Towards a Framework for
Collaborative Modeling and Simulation

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Abstract

We identify four methodologies that need to be present for modeling and simulation in a collaborative analysis or design project. The first of the four, methodology M1, refers to how participants perceive their problem situation and create static, or descriptive models. This paper describes the requirements for a successful methodology M1. It then describes Conversational Modeling (CM), a software-supported technique for collaborative modeling, and makes an argument for why CM fulfills those requirements. Finally it describes a case study in which CM enabled participants to construct static knowledge models in collaborative sessions.

Four methodologies in collaborative modeling

The analysis and design of a work system by a collaborative design team using modeling tools can be described as a *holon*[1] in terms of Soft Systems Methodology [1].

Characterizing modeling as a holon is a way of looking at the whole modeling effort as a systemic process. Figure 1 shows that this modeling process is not as simple as having one methodology for modeling, but in fact there is an interplay of four

methodologies (M1 through M4) that together define a modeling methodology as a whole. Each methodology defines a purposeful activity system, which itself can be seen as a holon.

Methodology M1 — A methodology for perceiving a system and constructing static models

A design team needs to have a principled and structured methodology for the process of understanding the problem situation or system as it exists. We describe this methodology, M1, more completely below.

Methodology M2 — A methodology for participatory design of simulation models

Methodology M2 describes the process by which formal system modelers co-develop a simulation model of a system with the design team members.

Methodology M3 — A methodology for implementing, debugging, and validating a simulation model

Methodology M3 is very tool-specific, and is focused on the creation and validation of dynamic simulation models. As part of this methodology there are two issues at hand:

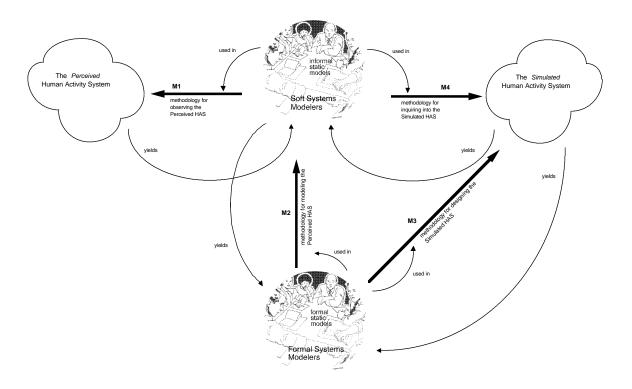[1] "The abstract idea of a whole having emergent properties."

Figure 1: Collaborative modeling as a Soft Systems holon

- An understanding of how to build useful and effective simulation models.

- A need for development tools and techniques for the *model-builder* as a user of a simulation tool.

Methodology M4 - A methodology for inquiry into a simulation

Methodology M4 refers to a consistent way for the *end-user* of a simulation to use simulation results to enhance the understanding of the problem or system under investigation.

Requirements for a successful Methodology M1

Modeling reduces complexity by creating categorization and order through which people can create meaning, in order to get a shared understanding, which allows them to communicate (see fig. 2).

There are five aspects that need to be addressed in any implementation of methodology M1:

- **Create meaning**: Verbal language is often not enough to share meaning with others. Modeling is a tool to create shared meaning through external conceptualization ("a picture says a thousand words". A methodology M1 needs to include a modeling technique for creating external representations that reflect meaning created by the participants.

- **Shared understanding**: The external conceptualization (i.e. the model) allows a group to share the creation of meaning. Through a scaffolding process between the members, a shared understanding will emerge [2]. A methodology M1 will need to include tools and techniques that mediate and nurture this scaffolding process.

- **Create structure**: Structure is an important aspect in the creation of meaning and shared understanding. A methodology M1 needs a framework that can be used as a guideline in the
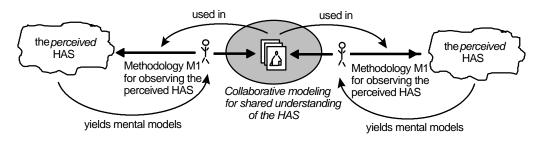
Collaborative Modeling Framework

Figure 2: Shared understanding through modeling

modeling process. Such a framework helps in creating a domain ontology that is consistent and understandable.

- **Communication**: A shared domain ontology (i.e. the model) allows people to talk about the domain without ambiguity and confusion. A methodology M1 needs a technique for modeling in such a way that it can be used in conversation.

- **Reduce complexity**: Very often complexity is a result of existing ambiguity. Modeling helps to solve ambiguity and, therefore, reduce complexity. A methodology M1 needs to include a modeling method that will reduce the complexity of the problem situation. With that we mean that applying the method will reduce the complexity of the situation.

Conversational Modeling — a candidate for methodology M1

In this section we briefly describe the Conversational Modeling methodology (CM), which has been described in more detail in [3]. CM consists of three equally important parts: a modeling framework, a collaborative modeling tool, and a facilitation approach.

World Modeling — a structured modeling framework

World Modeling is a structured domain modeling framework with its roots in CommonKADS and structured systems analysis methodologies [4, 5].

World Modeling prescribes eight orthogonal modeling aspects, and one distribution aspect (dependencies between the eight other aspects) that are important for any type of system. The analysis of these nine aspects are defined as separate modeling activities. The nine activities are:

Activity	**Model**
Modeling the functional aspects of the system	**process** or **task/activity model**
Modeling the data in the system	**object** or **data model**
Modeling the needed knowledge in the system	**knowledge model**
Modeling the time aspect of the system	**timing model**
Modeling the formal- and informal organizational roles of the system	**organization model**
Modeling the individuals and needed artifacts in the system	**resource model**
Modeling the person-person and person-machine communication in the system	**communication model**

Activity	Model
Modeling the geographical location of the resources in the system	**geography model**
Modeling the relations between all aspects of the system	**distribution model**

Table 1: Modeling activities for World Modeling

Collaborative modeling software

In its current form, Conversational Modeling uses and extends the hypermedia aspects of QuestMap[2], a commercially available software tool. QuestMap was built around the concept of IBIS argumentation, which it supports through icon nodes, rhetorical link types, and hypermedia functionality. CM adds modeling templates, a node coding and labeling schema, and specialized hyperlinking strategies, as well as software bridges to other tools, such as document processors. CMs hypermedia functionality is described in [6].

Facilitation and modeling support of the design team

CMs facilitation approach combines three aspects. The first is modeling facilitation, which guides design team members in collaborative construction, elaboration, and validation of models using the software tool. Facilitators also pay special attention to the capturing and display of informal, or conversational, insights and discussions, and assist team members in linking and managing these ideas. The second aspect is IBIS facilitation, which assists the team in surfacing assumptions and representing design rationale as argumentation [7]. Finally, CM facilitators pay attention to group process and the emotional climate of CM sessions, using the modeling approach as part of their toolkit to help surface and bridge communication problems and gaps.

[2] QuestMap™ is a trademark of Corporate Memory Systems, Inc.

Conversational Modeling as a successful methodology M1

From our experience in using CM in different modeling efforts in NYNEX we have come to realize that CMs three components —modeling framework, modeling tool, and facilitation —together cover the five required aspects of methodology M1.

The World Modeling framework creates the needed *structural support* to the modeling of the problem situation, and as such *reduces the complexity* of a modeling effort.

The collaborative modeling software, in part because of its conversational IBIS structure, helps in enhancing *communication* between the participants. Because the participants create models in their own language it helps them to have *shared meaning and understanding* through the creation of models. By providing visual representations and enabling management of large amounts of modeled information, it also provides *structural support* and *reduction of complexity.*

We have found that good facilitation is as necessary as having a modeling framework and modeling tools. Group process and IBIS facilitation help the group with the ability to *communicate* about the models. Good modeling facilitation enhances the ability of the group to create *shared meaning and understanding* of the problem situation.

The Resource Center project - a case study

The Resource Center project was a recent application of Conversational Modeling. The project comprised three sessions in which participants needed to develop initial requirements for a proposed system that would provide a single toll-free number for employee queries. The work center which would answer calls to the toll-free number will be known as the Resource Center. The immediate task of the modeling sessions was to identify which queries could be handled by front-line "generalists" and which required the deeper knowledge of subject matter experts (SMEs).

Goals for the Project

The sessions were commissioned by the organization responsible for development of the technology for the Resource Center, who were not themselves deeply knowledgeable about most of the subject matter areas. The development organization needed to gain a deep, situated understanding of the subject matter in as little time as possible, in order for them to develop detailed system and work process requirements, as well as designing implementation plans for the new work centers. Ideally, the gaining of that understanding would be in a form that would translate to requirements documents and implementation plans.

Participants

Most participants in the sessions were SMEs from the various disciplines. Each SME represented a sub-discipline, such as Personnel Policies and Practices, Compensation, or Employment. The SMEs were long-time employees who had deep experience of their sub-disciplines, though not necessarily deep knowledge of each other's work. Due to the high-pressure nature of their jobs, they rarely had opportunities to share experiences or knowledge. Other participants in the sessions included representatives from the development organization.

Structure

The sessions each began with the two CM facilitators providing a brief overview of the goals, structure, and techniques to be used in the session. Participants then brainstormed, coming up with lists of queries that they currently handled, ranging from frequently asked questions to complex inquiries. As they spoke, their ideas were captured and displayed using the collaborative modeling software (Figure 3). The software was running on a laptop computer and projected on a large screen in front of the room, so that all the participants could see how their words were being interpreted and transcribed. In this portion of the sessions, one of the two CM facilitators worked the software, while the other did most of the verbal interaction with the participants. The facilitators kept the tone light, frequently injecting humor, in order to encourage participants to relax and speak freely. They also occasionally requested the participants to direct

their attention to the screen in order to ensure that their words were being captured accurately.
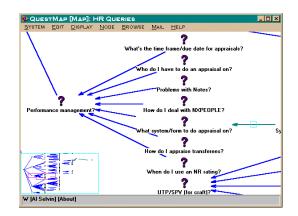

Figure 3: Query brainstorming

In the second part of the session, the facilitators guided participants in characterizing each of the queries from the brainstorm as either a "generalist" or "SME" query. For this section, the participants naturally focused their attention on the screen, since the facilitators used the tool to direct their attention to each of the queries and to the code designating each query's characterization. This activity generated a good deal of engaged conversation among the participants as to the characterizations themselves as well as aspects of the particular queries under review. The facilitators captured and added some of this conversation to the representation.

The third part of the session focused on building initial models of selected queries, following the World Modeling framework. Participants chose queries that seemed interesting and worked with each other and the facilitators to answer questions about the information (data), reference material (resource), knowledge, and system access (resource) required to handle the query. In addition, the participants identified caller characteristics (communication) and other issues that could affect handling of a query of that type.
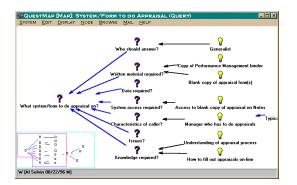
Figure 4: Portion of a model

In keeping with the facilitation approach of Conversational Modeling, participants were encouraged to speak freely and spontaneously, without needing to conform their ideas to particular terms or concepts. The facilitators elicited model content in such a way that the participants were able to provide substantive content and share ideas freely in relatively brief periods of time (each session lasted less than three hours in its entirety). At the conclusion of the sessions, the facilitators used the software tool to generate documents to be used in formal requirements specification as well as training for the new center.

Results

The sessions resulted in the identification of 207 queries, of which about half were characterized as generalist and half as SME. Of these, 24 were chosen for detailed modeling. As a result of the modeling, 44 resources, 29 knowledge items, 58 data items, and 8 organizational issues were identified.

The response from participants was positive. Many stated that they had learned more about each others' work in the CM sessions then they had been able to in the course of their normal work activities. The development organization has been able to use the output of the sessions to generate design requirements. In addition, output from the sessions will be used to train generalists in how to handle many of the queries that will come into the new center.

Discussion

CM proved to be an effective methodology M1 in this instance because it fulfilled all the requirements. The participants created meaning by fostering many kinds of insight into the need for, conception of, and requirements for the new Resource Center. The participants developed a much deeper shared understanding of their work and gained new language for characterizing their activities and artifacts. They were able to communicate effectively about organizational and technical issues. Finally, the sessions reduced the complexity of representing an entire knowledge domain in the form of characterized queries, and created structures that were useful both at the time of the sessions and for later work (such as requirements development and training).

Conclusion

In this paper, we have described a framework for characterizing collaborative modeling and simulation efforts. The framework comprises four methodologies which together provide a technique-independent way to assist in the identification of effective strategies and evaluation mechanisms for any modeling technique.

We then provide an example of how a particular technique (Conversational Modeling) appears to embody the characteristics of an effective methodology M1. We believe that any methodology that is used as a successful methodology M1 needs to have three components ~~modeling~~ framework, modeling tool, and facilitation ~~in~~ order to cover all five required aspects of methodology M1.

As we continue to develop and apply Conversational Modeling and other approaches, we will continue to use the four methodologies of the collaborative modeling and simulation framework to help us improve the relevance and effectiveness of modeling in the design of solutions to problem situations.

Future directions

As we develop and apply Conversational Modeling and other approaches, we will continue to use the four methodologies of the collaborative modeling and simulation framework to help us improve the relevance and effectiveness of our modeling efforts.

Further research will be done to apply and understand the use of Conversational Modeling as an instance of methodology M2, in addition to methodology M1, in order to bridge the gap between the development of informal static models and formal simulation models. We will also conduct further research in defining appropriate tools and techniques for the methodologies M3 and M4. In addition to this, we will apply our experiences to date to explore the use of Conversational Modeling for distributed collaboration over computer networks.

Citations

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