Introduction

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Abstract: This paper gives an overview of the recent field of collaborative modelling. We first address the dimensions of group productivity, model quality and consensus. We then explore the factors on individual and team level that have significant impact on group productivity. We continue with an overview of the most relevant streams of collaborative modelling research, and conclude with a short outline of the papers in this special issue.

Keywords: collaborative modelling; participative modelling; group modelling; individual factors; team factors; group productivity; model quality; consensus.

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1 Introduction

This paper gives an overview of the recent field of collaborative modelling. We put the focus on the process of modelling and especially the way that a modelling session proceeds. While the search for a complete understanding of the modelling process is far from over, we have made substantial progress on the way and the current special issue gives evidence of this fact.

Classical research on the modelling process stressed the importance of a modelling methodology: a recipe developed by experts that practitioners must follow to the point to ensure optimal results, i.e., models of high quality. But practice rarely follows these methods for a number of good reasons. They are too complex and not adaptable to the context in which they are applied. Method engineering is proposed as an answer to at least the latter issue but building a new method for each modelling project is not feasible in many cases either.

Under the heading of 'collaborative modelling' researchers have therefore gathered to turn the tables and study modelling descriptively instead of prescriptively: what does actually happen when people get together to model? And how can we support them in their activities?

In order to understand the modelling process we need to understand what the outputs or products of this process are and which process factors determine them. Again, classical research on modelling is often limited in viewing model quality as the major or even only output. Countless publications on model quality speak for themselves. We owe it to the collaborative modelling community that another output of at least the same relevance has been put on the agenda: the group's consensus on the model. Section 2 deals with both kinds of products.

The second issue, the factors determining the outputs, is studied in Section 3. This is done both from the perspective of an individual group member and the perspective of the team. We also discuss the role of the facilitator here.

In Section 4, we continue with a survey of the most relevant streams of collaborative modelling research. They are group modelling, participative enterprise modelling (PEM) and collaborative modelling architecture (COMA).

We conclude the editorial with a short outline of the papers in this special issue (Section 5).

2 Group productivity in collaborative modelling

The importance of determining and controlling the success of process modelling, or more precisely group productivity, has been widely recognised (Dennis et al., 2003; Lu and Sadiq, 2007; Luo and Tung, 1999; Recker et al., 2009; Rosemann, 2006; Sedera et al., 2004). The majority of this literature considers model quality as the major aspect of group productivity (see Section 2.1). We argue that group consensus is, though largely neglected, at least equally relevant (see Section 2.2).

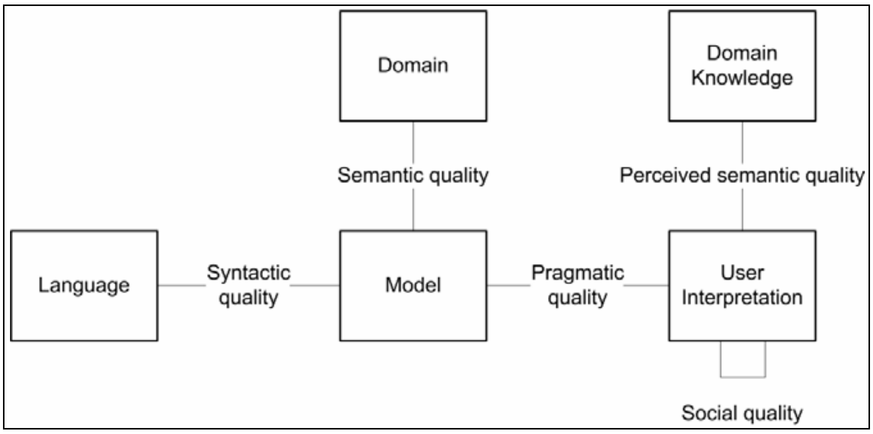
2.1 Model quality in collaborative modelling

Prevalent productivity measures primarily involve some form of model quality measure (Dean et al., 1994c; Mendling and Recker, 2007; Moody et al., 2003; Sánchez-González et al., 2010). When choosing a quality framework it makes sense to ensure that it is firmly rooted in an established and relevant theory. On the one hand, this provides the framework with a certain level of generality and makes sure that all the pertinent quality dimensions are covered. On the other hand it also contributes to the validity of the framework if the theory has already withstood a number of falsification attempts. As models are primarily signs, and are in turn made of signs (the model elements), it seems natural to base a model quality framework on semiotic theory.

But as pointed out in Moody (2005) many theory-based frameworks are not empirically tested. Out of the more than 50 approaches he studied only six are empirically validated. Only one of them is based on semiotic theory and covers conceptual models in general: Lindland et al. (which we will henceforth call Lindland and Krogstie after the major drivers behind that approach).

The basic ideas of this approach are described in Krogstie (2001), Krogstie and Jørgensen (2002), Krogstie et al. (1995) and Lindland et al. (1994). They started with a simple semiotic model involving model, language, domain and user interpretation. This was later extended to cater for the difficulties in accessing semantic quality directly. The new model is shown in Figure 1.

Figure 1 Conceptual modelling quality framework by Lindland and Krogstie



It distinguishes five quality dimensions: syntactic, semantic, perceived semantic, pragmatic and social quality. The model is written in a language, i.e., the modelling language. Syntactic quality refers to the extent to which the model observes the rules of the modelling language. Pragmatic quality is the degree to which the user's interpretation of the model coincides with the model's meaning. Social quality is defined as the agreement between the interpretations of different users. It is important because consensus building is one of the major goals in modelling.

The domain is the part of the real world that we aim to describe in the model and semantic quality measures the extent to which the statements in the model are correct and complete with respect to this world. Assessing semantic quality is practically impossible because access to the domain is filtered by our perceptions. We can only access our knowledge about the domain that is a product of these perceptions; domain knowledge is individual and subjective and does not fully and accurately reflect 'the domain' as individual perceptions differ. The term domain is therefore rather an abstract notion that refers to the collective domain knowledge of a set of individuals.

Because semantic quality cannot be measured directly it is common practice to use perceived semantic quality as a proxy (Fabbrini et al., 1998; Krogstie, 2002; Matulevicius, 2005; Poels et al., 2005; Schuette, 1999; Siau and Tan, 2005; Su and Ilebrekke, 2005). It measures the degree to which the user's interpretation of the model agrees with his or her knowledge of the domain.

As mentioned above the framework by Lindland and Krogstie is firmly rooted in semiotic theory and can therefore claim theoretic validity. But the framework has also been tested empirically in laboratory experiments (Moody et al., 2002, 2003). Together with the grounding in semiotic theory this makes it a reliable basis for a quality measurement instrument.

But the Lindland and Krogstie framework only specifies the relevant dimensions. It does not provide an indication as to how these quality dimensions should be measured. (Rittgen, 2010b) takes up this issue.

2.2 Consensus in collaborative modelling

While it is undisputed that model quality is relevant to success it is not the only and perhaps not even the most important success factor. The reason for this is twofold: the process model itself is a social construction, and its purpose is again to support some social process, e.g., a change project or system development project. In other words: the model documents the results of one social process (modelling) and serves as a point of departure for another one.

The results that are documented in the model are primarily the mutual knowledge that has been developed in the modelling session, the conflicts that had to be solved on the way, and the consensus that has been achieved among the group members as a result. It is precisely this consensus that is a prerequisite for people's commitment to the ensuing change project, for example. Often a poor model with high consensus goes further than a good model with little consensus. Hence, consensus is a major result that needs to be achieved in business process modelling sessions much like in many other forms of group work.

But while there is considerable research on consensus in other areas (DeStephen and Hirokawa, 1988; Priem, 1990; Yoo and Alavi, 2001) the topic received little attention in business process modelling with researchers barely mentioning the issue (Clegg, 2007; Decker et al., 2005; Kumarapeli et al., 2007; Rittgen, 2010b) and, to the best of our knowledge, not researching it in a systematic way, let alone measuring consensus. A first attempt at such a measure is made in Rittgen (2011a).

3 Factors in collaborative modelling

3.1 Individual factors in collaborative modelling

The impact of *competition* and cooperation on group productivity was addressed comprehensively for the first time in the theory of cooperation and competition (Deutsch, 1949). Deutsch found that groups perform better when their members cooperate instead of competing. But interestingly his so-called cooperative mode, where members are equally rewarded for group success, also bears distinct elements of competition: the group had to beat other groups to be successful.

Hammond and Goldman (1961) discovered that it is precisely the combination of intra-group cooperation and inter-group competition that leads to highest group productivity. The competition with other groups raises the group members' desire for achieving the group goal, and the cooperation with other group members helps them achieve it.

This can be achieved by dividing a group into modelling teams. Each team cooperates on the creation of a model proposal but only one team's model will eventually be selected for further development. Competitive-cooperative modelling sessions outperform purely cooperative groups in terms of group productivity as measured by social quality of the model (Rittgen, 2011b).

In the competitive-cooperative modelling scenario, we introduce a scoring of each model proposal by the other participants. After the complete scoring round the facilitator shows the whole group the average scores of all proposals as bars of different sizes and numbers. This is an exciting moment for participants as they get to know their own scores and how they relate to the others.

Being judged by their own peers (often colleagues) is a strong incentive to put as much effort into the modelling as possible and that is precisely what we want to achieve: the best possible effort by all group members. Nobody can hide behind more active group members. Competition thereby introduces a group-centric individual goal beyond the group goal of creating the overall model, which facilitates group productivity (Crown and Rosse, 1995).

The result of the scoring round, which usually takes ten minutes, is not only a winner but also a winning model. This is the basis for all further development as the highest overall score clearly indicates that this model has the strongest support and therefore the best chance of creating consensus. It cannot be taken as the final version, though, as some details might still be missing or misrepresented, in particular views represented in the discarded models. This needs to be settled in a consolidation step.

While competition can be assumed to increase motivation a participant's basic motivation is driven by the desire to achieve the group goal. This desire for goal (or *goal commitment*) is considered highly relevant in many studies of group performance (Klein and Mulvey, 1995; O'Leary-Kelly et al., 1994; Weingart, 2006) and is also present in cognitive theories such as focus theory (see Section 5.5). Goal commitment can be measured, e.g., according to Hollenbeck et al. (1989) with the four-indicator measure.

Much has been said about the elusiveness of motivational gains in group work (see Karau et al., 2000) for an overview and (Hertel et al., 2003) for a discussion on computer support) and the collective effort model has often been used to explain such gains (Karau and Williams, 1993). According to this model *individual motivation* will be high if group members perceive their own contribution to the group work as instrumental in reaching the group goal.

A fundamental problem with collaborative modelling is the fact that participants of such an exercise have no intrinsic motivation for the result itself. Most people are not interested in the model and do not see a need for it. But extrinsic motivation implies the risk of shirking (i.e., underperforming when not noticed). Consequently intrinsic motivation seems more promising, but instead of on the model we have to focus on the modelling process. Motivation for modelling is therefore a key factor.

Individual motivation can be measured, e.g., using the interest/enjoyment sub-scale of the intrinsic motivation inventory (IMI) measure that was introduced in Deci and Ryan (1985). It is based on self-determination theory (Ryan and Deci, 2000) and has been validated in McAuley et al. (1989).

Another important factor is the *degree of participation*. It indicates the relative number of group members that are actually active in a session. A higher degree raises model quality by making models richer but lowers consensus by adding views.

The former means that a higher degree of participation yields more proposals which leads to more contributions to the group model and hence a more complete model. This makes it more likely that group members agree with it as they can find their view in the integrated model. As a result group productivity will increase following this line of reasoning.

But on the other hand a higher degree of participation has a negative impact as other proponents might also introduce elements in the model that, in some individuals' opinion, do not make the model more complete but rather obfuscate it. In this case, the overall agreement decreases and with it group productivity according to that line of reasoning.

Focus theory by Briggs (1994) assumes that *individual effort* can be on communication, deliberation, and information access, but not at the same time. Productivity in one area therefore limits the effort that can be spent on the others. The overall productivity of an individual depends on high productivity in all three areas which constitutes a kind of a vicious circle.

3.2 Team factors in collaborative modelling

To structure work within modelling sessions one usually splits the whole group into smaller teams. The factors that control group productivity on the team level are medium, team size and team composition.

Media that are typically employed in these sessions are brown paper, a plastic board, a flip chart and sticky notes. Less frequently, computer tools are also used to support teamwork. The latter are somewhat controversial as early studies (e.g., Dean et al., 1994c) found a positive impact only for larger groups. But more recent studies involving more sophisticated tools suggest that even smaller groups can benefit from such support (Rittgen, 2010a).

The potential benefits of computer tools areanonymity, simultaneity, group memory, and group size (de Vreede, 1997). Anonymity means that the contributions cannot be attributed to a particular participant. Therefore, group members feel more comfortable in making statements that might be seen a controversial resulting in a richer discussion. Simultaneity implies that participants can give their input at the same time by-passing the usual air-time fragmentation.

The tool also serves as the memory of the group and can document the alternatives that were discussed and the reasoning behind the choice of an alternative. The impact of group size is discussed below under the heading 'team size'.

According to Rittgen (2012), adaptability is the major mediating factor explaining the greater involvement of participants in active model creation and hence greater group productivity in tool-supported sessions. This is because changes to intermediate versions of the model were easier to effect with the help of the tool, whereas changes on the brown paper required substantially more effort and often led to messy diagrams.

Understandability, richness and accuracy were mentioned as primary factors here. Higher involvement led to more understandable models and eventually to a proposal of higher quality.

Tools support also facilitates richer model proposals, i.e., proposals that contain a higher percentage of each team member's knowledge about the respective process. A rich proposal requires the use of the modelling language as a complex state of affairs is hard to articulate verbally. Proponents who rely on natural language therefore tend to make simpler suggestions that need to be aggregated by the team. Both the process of repeated natural-language statements and their compilation are error-prone and lead to lower proposal quality.

Tool support also improved the accuracy of proposals, i.e., the degree to which they conform to reality according to the perceptions of the team members. This is also due to the fact that verbal contributions are easily misinterpreted or misrepresented.

With respect to *team size*, Rittgen (2012) found that teams of two maximise model quality while teams of three lead to the highest consensus. The reasons for the impact of team size on model quality are individual effort, goal commitment and the absence of free-loading. Goal commitment is the main driver for individual effort, and a lack thereof is a reason for free-loading. Free-loading is the fact that less motivated people will shirk effort and leave the work to other team members.

In a larger group it is easier to free-load than in a smaller so this behaviour is seen primarily in three-person teams. Goal commitment decreases as team size increases. This is because members identify themselves more readily with a smaller team and its goals as group cohesion is greater there.

Taken together this means that the best proposals should come from a single person but knowledge added by other teams members compensates this so that the optimal team size is actually two, providing a good balance of team cohesion and diversity.

With respect to the impact of team size on consensus (Duggan and Thachenkary, 2003) summarises the most relevant factors: separation of idea generation and evaluation, enforced participation (no free-loading), absence of conformance pressure, and speedy convergence through, e.g., ranking or voting. Learning from others as a means to understand each other and reduce conflicts is also relevant here.

Learning from others is the major reason why larger teams perform better in terms of achieving consensus. If a group is divided into many small teams we arrive at a large number of different proposals and hence different views. With respect to group consensus small teams therefore perform badly. Team members learn little from each other and the conflict is just postponed to a later stage of modelling where it is harder to resolve.

On the other hand, if we divide a group into few larger teams we generate fewer but more consolidated proposals. In a larger team people learn more from each other and can therefore resolve many conflicts internally so that they do not surface to the group level. This is why a team size of three is optimal from the point of view of consensus.

Team composition refers to the team members' background. We distinguish matched and complementary teams. In matched teams the members have a similar background, e.g., they come from the same department. In complementary teams, they have different backgrounds.

The impact of team composition on consensus can be explained by the concept of early conflict resolution. The members of complementary teams come from different organisational units and are therefore likely to entertain different views on the process whereas in matched teams members are more likely to agree with each other. In a complementary team issues can therefore be discussed and potentially resolved much earlier, i.e., before the proposals are discussed in the whole group.

A conflict can be resolved more easily in a small team than in the larger group. The small team has a greater cohesion and is more focused on the problem as personal issues play a lesser role. Conflicts also tend to be more difficult to resolve in later stages of the modelling process when positions are more likely to have hardened. Complementary teams therefore perform better in terms of achieving group consensus (Rittgen, 2012).

3.3 Facilitation in collaborative modelling

Consensus building theory (Susskind, 2006) mentions that the facilitator has a significant impact on the collaboration output. He should therefore be professional and neutral. Professionalism can easily be ensured by hiring a consultant who does that work on a daily basis. But that does not automatically ensure that he is neutral, even if he has been recruited externally, i.e., not within the targeted organisation. *Facilitator bias* is always present because the facilitator has to translate the input from the participants into a process model. His perceptions will therefore influence the way in which the model is built.

With conventional techniques such as brown paper this can hardly be avoided as they leave the overall responsibility for the model to the facilitator who consequently plays a role that is too dominant. Reducing facilitator dominance can be achieved by *participant involvement* in model building. This also frees facilitator resources that to be used elsewhere and removes the facilitator bottleneck that prolongs modelling sessions. But according to conventional wisdom this is impossible because modelling requires a highly skilled modelling expert.

Our experience in the cases has shown the contrary to be true. Unskilled people can develop complex business process models after having played a modelling game for about an hour. These models are not always 100% perfect but they usually require very little re-working, mostly to fix poorly structured layouts.

From this we conclude that facilitation has to be seen from a different perspective: the facilitator should not elicit knowledge and transform it into a model, but he should rather support people in modelling themselves and help them with the *integration* of the different views. This approach was validated in, e.g., Rittgen (2010c).

4 Approaches to collaborative modelling

Modelling is an important design activity. Most design-oriented disciplines make use of some kind of model before building the actual artefact. Architects make blueprints; engineers develop technical drawings; artists do sketches; and so on. Models play an even greater role when the artefact increases in complexity. In software development, for example, there are several layers of models required: requirements, scenarios, architecture models, information models, process models, communication models, interaction models, prototypes, and finally the production code, which in turn is an input model for the next release round.

In this section we have compiled three approaches that take an explicit collaborative stance on modelling issues: group modelling, PEM and COMA.

4.1 Group modelling

In the '90s a group of researchers at the University of Arizona was convinced that the use of computer support would substantially improve group modelling (Dean et al., 1994b). They built three generations of group modelling support systems that were built on the existing of electronic meeting systems described above. They used the IDEF0 activity modelling language that describes a graph of activity nodes that are connected by ICOMs, i.e., definitions of inputs, controls, outputs and mechanisms. In spite of the graphical nature of the language the EMS-IDEF0 tool was essentially a collaborative text editor for model input. In the 3rd generation it was complemented by a graphical viewer that visualised the textual input 'online' on a separate (!) workstation. Manipulation of the graph itself was not possible, i.e., graph editing was not provided for. The approach was later extended to a graphical business process language in the collaborative distributed scenario and process analyser (Lee et al., 2001).

Its obvious technical limitations notwithstanding, the tool proved very successful. This success was partly due to the fact that the tool allowed for simultaneous editing of different model parts, which provided for parallelisation of the modelling effort that was especially beneficial for large groups and complex models. It should be noted though that only a few group members would actually work on the model at any time while the others would stand around the workstations and provide oral input. The tool is therefore not a fully collaborative tool where each participant would be equipped with computer support. We come back to this in Section 4.3.

An important part of the success can also be attributed to the fact that the tool gave instant feedback to the 'bystanders' who could immediately react to the visual display of the growing model by making comments and proposing changes. The impact of tool support on group modelling is dramatic according to Dean et al. (1994b). The tool allows for handling groups of twice the size that traditional techniques can handle (20 vs. 10). Individual efficiency increased by 85% in terms of activities, and group productivity went up by 251%. The time spent on modelling is decreased by almost 70%, making an EMS-supported project approximately three times faster than a traditional one (Dean et al., 1994a).

Quality has also increased in a number of measured dimensions but facilitation has an important influence here. Dean et al. (2000) developed a technique they call top-down integrated (TDI) approach, which goes some way in showing how the internal work of a group should be organised to leverage the benefits of tool support and to ensure high-quality models.

The lessons that Dean et al. have learned from their studies are also important lessons for collaborative business and information systems design. The fact that increasing model complexity warrants tool support is certainly applicable here as business and information systems are complex socio-technical systems. But the EMS-IDEF0 tool does not provide any support for the negotiation part of collaborative modelling. For full support of the group modelling process we therefore need to combine a group modelling system of EMS-type with a negotiation support system (see the respective section) in an adequate way. We elaborate on this issue in Section 4.3 takes up this issue.

4.2 Participative enterprise modelling

PEM focuses on the group process itself. It is based on a number of case studies, three of which are described in Stirna et al. (2007). An important aspect in PEM is the facilitation roles: process owner, facilitator, modelling expert, tool operator and domain expert. The authors have used two different scenarios for modelling sessions. In one the tool operator was supported by a computerised tool. The other roles were not supported by a computer system but they were able to see the current status of the model that was projected onto a screen. All interaction regarding changes to the model had to be channelled through the tool operator who consequently represented a bottleneck in the modelling process.

The second scenario involved a plastic wall that was used to attach post-it notes to it representing the nodes of the diagram. This allowed all participants to take an active role as everybody could go to the plastic wall and fix a note there to make a proposal regarding the model. It is interesting to note that this scenario resulted in models of higher quality than the ones produced with tool support. On the face of it, this seems to indicate that a simple plastic-wall support outperforms computer support.

But on closer inspection we can see a fundamental difference between the scenarios: The tool only supports the tool operator; the plastic wall supports all group members. A participant who wants to suggest something does not have to communicate her idea to somebody who then effects the change but can make it herself. The plastic wall is therefore rather a proof of the fact that active involvement of all participants is really the crucial point and that a computerised tool support should mimic the plastic wall in giving all group members direct computer access to make instantaneous proposals. But it should also provide features that go beyond the plastic wall to leverage other benefits of technology. The next section explores this issue.

4.3 Collaborative modelling architecture

The preceding sections have shown that is not enough to combine electronic meeting systems with modelling tools to support group modelling in an effective way. We also need negotiation support for the convergent part of modelling. But the lessons learned from participative modelling have shown us that this is still not enough. We must also make sure that all participants get actively involved to ensure that they embrace the result of the modelling process. A plastic wall makes it easy for group members to contribute and a collaborative modelling support system should allow for the same instead of just supporting the facilitator. The COMA (Rittgen, 2009) accomplishes that by studying interactions between group members during modelling from a social and pragmatic perspective. The result is an architecture for collaborative modelling comprising social norms, a negotiation pattern and core modelling activities.

The social norms within a modelling team are mainly made up of rules for determining whether a proposal is accepted or rejected. It has been observed that these rules do not have to be logical complements which allows for situations where a proposal can be neither rejected nor accepted but requires further convincing to decide one way or the other. A termination rule is applied occasionally to force a decision if a negotiation gets stuck, i.e., when there is no more changes in the individuals' convictions over an extended period of time. There are two types of rules:

- Rules of majority, where a certain number of group members has to support or oppose a proposal in order for the whole group to accept or reject it (e.g., more than half). A tie-break rule is sometimes specified (e.g., for the case of an equal number of supporters and opponents). A tie-break might involve issues of seniority.
- Rules of seniority, where the weight of a group member's opinion is related to her status within the group. The status can be acquired (e.g., by experience) or associated with a position to which the member is appointed. A frequent example of this is the case of a more experienced modeller who is considered as the leader by the group and takes decisions on their behalf. Other members often fill the role of 'consultants' in such a case.

These rules are sometimes set up explicitly before the group begins their work, or in an early phase of the work. But in most cases they rather emerge as the result of each member's behaviour. Individuals making regular contributions of high quality are more likely to acquire seniority. In homogeneous teams majority rules are used more often.

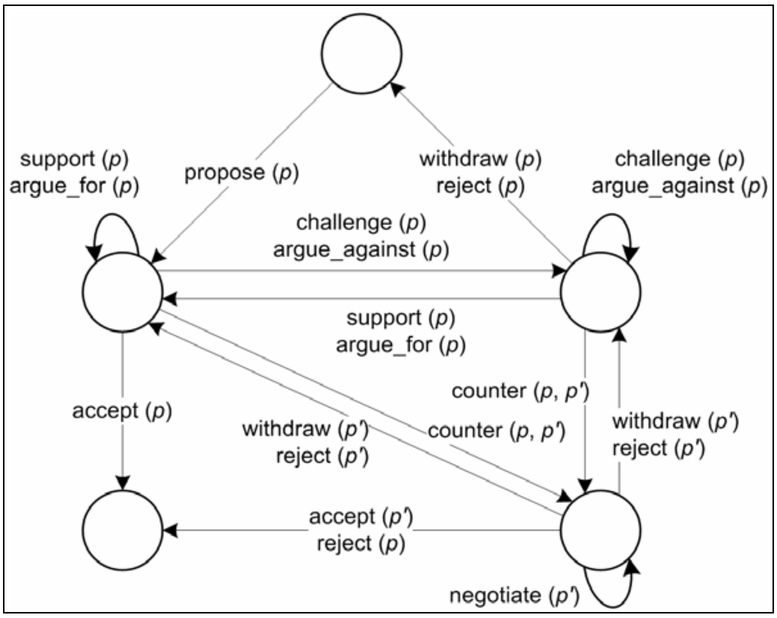
Analyses of core modelling activities on a pragmatic level revealed recurring activities that the group members engage in to solve their modelling problems. In general terms they can be summarised as follows:

- create/change an individual model
- discuss a proposal
- propose a new/changed individual model to the group
- comment on a proposal
- vote on/assess a proposal
- discuss an unclear issue
- decide on a group model (new version)
- merge proposals
- discuss use of modelling language
- reuse parts of a proposal/version.

A substantial part of activities on the pragmatic level are associated with negotiation. This is surprising as modelling is typically rather pictured as an elicitation process that is combined with individual model construction by the facilitator/modeller. The results rather suggest that modelling is a process that combines idea generation with model negotiation.

The negotiation activities on the pragmatic level reveal a structure that goes beyond a set of generic activities. The negotiation process actually follows a certain pattern. This pattern is shown in Figure2.

Figure 2 Negotiation pattern



It consists of an initial and reject state at the top, a state where acceptance is favoured (upper left-hand corner), a state where rejection is favoured (upper right-hand corner), a recursive sub-state for negotiating a counter-proposal (lower right-hand corner) and an accept state (lower left-hand corner). Each of the states allows for a set of certain pragmatic activities that take the negotiation to a different state. We have left out the parameters concerning the modeller who performs the activity and the argument (if present). In general, any modeller can perform any activity but there are a few rules to be observed. A modeller making a proposal is implicitly assumed to support it. He is the only one who may withdraw it. A counter-argument is brought up by a different modeller but a counter-proposal can also be made by the proponent of the original proposal, e.g., to accommodate counter-arguments.

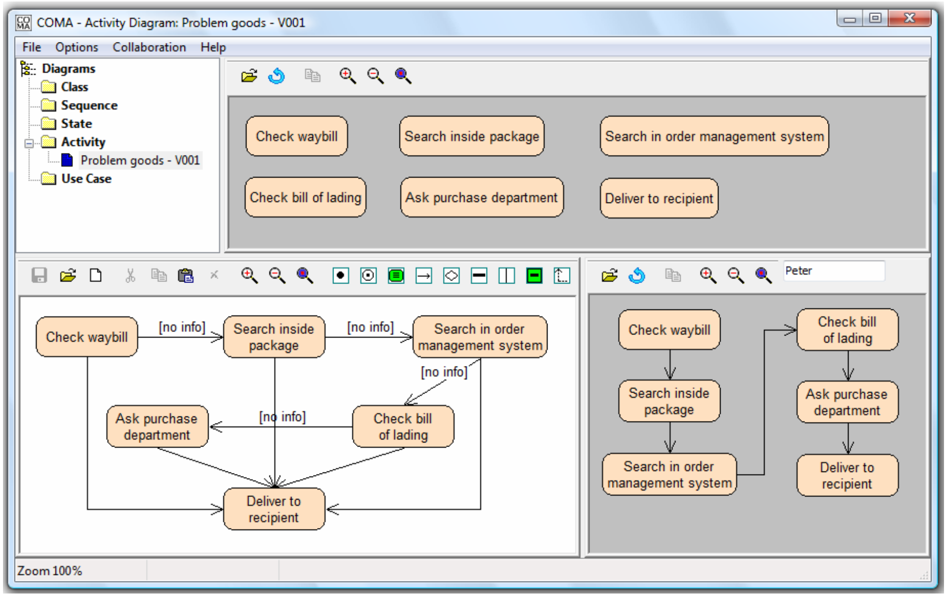
With the help of this pattern the negotiation component of a modelling support system can be controlled. On other semiotic levels the pattern of activities depends on the modelling language that is used, which restricts the potential for generalisation. This will affect the kind of support a tool can provide at the language level.

The core modelling activities, the negotiation pattern and the social rules together are called the COMA. This means that COMA covers the social and pragmatics levels of the semiotic ladder. For the semantic and syntactic levels it relies on existing modelling languages. The details regarding COMA can be found in Rittgen (2007b).

Functions supporting the core modelling and negotiation activities as well as the social rules are implemented in a tool for collaborative modelling. It is called the COMA tool and can be downloaded at http://www.coma.nu (Rittgen, 2007a).

Activities involving discussions are not supported. For them COMA relies on face-to-face conversations, i.e., it is assumed that the group members are located in the same room. If this is not the case, the group can avail themselves of standard voice-over-IP teleconferencing for this purpose. Figure 3 shows a screenshot of the COMA tool that was taken during a modelling session.

Figure 3 COMA screenshot (see online version for colours)



It shows a snapshot of the modelling process at a certain stage. This is supposed to give the reader an example of how modelling in COMA proceeds and how it helps with a particular problem, namely that of 'making different views converge'. The group in question was concerned with the handling of so-called problem goods, i.e., goods with an unclear recipient. In a first step they simply wrote down all activities that are involved thus arriving at the first version (eliciting individual views, upper pane). One member suggested to order the activities in a certain sequence and made a respective proposal (lower right pane). He knew from experience that this was indeed the order in which the activities were carried out at goods receipt. Another modeller agrees with the principle sequence but he is quite sure that the search for the recipient is terminated as soon as the recipient is identified and further steps are skipped. He draws the respective diagram in his editor window (lower left pane) and makes a counter-proposal. On seeing the apparent conflict the first modeller confirms with the operations staff that this is indeed the case and withdraws his original proposal in favour of the new one. The new proposal received supporting votes by the other team members and was subsequently adopted by the group as version two.

The effectiveness of COMA in supporting group modelling has been demonstrated in a comparative empirical study (Rittgen, 2009). It found better model acceptance by the group, faster progress in modelling, less facilitator overload, improved convergence of views, increased perceived model quality, and better model comprehension in the tool-supported sessions.

5 The papers in this special issue

This special issue features five papers that represent a wide spectrum of the research that is currently done in collaborative modelling. The first one, ‘A dialogue game for analysing group model building: framing collaborative modelling and its facilitation’ by Stijn Hoppenbrouwers and Etiënne Rouwette, provides a novel approach to organising the process of modelling. The authors interpret modelling as a rational conversation. Such conversation has a goal and follows specific conversational rules. It can thereby be seen as a dialogue game where the facilitator sets some rules and the participants ‘play’. They apply their approach to group model building in system dynamics and present a real ‘game’ supported by a prototypical application.

The second paper, ‘Group model building: a collaborative modelling methodology applied to critical infrastructure protection’ by Josune Hernantes, Leire Labaka, Ana Laugé, Jose María Sarriegi and Jose Julio Gonzalez, is also concerned with group model building but here the focus is on very large modelling projects involving many teams from many countries around the world. The authors discuss changes to the basic method required in the case of multi-team collaboration in modelling large-scale infrastructure crises to improve their management.

The third paper, ‘Collaborative maintenance of business process models’ by Nuno Castela, Paulo Dias, Marielba Zacarias and José M. Tribolet, deals with the issue of keeping enterprise models up to date. The authors propose an annotation mechanism to create interaction contexts and enable business actors to communicate knowledge about organisational processes and to discuss existing process representations in order to update them by comparing modelled with actually executed activities.

The fourth paper, ‘Modelling and facilitating RFID-based collaborative logistics processes’ by Yu Li, Andreas Oberweis and Huayu Zhang, focuses RFID-based logistics processes. Such processes are highly complex and collaborative, which in turn requires substantial collaboration in their modelling. The authors suggest a modelling language based on high-level Petri nets that caters for these processes. It supports automatic execution, as well as social networking coordinated by community processes.

The fifth paper, ‘Improving the quality of business process models through separation of generation tasks in collaborative modelling’ by Michiel Renger and Job Honig, takes a look at the influence of the collaboration process on model quality. The authors compare a setting where collaboration is not predetermined and completely left to the team members and a setting where participants first need to engage in a concept generation task.

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