed (Carlile 2004). Dependence is a condition where two entities must take each other into account if they are to meet their goals (Litwak and Hylton 1962). The third property of knowledge is how *novel* the circumstances at a boundary are. According to Carlile (2004), "… novelty comes when an actor [e. g. the customer] is unfamiliar with the common knowledge being used to represent the difference and dependence between domain-specific knowledge" (p. 557), or if a customer, that delivers new requirements, is unable to express himself in a form that a developer can understand.

In other words, to observe an increase/decrease in novelty (and thereby increase/decrease in relative complexity) of the circumstances at the boundary during brokering situations, different *types and changes in the amounts of knowledge* and their *interdependence* must be taken into account. However, in case of a mismatch between the complexity of the boundary faced and the BO used, effectively sharing and assessing each other's domain-specific knowledge can be handicapped (Carlile 2004). Thus, we argue that the types of BOs that are used during those situations should also be taken into account and analyzed. However, researchers should not focus on brokers and the BOs they use at the boundary in isolation, but should examine their interplay as well (Kimble et al. 2010). Existing IS research on boundary spanning (e. g., Levina 2005; Levina and Vaast 2005) focuses rather on the conditions necessary for boundary spanners-in-practice and objects-in-use to emerge, not on their interplay during use or after emergence. This sets the venue for our research. We examine the interaction between brokers (already in-practice) and BOs (already in-use) in boundary situations in order to investigate requirements elicitation in DWH development more closely within an exploratory study.

Research Approach and Design

We collected data by expert interviews in three interconnected phases. The interviews were conducted in Croatia and lasted from 30 to 120 minutes. All interviews were recorded and transcribed. In the first two phases, one researcher conducted interviews with 20 experienced DWH professionals (cf. Table 1) who had been working on various projects in different industries, either in-house or as consultants. All interviewees have a master's degree in computer science or related areas. The number of participants in the reported projects ranged from 4 to 70, with an average of 15. The durations of these projects were from 6 months to 6 years.

Phase I covered eight open interviews. We applied a variant of the critical incident technique (Flanagan 1954). No interview guideline was used, but subjects were generally asked: (a) to identify and discuss brokering activities and objects they exchanged within early phases of DWH development projects; (b) for their impressions of the goals of BEDFs and OSPs, and of their own project goal; (c) to describe the activities of DWH professionals. Each of these open questions was followed by unprepared probing ones.

Table 1. Overview of Interview Subjects and Reported Projects from phase I and phase II

Interviewee	Years in IS	Years in DWH	Reported projects	Industries	Interview in phase I	Interview in phase II
James	6	2.5	L, M	Banking/Telecom.	✓	✓
Ryan	8	8	Ω, E	Banking/Energy	✓	✓
Tyler	8	8	U, V	Telecom./Pub. Health Ins.	✓	
Jack	12	2	Z	Higher education	✓	
Kevin	8	8	W	Higher education	✓	
Alex	9	7	C, D, X	Banking/Insurance/Trading	✓	✓
Justin	10	7	Π	Telecom.	✓	
Isaac	10	10	A, Y	Banking/Energy	✓	
Eric	5	5	F	Trading		✓
Ian	15	10	N	Telecom.		✓
Luis	11	8	P, O	Trading/Metal Industry		✓
Adam	4	3	H, Σ	Banking		✓
Julia	6	4	J, K	Banking		✓
David	6	6	G	Banking		✓
Emma	3	3	R	Telecom.		✓
Sara	8	8	E, S, T	Energy		✓
Caroline	5	4	Q	Telecom.		✓
Kyle	12	10	A, B	Banking/Tobacco Industry		✓
Jake	11	11	A, B	Banking/Tobacco Industry		✓
Amber	3	2	C	Banking		✓

In phase II we directed our questions towards revealing all possible factors that enable DWH professionals to successfully elicit requirements and factors that prompt OSPs and BEDFs to successfully share their knowledge with DWH professionals because we assume that brokering roles are not only delegated to DWH professionals (cf. "Related Work and Theoretical Background"). Phase II covered 15 semi-structured interviews in total and focused on exploring brokering situations in more detail. We used topic guidelines, asking interviewees to be as inclusive as possible in their descriptions of: (a) the team's skills and familiarity with the project's business domain; (b) individuals from the OSP and BEDF community, including their familiarity with the business domain as well as IT background of the data delivered by source systems; (c) what objects they exchanged during requirements elicitation. If the objects were characterized as BOs we coded them according to Carlile's (2002) categorization of BOs.

In phase III, we investigated two specific projects (out of the previous 20) and one additional, new project (cf. Table 2). This time we conducted semi-structured interviews with team members from OSP and BEDF communities as well in order to ensure data sampling from the members of all three participating communities (triangulation). In addition to the topic guidelines used in phase II, the semi-structured interviews in phase III were designed to also investigate the following events and changes in time: (a) participants' familiarity with the domain knowledge of all three involved communities; (b) all changes of personnel, and (c) all changes of BOs within the project.

Table 2. Overview of Interview Subjects and Reported Projects from phase III

Interviewee	Community of Practice	Reported projects	Industries
Mary	BEDF	Σ, Φ	Banking
Molly	DWH	Φ	Banking
Mark	DWH	Φ	Banking
Lillian	OSP	Φ	Banking
John	BEDF	E	Energy
Nicole	OSP	E	Energy

The interviews in all three phases were coded by two researchers using MAXQDA and open coding (Miles and Huberman 1994). The interviews from phase I were coded by two researchers in Croatian, whereas the interviews from phase II and III were professionally translated and then coded by two researchers in English. Our coding scheme gradually emerged, and from phase II on we concentrated on exploring brokering situations in more detail by coding: (a) BOs and (b) different types of knowledge that participants (DWH professionals, BEDFs, and OSPs) brought into the brokering situation, and (c) outcomes of brokering situations (e. g., misunderstanding, developed shared understanding, etc.). Figure 1 a. shows an excerpt of our preliminary coding scheme and Figure 1 b. of the final coding scheme.

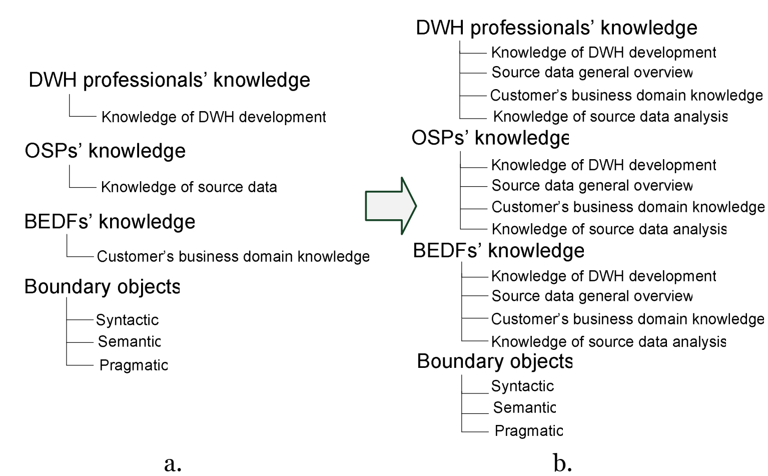

Figure 1. Exemplary Development of Coding Scheme (Excerpt for "Types of Previous Knowledge")

The preliminary coding scheme includes the domain knowledge for all three participating sides (DWH professionals, BEDFs, and OSPs) and the three types of BOs (syntactic, semantic, and pragmatic). Both coders iteratively revised the coding scheme until they determined that all relevant themes or issues were reflected (Eisenhardt 1989) (cf. Figure 1 b., where several additional "knowledge" types have been added as categories).

Analysis and Results

Brokering Situations – Community Representatives as Brokers

Participation in requirements elicitation for DWH development necessitates "a clear definition of business needs" (Hwang and Xu 2008, p. 52), exposing DWH professionals to problems that could be outside the realm of their natural competences domain: *technical knowledge* on how to develop a DWH (Figure 1 a., "Knowledge of DWH development"). In order to develop a DWH that can fulfill all user requirements, DWH professionals need to be familiar with the customer's business domain. Several interviews from phase I and II revealed that the DWH professionals' community responded to this challenge by bringing in community members who were most familiar with the customer's business (extension of the DWH coding scheme in Figure 1 b., "Customer's business domain knowledge"):

> "*If you have experience in the customer's business branch, then you partially know what customers want from you. Although they have problems expressing themselves, you can adjust their statements and produce more fitting reports.*" (Alex, project D)

Further, users (BEDFs) have strong *business knowledge* (Figure 1 a., "Customer's business domain knowledge") but generally do not posses extensive technical knowledge, and they usually do not engage directly or deeply with technical components or artifacts. However, our analysis revealed that specific BEDFs had already conducted data analysis and were therefore familiar with the meaning of the source data required for further DWH development. Therefore, we extended the coding scheme for BEDFs with the category *knowledge of source data analysis* (cf. Figure 1 b.):

> *"Perhaps they have worked with similar [reporting] systems before or they have managed to get the same functionality they later received with the new system by using, e.g., Excel. The goal is the understanding of data, and you generally have to do that on your own. Sometimes such people [i. e., technically experienced BEDFs] unexpectedly help you."* (James, project M)

Also, OSPs who usually have strong technical knowledge, and typically lack business domain knowledge, expand their competence domain (Figure 1 a., "Knowledge of source data") with the domain of customers' business in day-to-day work and data preparation for business users (extension of the OSP coding schema, Figure 1 b., "Customer's business domain knowledge"; "Knowledge of source data analysis"). Moreover, in case the number of source systems is greater than one, these members of the OSP community, who have a general overview of all data sources, play an important role in aligning the understanding of all relevant concepts and terms right from the start of the project:

> *"They had people who were in charge of certain segments of that [ERP] system. We actually never talked to anyone who would be the architect of the entire system. … They did seem like islands over there. … I remember that there were problems … it's hard to catch someone who knows how to work with it."* (Jake, project A)

Therefore, we changed the preliminary code for OSPs from "Knowledge of source data" (cf. Figure 1 a.) to "Source data general overview" (cf. Figure 1 b.). Furthermore, due to the fact that DWH technology already exists for several years, some companies already have running DWHs. Our findings imply that work experience with previous versions of such a DWH can influence the development of shared understanding between participants. This led to further extending the OSP coding scheme (cf. Figure 1 b., "Knowledge of DWH development"):

> *"… for a long number of years, actually, the company did have a DWH and a reporting system, however, only for Sales, but some of the people were already familiar with it, part of the IT [OSP] … They worked on the ERP system and the DWH. So, they managed well with the user needs.. They can manage the whole story and they have inside information on how all of it works."* (Kyle, project B)

Based on the iteratively revised codes from phase I and phase II we find that *different types of knowledge influences brokers' overall competence* (cf. Figure 1). We argue that all four factors – (1) Customer's business domain knowledge, (2) knowledge of source data analysis, (3) source data general overview and (4) knowledge of (previously conducted) DWH development – play a significant role in successful brokering situations during requirements phase of DWH projects for all three communities.

Chakraborty et al. (2010, p. 235) have already discussed similar types of developer-based (e. g., prior experience working with the user's business or technical knowledge) and user-based factors (e. g., organizational knowledge), acting as enablers or inhibitors of the requirements elicitation process (cf. Section "Related Work and Theoretical Background"). However, previous research has grouped these factors according to the participants' roles in the project (Chakraborty et al. 2010; Fisk et al. 2010). In contrast, our findings show that the line between those participants who possess necessary knowledge due to previous experience and those who do not was dynamically moving in the course of different projects. For example, in case of the in-house DWH development project W, the community of DWH professionals consisted mostly of employees from the company (no external consultants), implying that they had a good understanding of the customer's business and a general overview of source data and their analysis. Therefore, we also extended the coding scheme for DWH professionals with the categories "Source data general overview" and "Knowledge of source data analysis" (cf. Figure 1 b.).

Likewise, one interviewee reported a situation for project E where a BEDF was not only familiar with the source data, but had apparently participated in its development. This "power BEDF broker" was able to define his requirements by directly referring to the source systems. In addition, he helped to define the ETL process, hence exhibiting membership in both BEDF and OSP communities:

> *"We've worked with quite an advanced user that had a degree in math, worked at first in the production department, afterwards in the IT department and de facto developed their information system, and now works in the department of strategic planning. He understands both IT and the company's business process, being able to sketch examples of reports he expected. We pretty much understood it all."* (Ryan, project E)

Similar situations could be observed in other cases, for example, "power OSP brokers", and subsequent probing in phase II confirmed that the four aforementioned factors varied for each participating community from project to project. For example, the already reported episode from project B, where DWH technology already existed for several years, shows that OSP members can become familiar with DWH development techniques as well (cf. Kyle, project B). An episode from in-house project F further demonstrates that only few business departments (BEDF communities) had experience with data analysis of source data due to the nature of their job. As a result, only two departments (D1 and D2) had brokers who could articulate future system requirements and thereby help DWH professionals to better elicit requirements compared to the other departments (D3, D4, D5, and D6):

> *"Most of them [users from D1, D2] knew exactly what they wanted and what they could get from the information system. They didn't have unrealistic requirements because they knew the system's limits (restrictions) and such things … they had that somehow in their heads. Most of the users who work with reports understand neither the DWH nor what is going on in the background [in D3 through D6], whereas they [users from D1, D2] had a good idea about it. There [in D3 through D6] were mainly business clients who knew how to define very good reports, but communication with someone, who has background in informatics [as in D1, D2], was much easier…"* (Eric, project F)

Our analysis also reveals that in absence of BEDF brokers, OSPs who were familiar with those BEDF communities' business were able to compensate for ambiguous statements in users' requirement definitions:

> *"There were cases when users had a request that we could not understand. Then we explained to them what they could and could not get. Finally we have adjusted their requirements. Some of us were part of the department of informatics [OSP] and we were supposed to know the business side of the data very well. We could explain to the user what can be produced and what couldn't since we knew what data were available."* (Eric, project F)

All of these observations led to an extension of the coding scheme for BEDFs (cf. Figure 1 b., "Source data general overview"). Finally, for completeness, we extended the coding scheme for BEDFs with the category "Experience with DWH development" (cf. Figure 1 b.). However, in our analysis of the interviews, we found no evidence that BEDFs had this experience.

Brokering Situations – The Role of Boundary Objects

Informants from all projects mentioned a wide range of BOs within the process of requirements elicitation (e. g., prototypes, functional and technical specifications, database documentations, and so forth). For the brokering situations reported in our data, we applied the categorization of BOs used across the three types of boundaries (cf. Figure 1 a., "syntactic, semantic, or pragmatic BO"). The results of our analysis confirm Carlile's (2004, p. 560) classification of the relative complexity of the circumstances at the boundary and the importance of the fit between the border's complexity and the used BO. If the communication border between two communities is positioned on the syntactic level, a common lexicon suffices to specify the differences and dependencies of consequences at the boundary. In this situation, syntactic BOs can be used to support communication (Carlile 2004, p. 558). For project C, for example, statements refer to the use of Excel spreadsheets with required calculations in reports:

> *"Q: In the beginning of the project they gave you an Excel table with calculations?*
>
> *A: Yes. They gave us … a table with some calculations that defined how some data is to be calculated.*
>
> *Q: So, it was all clear to you in the analysis phase? Have you made mistakes during development that were connected with the wrong interpretation of the table?*
>
> *A: Well, one of the biggest mistakes, I wouldn't call them mistakes but misunderstandings, happened due to the fact that we understood something differently [from what they had in mind]. We had literally implemented according to their definitions in that table. When they saw an example in our prototype, they responded: "well, we don't want this in this way, but in the other way" … A second problem was that they changed the table with the calculations 4-5 times… Only after we put the developed prototype into production, they realized that they've made a mistake [in the definitions]. So they changed the table.*
>
> *Q: And without those milestones … they wouldn't be able…?*
>
> *A: No, they wouldn't be able to [get what they really wanted in the first place]… We would work, work, … and finish and then when they would be using the system, only then, they would figure out, that that was not what they wanted in the first place."* (Alex, project C)

During the first few brokering situations in project C (pilot meetings), representatives from the BEDF community are reported to have shared requirements definitions with DWH professionals in form of old reports defined in Excel spreadsheets. The spreadsheets supposed to represent a cross-boundary repository of requirements definitions (syntactic BO), and "supply a common reference point of data, measures, or labels across functions that provide shared definitions" (Carlile 2002, p. 451).

The problem that the DWH professionals did not foresee was that although they possessed "operational knowledge," namely knowledge of how to create a DWH and to build a set of reports, they lacked "diagnostic knowledge" (Black et al. 2004). Our analysis indicates that the DWH professionals were not able to interpret the BEDFs' requirements from the Excel spreadsheets (shared repository; syntactic BO) given to them by BEDFs. In other words, although the DWH professionals had experience of working in businesses similar to the one of the BEDF community, their relative deficit of *general* BEDFs' business domain knowledge is reported to have hampered their ability to interpret the implicit knowledge embodied in the exchanged syntactic BO. The DWH professionals tried to guess the meaning of concepts or to use their "own" semantics to transfer knowledge, but they actually first needed to transform and align with representatives from the BEDF community the concepts' meanings semantically. This knowledge imbalance created a pragmatic boundary across which knowledge not only had to be transferred, but also had to be transformed into a "common lexicon" that DWH professionals could interpret. In such situations, DWH professionals may think that they have understood what they have been told, even though they have not. DWH professionals might believe that they have reached a shared understanding with the BEDFs, whereas, in fact, they only experience an "illusion of evidence" (Bromme et al. 2005). For example, by the time DWH professionals and BEDFs jointly reviewed the first prototype in project C, they realized their misinterpretations of the BEDFs' requirements based on the old reports:

> *"We were lucky to have the milestone meetings while we were developing. We were presenting them the results of our development, allowing them just-in-time corrections. The end result was of a very good quality and they were very satisfied with the final product as well…*
>
> *Those milestones, during which they continuously corrected our work, saved us literally. They were able to express what they thought made sense and what didn't. …*
>
> *The analysis phase of the project was very good and we succeeded to cover users' wishes 80-90%. In the end of the project even 90%. The missing 10% were some differences we faced due to the fact that the users expressed themselves incorrectly … and only when they saw the [finished] system, they figured out that they had expressed themselves inaccurately."* (Alex, project C)

In this case, the prototype facilitated a process where individuals could jointly transform their knowledge. Adapting Star and Griesemer's (1989) categorization of BOs, Carlile (2002) argued the objects such prototypes have sufficient capacity for resolving the misunderstandings on the pragmatic boundary. Only after switching to BOs that had the adequate capacity for discussions about the (semantic) meaning of the calculations, the DWH professionals were able to create a shared understanding with the BEDFs.

Further analysis of the in-house project F (cf. Eric, project F) reveals that BOs having adequate capacity are highly instrumental in enabling the fine-tuning of knowledge to be shared between participants. In absence of BEDF brokers, OSPs who were familiar with those BEDF communities' business were able to compensate for ambiguous statements in users' requirements definitions.

In contrast, our findings from project O show that the departure of a broker (an OSP broker) increased the relative complexity of the circumstances at the boundary leading to a project standstill. The DWH professionals were unable to interpret the data within a Cobol application (repository, syntactic BO):

> *"A: When the new owners arrived, they brought a man with them whom they appointed as IT director at the forge… However, all the others, his new IT department, who knew their old Cobol database – they would pull out certain data from there, print it out, but they had serious issues with Excel, something unheard of for us. You have an IT specialist who can't find his way around Excel, let alone doing something in more modern databases.*
>
> *Q: So who did you do the analysis with, with this manager (IT leader)?*
>
> *A: More or less, with him, since he had the technical skills and has been troubling himself with these people, dragging the information out of them, making them… that project did not end very well… I think there is now a DWH, being filled as we speak, but that man has given up in the meantime, he is through with quarreling with the IT. Now the whole thing is hanging in the air."* (Luis, project O)

Brokering Situations – The Interplay between Brokers and Boundary Objects

The first analysis of our results from phases I and II revealed that BOs cannot only have a positive effect on knowledge transfer in brokering situations, but also have a negative impact in case they are mismatched and their capacity is found insufficient for handling the complexity on the border between communities of practice. If not mismatched, BOs enable knowledge to be shared between participants. However, in cases where significant gaps in understanding were apparent (e. g., in projects E, F, and O), we found that Carlile's (2004) framework cannot explain all effects we discovered in the data. The role of special brokers was significant in closing the occurring knowledge gaps. Without either the active participation of OSP brokers familiar with the BEDF communities' business (cf. Eric, project F), or the "power BEDF brokers" (cf. Ryan, project E) with experience in development of operational IT systems, other participating communities would have been struggling to exchange knowledge. In other words, if OSP brokers would not have been involved in the brokering situation, the border between DWH professionals and BEDFs would have been pragmatic. In that case, developers would have had to switch from the document containing requirement definitions (syntactic BO) to BOs that have more adequate capacity (e. g., prototypes, as in project C). However, due to the OSPs' involvement, the exchanged syntactic BO was sufficient.

The interesting example from project O reveals that the departure of such a relevant broker (cf. Luis, project O) can even cause a project standstill. Moreover, as shown above, the distinction between participants with and without necessary knowledge is quite dynamic and not necessarily role-based. We found that each broker from one community of practice may become familiar with domain knowledge of another community and compensate for their missing or inaccurate interpretations of discussed issues during brokering situation.

This discussion reveals, on the one hand, that the interplay of brokers with BOs during requirements elicitation appears to be very important for the successful knowledge exchange between different communities. On the other hand, it shows how involvement of special brokers can extend the borders of Carlile's (2004) framework as well. Carlile (2004) only suggests that the problems on the pragmatic boundary can be resolved by an investment of time in the discussion over a pragmatic BO.

Thus, in order to observe how the interplay within the process of requirements elicitation in DWH development proceeds, we conducted a more detailed analysis of the (1) *types and changes in the amount of brokers' knowledge* as well as (2) *types of BOs* they use during brokering situations. We propose that for analyzing the *interplay* between brokers and types of BOs they use during different broking situations, one should also account for the *interdependence* between different types of brokers' knowledge. In the following, we analyze how the "fit" between different types of brokers' knowledge changes in time and how, if at all, this process is accompanied by BOs.

Analysis of Knowledge Fit in Requirements Elicitation

We use the term *knowledge fit* to describe the overlap between different brokers' individual knowledge in a brokering situation. To observe the increase or decrease in knowledge fit during brokering situations, we account different types of brokers' knowledge and changes in the amounts. We use the four previously defined *knowledge types* (cf. Figure 1): (1) customer's business domain knowledge, (2) knowledge of source data analysis, (3) source data general overview, and (4) knowledge of DWH development. We distinguish between: "none", "basic", and "comprehensive" amounts of knowledge. Depending on the existing types and amounts of knowledge that brokers possess, a certain *amount of knowledge fit* between brokers is established in the beginning of any brokering situation. As BOs with adequate/inadequate capacity can help to increase/decrease the preliminary knowledge fit, we audited all *BOs* used by the participants within a reported brokering situation with regard to their capacities. Finally, we estimated *the growth rate of the knowledge fit* that resulted from a brokering situation as a composition of: (1) participants' preliminary knowledge and (2) used BOs in (3) time. The growth rate of the knowledge fit can increase or decrease, depending on the rate of participants' individual knowledge growth. However, it can never be considered negative, as the participants always continue to exchange their knowledge and increase their individual knowledge (at least with the minimal rate).

Change of Knowledge Fit: An Exemplary Episode

As the next step, we illustrate this analysis for a sample episode of project Φ. The episode describes the part of project Φ that took place at a bank. Some members of the DWH professionals' community (from external company Infocom) had been working on the project for several years. However, for the development of a set of new reports, the bank employed a group of DWH professionals from another external company, Softcom. (Note: We do not focus on cultural, political, or power aspects of this situation.). A third community that participated were the BEDFs from the accounting department.

In Figure 2 we summarize the amounts of different types of brokers' knowledge at the beginning of the episode (left side) and observe the changes in amount of knowledge fit between brokers over time (middle) and knowledge fit growth rate (bottom). Different states (S_1-S_6) between reported brokering situations are positioned on the time line and the growth rate of the knowledge fit was estimated according to the relative difference in reported knowledge fit after every brokering situation. (Note that we estimate the knowledge fit and its growth rate explicitly as "schematic – not to scale" to emphasize the fact that there is no notion of scale in our ruminations about the time or the increase in knowledge fit.)

Next, we discuss how the knowledge fit changed from state to state in time based on this observed episode. At different stages of the episode we found evidence of changes of either BOs or brokers (or both). These changes had an impact on the rest of the episode. As our analysis proceeded, we concentrated on these changes and divided the episode in several different brokering situations, ending or beginning with a change.

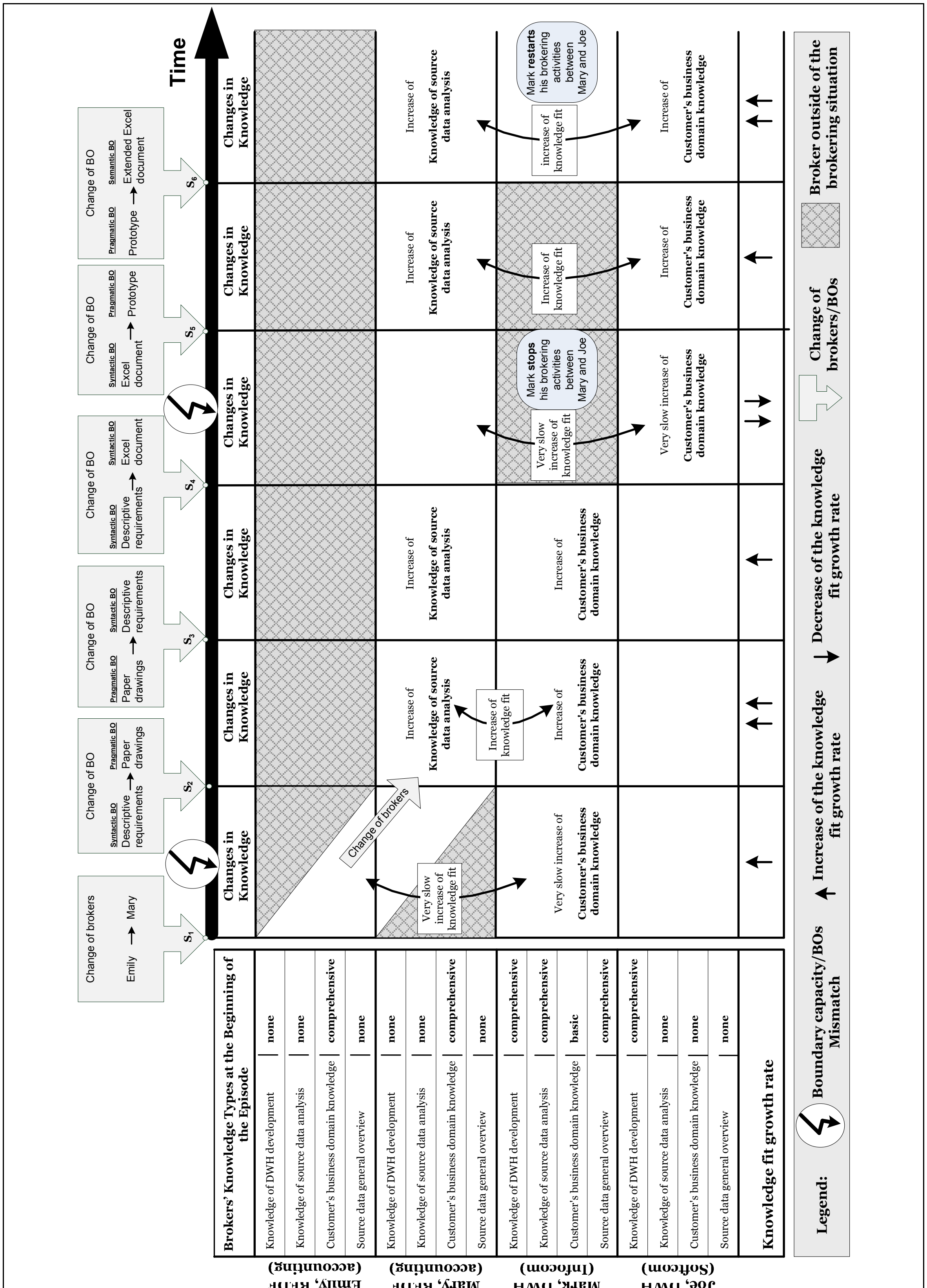

Figure 2. Descriptive View of Knowledge Fit – an Episode from Project Φ

For example, at the beginning of the episode, the whole project was on holdup:

> *"A: … In fact, I had a feeling that they were going in circles. Everyone was waiting for the other to do something again, so the circle closed at the back. This is what it looked like roughly.*
>
> *Q: And they never got a small prototype …*
>
> *A: No, no… not at all… They didn't reach that phase at all. Slowly, there was also a fear on one hand… from Softcom colleagues… that were engaged in making a software solution and from our people also, because in August [was the deadline]… I came in April…"* (Mary, citation 1)

The reason for this standstill was the misunderstanding between the BEDF broker (Emily) and the DHW professional from Infocom (Mark). On the one hand, Mark reported that Emily had been missing the ability to analyze the delivered results and had been refusing any additional help. Therefore, we set Emily's "Knowledge of source data analysis" in Figure 2 to "none" (as well as all the other DWH-domain or OSP-domain knowledge). On the other hand, Mark stated that he did have some knowledge of the BEDFs' business, but that he was not able to find those mistakes on his own (cf. Figure 2, "Customer's business domain knowledge" set to "basic"). Due to both the number of years he spent in the company and his extensive cooperation with all involved communities, he possessed comprehensive knowledge in both DWH and OSP knowledge domains.

The overlap of the amounts of different knowledge types (knowledge fit) between Emily and Mark was very small, resulting in very high complexity on the boundary between them (pragmatic boundary). Additionally, BOs reported on this border were descriptive business requirements Emily gave to Mark (syntactic BO). According to Carlile (2004), if a mismatch between the complexity on the boundary and the BO being used occurs (cf. Figure 2, the "lighting" on the timeline, S_1-S_2), effectively sharing and assessing each other's domain-specific knowledge can be handicapped. In this light, it is understandable why neither Mark nor Emily had been gaining significant new knowledge to this point (cf. Figure 2, "Knowledge fit growth rate", S_1-S_2). The circumstances changed, however, when a new BEDF broker, Mary, joined the project and replaced Emily (cf. Figure 2; in S_1 the status of Emily switches to "broker outside of the brokering situation" – the gray shading – while Mary enters the project – the gray shading turns to white):

> *"Everyone needs to step into everyone else's territory. So for example, with Mary it was easy to communicate – since she had an IT-related background and she knew, if necessary, to write a SELECT [a programming language command], so she was easy to talk to. While before, at the beginning of the project, Mary was not involved at all. There was a different person [Emily], a leader, who utterly refused 'I don't know anything. I am not interested in anything. Why would I need this?' And then it's very difficult."* (Mark, citation 1)

Mary had some IT background due to her previous high school education, but her preliminary knowledge that was relevant for project Φ was not significantly different from Emily's (cf. Figure 2, brokers' knowledge at the beginning of the episode). However, Mary succeeded to develop analytical skills in the next brokering situation, thereby increasing the fit with Mark (cf. Figure 2), as opposed to her colleague, Emily. Namely, Mary at first reported to have inherited "the old way" of how the requirements were gathered on the project:

> *"From the beginning… as was the way I inherited, that was the way we worked… We say what we want in a descriptive way. Then Mark would communicate with Softcom then they agreed on the technical part."* (Mary, citation 2)

As Mark did not have the overall business knowledge of the BEDFs and Mary had just joined the team, the complexity on the border appeared to be too high for them to exchange "descriptive" requirements (syntactic BO). By switching the BO to paper drawings (pragmatic BO) in S_2, Mark successfully introduced Mary with the source systems in the bank and gave her a rough overview of how the DWH system "pulls out" the source data (cf. Figure 2, Mary develops "Knowledge of source data analysis"):

> *"I said: 'you know what, you have to spend a little time. I will come to you. Give me an hour, draw for me how it functions in the first place.' Because when, in the end, he gets that report, I wanted to know which data of those came in directly from the source through the DWH, and which data was a result of the application's work. Because when something is wrong and something needs to be*

developed, [it's important] to know whom to contact: either the DWH team, the sources, or... And that's where the intense collaboration started. When we drew that up, when we got that scheme, drawing and when after that we sat down and started organizing the code lists, that's where the whole thing actually picked up. And that's it." (Mary, citation 3)

In this brokering situation (Figure 2, brokering situation S_2-S_3), Mary and Mark discussed using a pragmatic BO (paper drawings), which was adequate for the level of complexity at the BEDF/DWH boundary. After the brokering situation, Mary increased "Knowledge of source data analysis". Meanwhile, Mark also increased his understanding of the customer business. The total knowledge fit between Mary and Mark increased. In other words, both the change of the broker in S_1 and the change of the BO in S_2 enabled the creation of a *better* knowledge fit between participants.

We propose that the change of the broker and the switch to an adequate BO positively influenced the amount of knowledge fit in the project. Therefore, we display the change of brokers as an acceleration effect leading to a higher amount of knowledge fit through the transition from S_2 to S_3, compared to the transition between S_1-S_2. The S_2-S_3 transition implies a relatively *faster growth rate of knowledge fit* per time compared to the S_1-S_2 (cf. Figure 2, "Knowledge fit growth rate"). If the BO in S_2 had never been changed, participants would have needed to invest an increased amount of time to reach the same fit.

Due to the increase in knowledge fit, the complexity of the circumstances on the boundary decreased and the BEDF (Mary) and DWH professional (Mark) were now able to discuss further issues using other BOs with less capacity (e. g., definition of requirements in the descriptive form). Even after reaching the better knowledge fit, Mary and Mark could have continued using the paper drawings (pragmatic BO). However, it was not necessary for her to draw the sketches of the BEDFs' requirements on paper anymore. She only needed to "say what we want in a descriptive way" (Mary, citation 2). Her decision to switch from the pragmatic BO back to a syntactic BO reduced the time Mark needed to spend collecting the BEDFs' requirements and thus increasing his understanding of the customer business, reaching the altogether better fit between him and Mary (cf. Figure 2, brokering situation S_3-S_4). This time when Mary defined the requirements in a descriptive form (business definition of a new report), Mark successfully interpreted and translated the requirements in a more understandable form and forwarded them to Joe (definition of a new report – technical, as already reported in Mary, citation 2).

Again, we display the result of the change of BOs as acceleration in the knowledge fit growth rate. However, based on our analysis, the fit between Mary and Mark increased faster in the transition S_2-S_3, where Mary firstly developed any understanding of source data analysis. Therefore, compared to the transition S_2-S_3 the knowledge fit growth rate between S_3-S_4 is a bit lower (cf. Figure 2).

Although the way the things were organized on the project resulted in an increase of the knowledge fit (Figure 2, brokering situation S_3-S_4), management decided to integrate two BOs (descriptive business and technical definitions of a new report) into a single document:

"... In the end, we came to the phase, ... at one moment we were in the phase that we had much more in our heads and all of us knew everything. And it was quite on paper that we didn't have much. Then we realized that we have to document because of other people, not because of us...Now we have unified it to one place... an Excel table, where in the first column we start with the [prescribed] regulation. Then in the column next to it we explain it to ourselves, in relation to our data and our systems, what that would mean. Do we have it, or not? We interpret for ourselves." (Mary, citation 4)

The purpose of the joined (Excel) document was to directly connect the BEDFs with the developers (DWH professionals from Softcom) without the interaction from Mark (cf. Figure 2, the status of Mark stays "active", but he does not perform brokering between Mary and Joe – the gray shading between S_4-S_6). However, according to the analysis of the interviews, the first versions of the document caused only misunderstandings between Mary as the BEDF broker and Softcom developers:

"It's just a thing of format and basically how detailed in that specification, in what way it is described. We give them [DWH professionals from the Softcom] the specification. They go through it. But after that: 'let's sit down together. Let's go through it together. Is there anything that isn't clear to you?' Because we had situations, that some things weren't interpreted correctly. Then we thought, everything was great, crystal clear. And then, when the time came they do their development, it was all wonderful. It comes to us for testing, and that wasn't that. Let's return it." (Mary, citation 5)

The reason for the misunderstandings was the syntactic nature of the document. On the one hand, the new Excel document (cf. Figure 2, semantic BO in S_4) was adequate for the (syntactic) border between Mary and Mark, the DWH professional from Infocom. On the other hand, when the same BO was used on the other (pragmatic) border between Mary and Joe (DWH professional from Softcom), Joe was not able to interpret the BEDFs' requirements written in the document (cf. Figure 2, the "lighting" on the timeline, S_4-S_5). This may be explained by the fact that the complexity on the border was too high for the BO being used. The result was again a holdup for the project: the rate of knowledge fit growth in the project simply slowed down. Joe struggled hard with interpreting the requirements contained in the Excel document, only very slowly increasing his understanding of the customer business (cf. Figure 2) and the knowledge fit between him and Mary. We display the result of this change of BOs with a significant decrease of knowledge fit growth rate per time in the transition from state S_4 to S_5 compared to the S_3-S_4 transition (cf. Figure 2).

Only when in the following brokering situation Mary was confronted with the prototype (pragmatic BO), she was able to realize that the problem existed at all (Mary, citation 5; Figure 2, brokering situation S_5-S_6). However, although the BO being used in this brokering situation to resolve the misunderstandings had an adequate capacity (pragmatic BO), the gap turned out to be too large to be closed in the time calculated for this project phase (cf. Figure 2, slow increase of the knowledge fit growth rate S_5-S_6).

The further involvement of Mark (cf. Figure 2), having a very good understanding of the customer business, had a positive influence on reducing the gap in knowledge fit. He extended the Excel document with descriptive columns turning it from a syntactic into a semantic BO (cf. Figure 2). The resulting version of the document further helped Joe to increase his understanding of the customer business. This led to another acceleration of the knowledge fit growth rate (cf. Figure 2, transition from S_6 on):

> *"… we decreased the risk in a sense, through the manner of writing those specifications, for them [Softcom] not to take the wrong data … we managed to have Mark write something in the final column, the technical part. Like up to now, he works on the queries for the base, with some SQL. I mean with that IT language, they [Softcom] would get the data out."* (Mary, citation 6)

Discussion

The Change of Knowledge Fit in Time

Our research revealed that the higher the knowledge fit between different brokers is, the better *the group capability to transfer knowledge* within a brokering situation is. This also shows some similarities with the phenomenon known as the *learning curve effect* (Wright 1936). The learning curve represents an aggregated model that may be used to represent both individual learning and group or organizational learning (Argote 1993; Argote 1999). According to a wide range of research on learning processes (Argote 1999; Dutton and Thomas 1984; Yelle 1979), there are substantial differences in the rates at which some organizations, groups, or individuals gain a certain capability. By transferring the insights of the learning curve effect to our research on brokering situations during requirement elicitation, we can infer that different types of brokers' knowledge increase over time. However, as the work of IS development teams changes over the lifetime of a project (Walz et al. 1993), a misalignment can develop between the complexity of the boundary between brokers and the capacity of the BO being exchanged. Such misalignment causes severe misunderstandings between participants and break-downs in knowledge transfer follow. We therefore suggest that both the composition of community representatives' knowledge and the BOs they exchange during a brokering situation influence how fast they establish a better knowledge fit. Hence, we argue that knowledge fit between different brokers represents a function of (1) composition of community representatives' knowledge and (2) used BOs in (3) time.

By changing one of the two input parameters (here: community representatives' knowledge or used BO) we found that the knowledge fit grows with different acceleration rates (e. g., see the change in acceleration between S_1-S_2 and S_2-S_3 in Figure 2). The analysis of the change in the growth rate helped us to reveal that for very low levels of knowledge fit Carlile's (2004) framework cannot explain all the effects we found in our data. In his framework, Carlile (2004) suggests that discussions over a pragmatic BO, which take time, can resolve problems on the pragmatic boundary. However, an interesting question is what happens on such pragmatic borders when the knowledge fit between participants is very low (e. g., as the fit between Mark and Emily in the beginning of the presented episode for project Φ)?

The Complexity on the Boundary and the Capacity of Boundary Objects

In order for 'delegated' boundary spanners to become boundary spanners 'in-practice', Levina und Vaast (2005) argue that they have to develop, at the very least, a peripheral understanding of each practice they participate in (cf. Section "Related Work and Theoretical Background"). This peripheral understanding should help them close the knowledge gap on the community's boundary. For example, Mark was already familiar with the business of the accounting department. On the one hand, however, the knowledge gap between him and Emily was too large for him alone to close *in the given timeframe of the project*. On the other hand, the use of pragmatic boundary objects seems to be inefficient as well. If Mark had not changed the Excel document (cf. Mary, citation 6), then Mary and Joe would have needed a significant amount of time to resolve all misunderstandings only by discussing about the prototype. Therefore, if a broker had not joined the team in the beginning of the presented brokering situation, the project would never have met the deadline. In case of high complexity on the border between projects participants, these time-restrictions hinder 'delegated' brokers (e. g., Mark and Emily) to become brokers 'in-practice' (in the sense of Levina and Vaast's (2005) boundary spanners-in-practice). The reported findings from phase II (cf. Luis, project O; section "Brokering Situation – The Role of Boundary Objects") also show that the departure of a broker (in this example, an OSP broker) may lead to a project standstill. Therefore we propose that:

> *In case of initially low knowledge fit between project participants in time-restricted DWH development projects, involvement or departure of knowledgeable brokers is very important for project progress.*

Additionally, we noticed that the used BOs in some brokering situations had more capacity than the complexity on the border required. For example, by the time project Φ moved from state S_2 (Figure 2.), Mark and Mary understood each other very well. When management decided to merge all the BOs into one BO (Excel table) at state S_4, both parties could have kept the descriptive form of requirements definition (syntactic BO). Nevertheless, they continued using and maintaining the semantic BO (Excel table with additional columns describing the bank's terminology) for documentation purposes. This proved to be much more time-consuming (cf. Mary, citation 6). Although Carlile (2002; 2004) argued that at the syntactic boundary the BOs with less capacity should be used, he did not exclude the use of BOs with more capacity. However, according to our analysis we propose:

> *If during brokering situations in DWH development projects BOs with high capacity are used at the boundary with low complexity, the BOs are not used for the purpose of knowledge transfer, but for the purpose of documentation. In that case, if any broker happens to leave the project, knowledge will be preserved.*

Brokering Situations and Consequences for IS Research and Practice

IS development should not be viewed as a "black box" but instead as a process of creation, innovation, knowledge sharing, and learning (Siau et al. 2010). Information generated during this process from communication between users and developers is therefore a major determinant of IS development success, and refocusing of software development methods from pure engineering to socially-centered methods seems to be appropriate (Sawyer and Guinan 1998). So far, research in the field of boundary spanning between users and developers has only focused on the emergence of boundary spanners-in-practice and boundary objects-in-use (Levina and Vaast 2005) and not on their interplay. Likewise, existing models of social interactions and user-analyst relationships have generally examined the process of requirements elicitation in isolation (Chakraborty et al. 2010; Fisk et al. 2010; Newman and Robey 1992). The interplay between brokers and BOs has been neglected so far (Kimble et al. 2010). However, as IS development teams constantly change and evolve, Sawyer et al. (2010) warn that understanding the patterns of variations across time and the relationships among those variations is still under-researched.

We argue that our concept of "brokering situation" gives a sharp lens for analyzing the interplay of BOs and brokers in time, and their relations with regard to knowledge transfer during requirements elicitation in DWH development. Analyzing a *chain* of brokering situations offers a chance for a detailed audit of: (a) all the participating brokers, (b) all BOs the participants utilized with regard to their capacity, and (c) all the changes of BOs or brokers. Thereby we extend the research on BOs and brokering as well as existing models of the requirements elicitation process by providing a more holistic view of how brokers and BOs interact and drive each other in the process.

Although developed in the DWH domain, we argue that our findings can help both researchers and practitioners in other IS development situations. We suggest that the concept of brokering situations could help us examine and analyze three persistent problem areas of IS development in general in more detail: (1) the diversity of IS development projects; (2) the dependence on developers' knowledge; and (3) the relationship between structure and IS development practice (Kautz et al. 2007).

Diversity in terms of size, application domain, underlying technology, and the number, knowledge, needs and requirements of people involved is a fundamental challenge in IS development; nevertheless, it can be handled in different ways at different contextual levels (i. e., the business environment, company, project, team and individual) by either absorbing or reducing diversity (Kautz et al. 2007, p. 231). Our concept of brokering situations could be applied both at the individual and at the group level, for example, to pinpoint the "critical" events resulting from the use of "unfitting" BOs on the boundary (diversity) and explore how these events are resolved. As regards the dependence on developers' knowledge, Kautz et al. (2007) argue that in all types of IS development projects it is necessary to identify "what kind of knowledge is needed, how much is enough and how it can be acquired and communicated" (p. 232). Observing the change in participants' knowledge from one brokering situation to another, we argue that the complexity on the border, as well as the amount of necessary knowledge for overcoming this complexity, could be traced in time by chains of brokering situations. Further, we argue that by offering answers to the questions *when* and *how* brokers will use brokering situations to modify social structure – for example, in form of BOs –, we help both researchers and practitioners to better understand the relationship between structure and IS development practice (Kautz et al. 2007). Observing the complexity on the border and the BOs being used within a sequence of brokering situations, researchers could be enabled to explore, describe, and explain when and how brokers will use brokering situations to modify social structure.

Conclusion

Brokering situations are knowledge exchange situations with at least two boundary spanners from different communities of practice using BOs to mediate knowledge exchange. Following from our findings, we suggest that requirements elicitation in IS development in general and DWH development in particular may be understood as a *chain of successive brokering situations*. We argue that during brokering situations the IS development process is not only challenged by the knowledge fit between different types of participants' knowledge and different BOs they exchange, but by their interplay as well. Thus, we argue that the research IS development should focus more on interplay brokers and BOs.

Our analysis revealed that Carlile's (2004) framework is not sufficient when the temporal dimension of the development process is taken into account. In the case when there is a significantly low knowledge fit, the involvement of "knowledgeable" brokers is deemed highly important. Finally, we argue that, if BOs with more capacity are used at the boundary with less complexity, the BOs are not used for the purpose of knowledge transfer, but for the purpose of documentation.

We acknowledge the limitations of our study with regard to the data. The explanatory power of our findings is restricted to DWH development and closely linked to the data sample. The study itself, although illustrative, does not test in any way our findings. Our research also neglects several aspects of social interaction in DWH development, such as culture, politics, or power. In order to alleviate these issues, we plan to conduct more intensive case studies.

Observing a sequence of brokering situations in time, we were able to show the *process* of requirements elicitation's progress or deterioration in time. We therefore plan to further explore the use of process models and process theory.

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