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STAKEHOLDER EXPERIENCES WITH CONCEPTUAL MODELING: AN EMPIRICAL INVESTIGATION

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Abstract

During the design of an information system, a significant task that is sometimes undertaken is conceptual modeling. It involves designers building a representation called a *conceptual schema* that captures application domain features to be included in the information system.

For five reasons, conceptual modeling has become increasingly important: (1) conceptual schemas help clarify different assumptions that stakeholders hold about the domain being modeled; (2) integrating conceptual schemas is critical to organizations effectively re-engineering their business processes; (3) the quality of conceptual schemas affects the quality of database schemas that can be generated automatically; (4) the quality of conceptual schemas affects the usability of databases; and (5) stakeholders working with distributed, heterogeneous databases cannot effectively transcend boundaries without high-quality conceptual schemas.

While researchers have expended substantial effort on developing conceptual modeling methodologies, little empirical work has been done on stakeholder experiences with conceptual modeling. The meager results obtained suggest that organizations have found few benefits from conceptual modeling and that often it has fallen into disuse. Laboratory work indicates, however, that improved design outcomes occur when conceptual modeling is undertaken.

For two reasons, we expect that stakeholders will experience problems with using conceptual modeling in practice. First, we believe that many designers approach conceptual modeling with a functionalist view of the world. We believe that a social relativist view more accurately describes how stakeholders conceive the world. Second, many conceptual modeling tools provide only incomplete representations of the application domain to be modeled.

We are currently undertaking case-study research to document the conceptual modeling practices engaged in by a large public-sector organization. We are also seeking to identify the problems that stakeholders experience when they participate in conceptual modeling exercises. Our goal is to provide a taxonomy of problems that the stakeholders face and ultimately to develop theory to account for why these problems occur.

Keywords: Conceptual modeling, functionalism, social relativism, ontology, case study research, interpretivism, positivism, ethnography.

1. RESEARCH OBJECTIVES AND QUESTIONS

During the design of an information system, a significant task that is sometimes undertaken is conceptual modeling (Batini, Ceri and Navathe 1992). It involves designers working with users to elicit and to build a representation called a *conceptual schema* that captures those features of the application domain to be included in the information system.

For *five* reasons, the task of conceptual modeling (building conceptual schemas) has become increasingly important:

1. We are now more aware that users often hold diverse, unstated assumptions about phenomena in the application domain that undermine the likelihood of designers developing and implementing successful information systems (Hirschheim and Klein 1989). Conceptual schemas provide an important means of eliciting different views, providing a basis for informed discourse, and enabling reconciliation and compromise (Hirschheim, Klein and Lyytinen 1995).
2. Integrating multiple conceptual schemas (sometimes called “view” integration) (Batini, Lenzerini and Navathe 1986) has become more important as organizations reengineer their business processes (Hammer and Champy 1993). To provide high levels of customer service via, say, processes that implement case management strategies (Davenport and Nohria 1994), employees often need to access data residing in multiple application domains.
3. Automatically generating database schemas from conceptual schemas is occurring more frequently (Ferrara and Batini 1984). The quality of the conceptual schemas developed at the outset significantly affects the quality of the database schemas ultimately created.
4. Research has now shown that the quality of conceptual schemas impacts the usability of databases. For example, poor conceptual schemas undermine users’ ability to interrogate databases (Papazoglou 1995).
5. The quality of the conceptual schemas in distributed, heterogeneous database environments impacts users’ ability to transcend the boundaries of different databases. If the semantics of one database environment cannot be translated into those of another, users must work within a local environment or risk erroneous interactions with foreign databases (Lee and Siegel 1994).

Despite the importance of conceptual modeling, only meager empirical research has been undertaken. For example, little is known about the strengths and weaknesses of the many conceptual modeling methodologies that have been proposed nor the nature of those conceptual modeling activities in which practitioners engage. Batra and Marakas (1995) point out that laboratory studies suggest better design outcomes arise when stakeholders engage in conceptual modeling. Nonetheless, the few field studies undertaken show that (1) organizations have obtained little benefit from conceptual modeling and (2) often conceptual modeling has fallen into disuse. Batra and Marakas criticize researchers for undertaking too much work on methodologies and too little work on practitioner experiences and needs.

In the research in progress we describe here, we seek to understand the nature of the conceptual modeling practices in which organizations engage. Our objectives are twofold. First, in a limited number of organizations, we wish to determine whether conceptual modeling practices are even undertaken and, if so, what types occur. Second, we seek to construct a taxonomy of the difficulties that stakeholders encounter when they undertake conceptual modeling. By better understanding these problems, we ultimately hope to build a theory to account for them and to develop strategies to mitigate their effects.

2. THEORETICAL FOUNDATIONS

Our research relies in part on interpretive research methods (Walsham 1995). We seek to understand and document conceptual modeling practices from the viewpoints of the stakeholders who engage in them. Thus, our research is not theory-driven in a positivistic sense. Rather, we seek to lay foundations for subsequent theory building.

Nonetheless, two bodies of theoretical work motivate our beliefs that stakeholders will encounter significant problems when they engage in conceptual modeling. The first is based on the work of Hirschheim, Klein and Lyytinen. These researchers argue that current (conceptual) modeling methods are rooted in two paradigms. The first is the functionalist paradigm, which posits an independent, objective reality. Knowledge about this reality can be obtained through “appropriate” scientific inquiry. The second is the social relativist paradigm, which posits that an individual’s reality is socially constructed. Knowledge about this reality must be obtained through interpretive methods. Most conceptual modeling methods are founded on a functionalist paradigm. Thus, Hirschheim, Klein and Lyytinen argue their use is likely to be problematical because social relativism better reflects how stakeholders perceive the world.

Our own view is that conceptual modeling practices inherently are neither tied to functionalist nor social relativist assumptions. We believe, however, that most designers have been inculcated with a functionalist philosophy. Moreover, like Hirschheim, Klein and Lyytinen, we believe social relativism provides a “better” account of how stakeholders view their worlds. Thus, designers who seek a single, objective reality using “appropriate” methods are likely to encounter substantial difficulties in their interactions with stakeholders. The reality that conceptual models ultimately represent must be a *negotiated* reality. Disagreement, discourse, and discernment are messy but important steps toward reaching good designs.

The second body of theory that drives our research is based upon Wand and Weber’s work (see, e.g., Weber 1997). These two researchers have sought to articulate the ontological foundations that underlie conceptual modeling. One objective they have is to identify fundamental classes of (socially constructed) real-world phenomena that conceptual modeling tools must be able to represent. In this regard, they have evaluated several widely used tools (e.g., entity-relationship models). Based on these evaluations, they have identified four deficiencies:

1. *Ontological incompleteness* occurs when a tool cannot represent some fundamental class of real-world phenomena (e.g., events).
2. *Construct overload* occurs when a single construct in a tool is used to represent two or more fundamental classes of real-world phenomena.
3. *Construct redundancy* occurs when two or more constructs in a tool can be used to represent a single fundamental class of real-world phenomena.
4. *Construct excess* occurs when a construct in a tool does not map to any fundamental class of real-world phenomena.

Whenever a tool exhibits these deficiencies, Wand and Weber hypothesize that stakeholders’ understanding of an application domain’s semantics will be undermined. In our empirical work, therefore, we expect to see these deficiencies manifested when stakeholders use conceptual modeling tools. Indeed, the four deficiencies provide an initial taxonomy for some problems we expect to see stakeholders encounter. Nonetheless, we also anticipate other types of problems will be evident. Thus, Wand and Weber’s classification provides only a preliminary, partial basis for constructing our taxonomy of conceptual modeling problems.

3. RESEARCH METHODOLOGY

Our research methodology has two phases. During the first phase, which is now complete, we sought out large public-sector organizations that have experience with conceptual modeling. Our motivations for focusing on public-sector organizations were the following: (1) they are more likely to have experience in substantive conceptual modeling exercises than private-sector organizations in the city in which we reside and (2) we have contacts in these organizations who are more likely to provide the substantial assistance we need with the second phase of our research.

Our goal during the first phase of the research was twofold: (1) to clarify the research approach to use in the second phase of our research and (2) to obtain one site that was willing to participate in the second phase of our research. During the first phase, we interviewed stakeholders and participated as passive observers in some of their meetings.

The second phase of our research, which has just commenced, involves our undertaking a case study of some conceptual modeling exercises to be completed during the development of a large, complex information system in a major public-sector organization. We have chosen a case-study approach because our work is exploratory (Benbasat, Goldstein and Mead 1987). Moreover, to facilitate our theory building efforts, we believe we must now move beyond the “thin,” artificial phenomena that characterize the experimental settings that primarily have been used so far to study conceptual modeling practices (e.g., Weber 1996) to the rich, natural phenomena that characterize organizational settings.

Our unit of analysis is the individual stakeholder who participates in a conceptual modeling exercise. We are interested in each stakeholder’s perceptions of the problems they have encountered during the conceptual modeling work. In addition, we are interested in identifying practices and behaviors that we predict will be problematical (perhaps unbeknown to the stakeholders).

We are focusing on a single system within one organization because pragmatically we have no other choice. After some 18 months of negotiating with potential case-study sites, only one organization has agreed to allow us to proceed with the research, and they have restricted our work to a single system. Nonetheless, we believe the system will provide sufficiently rich data to enable us to accomplish our research objectives.

We will use three data gathering techniques. First, we will conduct interviews with the stakeholders in the system. Where possible, we will tape record the interviews and then prepare typed transcripts. Whenever we are not permitted to record an interview, we will keep extensive interview notes. Second, we will act as passive observers during meetings between the stakeholders. Again, we will either tape record the meetings if permitted and prepare typed transcripts or keep extensive interview notes. Third, we will analyze documentation prepared by stakeholders during conceptual modeling activities.

Our case data analysis techniques will combine ethnographic, interpretivistic, and positivistic methods (Cavaye 1996; Lee 1989). On the one hand, in the spirit of ethnographic research, we are seeking to understand how the stakeholders in the system assign meaning to the problems they encounter during conceptual modeling activities. We want them to describe their reality as opposed to our own. Our role will be to try to identify and to organize common themes in their descriptions. On the other hand, we are seeking evidence to either support or refute predictions made by Hirschheim, Klein and Lyytinen and by Wand and Weber (e.g., Wand and Weber 1993). For example, we will look for communication breakdowns that seemingly have occurred because (1) stakeholders have different socially constructed realities or (2) the tools stakeholders are using manifest ontological incompleteness, construct overload, construct redundancy, or construct excess. The pursuit of these goals will provide some structure to our data gathering methods. Moreover, to address internal validity concerns, we will also seek to identify other factors that may be an important source of breakdown. For example, the characteristics of the domain being modeled (e.g., complexity) may affect the likelihood of breakdown, and certain phenomena within the domain (e.g., processes) may be more susceptible to modeling breakdown than others (e.g., constraints).

4. CURRENT STATUS OF THE PROJECT

As we indicated above, the first phase of our research is now finished. We completed eight interviews in six organizations. In addition, we participated as passive observers in three meetings of stakeholders in a conceptual modeling exercise that one organization was undertaking.

In brief, our *preliminary* findings to date are eightfold. First, conceptual modeling has been used only spasmodically in the organizations we studied. The reaction to the benefits of conceptual modeling is mixed. As a result, designers were given some latitude in choosing whether to use conceptual modeling in their system development work.

Second, our participants report unilaterally that conceptual modeling is a difficult, complex task. Users indicate they have problems understanding the conceptual modeling work that designers undertake and the meaning of the conceptual models that designers prepare. Designers indicate they encounter difficulties in getting users to clearly articulate the semantics of the domain to be modeled.

Third, in those organizations where enterprise modeling had been attempted, the designers we interviewed reported unilaterally that it was a failure. They had struggled to obtain a consensus view on how their organizations should be modeled. Moreover, they felt the models they had prepared were so abstract as to be virtually useless. In addition, little use had subsequently been made of the enterprise models they had developed.

Fourth, some conceptual models we were shown were appalling. Even though the designers were well trained and experienced, the conceptual models reflected that they lacked a deep understanding of how to model and represent application domains. They also lacked a deep understanding of the conceptual modeling tools (e.g., entity-relationship model) they were using and, in particular, the strengths and weaknesses of these tools. Our assessment is not a condemnation of the designers' capabilities. Rather, it reflects the poor state of the theoretical foundations that underlie conceptual modeling.

Fifth, we found that small "breakdowns" in conceptual modeling quickly undermined stakeholder confidence in the value of conceptual modeling. For example, if it was unclear how some aspect of the application domain should be represented using the entity-relationship model, users quickly lost confidence in the value of the model.

Sixth, those conceptual models that were developed were then poorly maintained. The designers we interviewed suspected that (1) maintenance personnel had difficulties understanding conceptual models that were prepared by others and/or (2) they saw little value to updating conceptual models to support their maintenance work.

Seventh, the designers disagreed about whether conceptual modeling work could proceed independently of data modeling work. Some argued they should *not* consider constraints imposed by the need to eventually map a conceptual model to a data model. Others argued that ignoring the target data model resulted in their having to undertake too much rework when the mapping eventually was done.

Eighth, the designers reported that conceptual modeling was less likely to be undertaken whenever their organizations used packages to implement application systems. They equivocated about the value of conceptual modeling in these circumstances. Some argued that conceptual models were still important when packages were used. Others argued they had little or no value.

In the second phase of our research, we have undertaken one interview and participated as passive observers in one stakeholder meeting. Depending on the time it takes for our results to converge, we will continue our data gathering over the next six to twelve months.

5. CONFERENCE PRESENTATION

At the Conference, we will present the results from the first phase of our research. In addition, we will have completed a fair number of the interviews, participant observations, and documentation reviews that are to be undertaken in the second phase of our research. Even though our data gathering will still be incomplete, we believe our major results will be clear. During the Conference presentation, we will present these results with a view to getting feedback from the Conference participants.

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