Collaboration Features in current BPM Tools

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Abstract: In cross-organizational, distributed environments, Business Process Management requires collaborative technologies to facilitate the process of discovering, modeling, and improving business processes across geographical and organizational boundaries. This paper provides a comprehensive understanding of collaborative business process modeling that is based on a review of literature and a case study of three selected modelling tools. The application of the framework reveals that current process modeling tools consider different perspectives on collaboration, and that the included features are orthogonal. This paper informs practitioners about the state of the art in tool support for collaborative process modelling. It also informs vendors about opportunities to enhance the technology support. For research, our paper paper informs social aspects of BPM technology through its explicit focus on the collaboration of BPM stakeholders in the process of distributed modeling.

Keywords – Process modeling, collaboration, distributed modeling, collaborative technology

1. Introduction

Collaborative technology has found widespread use in many work practices of analysts, for example, in decision making (Kiesler and Sproull, 1992) in requirements engineering (Brouse *et al.*, 1992), or design (Kamara and Pan, 2004). Specifically, the introduction of networked environments has provided organizational staff with the opportunity to engage in remote forms of collaboration, first by email, then via attachments in email, chatting, from text to multimedia forms involving audio and video, and, recently, to fully collaborative virtual environments (Davis *et al.*, 2009).

As a result, collaborative technology has also been suggested to organizational analysts as a powerful aid in *process modeling*, which can be described as the design of graphical blue-prints of inter- or intra-organizational business processes for the act of process performance measurement, organizational re-design or workflow automation (Rittgen, 2009a).

Process modeling is typically performed using process modeling grammars, semi-formal notations that provide graphical elements to map out business processes. This typically involves the description of the tasks that have to be performed, actors that are involved in the execution of these tasks, relevant data and data sources (papers, forms, systems and technology), and a business rule logic that describes the logical and temporal order in which tasks are performed (Recker *et al.*, 2009).

While a variety of tools are available to create and analyze such models of business processes, studies and anecdotal evidence alike still report challenges in the process of process modeling (Indulska *et al.*, 2009), most notably in the phases of eliciting business process information from relevant stakeholders, and formalizing them in a process model (Koschmider *et al.*, 2010). Some authors have argued that this challenge is due to a lack of support for the process of process modeling, i.e., support for the collaboration between business analysts and domain experts in the development of process models (Frederiks and van der Weide, 2006) or the support by an appropriate process modeling methodology (van der Aalst *et al.*, 2003).

This challenge is exacerbated further in globalized set-ups of organizations and projects in which cross-organizational processes have to be designed. This is because in these contexts, the required modeling stakeholders (e.g., analysts, project managers and domain experts) are often geographically dispersed and need to engage in the process modeling effort from remote locations.

The fact that organizational process set-ups and inter-regional, distributed process collaboration are on the rise is reflected in academic literature (Niehaves and Plattfault, 2011) as well as forecasts of technology trends. In 2010, Gartner identified the convergence of process-relevant software with social software (Gartner Group, 2010), predicting a significant impact of concepts and technologies from the field of computer-supported collaboration (for instance via Facebook or Twitter) on existing process modeling and analysis work. The integration of collaboration features in process modeling tools is expected to lead to a better collaboration between process stakeholders and thus a more efficient way of conducting process modeling in general.

And indeed, in 2009/2010, many tool vendors introduced new process modeling tools with collaboration or “social” features. Still, at present, the attention that collaborative process modeling has received in the vendors' community has not yet been balanced by a critical theoretical analysis. This paper sets out to make a first contribution to that end, and defines the following research questions:

1. Which aspects of collaboration are relevant to process modeling?
2. Which technological features can be used to support these aspects of collaboration?
3. Which features of collaboration tools are actually used in BPM practice?

The first research question focuses on understanding the process of modeling and identifying dedicated requirements of *collaborative* process modeling in distributed scenarios. We seek to answer this question by identifying collaborative characteristics of process modeling, which can then be assigned to aspects of collaboration that focus on these characteristics. The second research question focuses on the technical support that can be provided to facilitate collaboration. We seek to answer this question by describing features of collaborative technology that can be implemented in process modeling tools to provide collaborative functionality. The third research question finally focuses on the application of collaborative technology features in process modeling practice. We answer this question by reviewing the tool features in current collaborative process modeling tools.

2. Background

A) Process Modeling as a Collaborative Activity

Background to Process Modeling

In recent years, the documentation of business processes and the analysis and design of process-aware information systems has gained attention as a primary focus of modeling in information systems practice (Davies *et al.*, 2006). The practice of process modeling has emerged as a key instrument to enable decision making in the context of the analysis and design of process-aware information systems (Recker, 2010a). Process models are designed using so-called process modeling grammars (sometimes called notations or techniques), i.e., sets of graphical constructs and rules which define how to combine these constructs. Such grammars are widely available and differ considerably in terms of 'how' process models can be designed (Rosemann *et al.*, 2006). Yet, invariably, all available grammars are essentially graph-based flowcharting notations that make use of basic shapes such as rectangles or circles, and arcs. This representation scheme, notably, is also used in the current industry standard for process modeling; the Business Process Modeling Notation BPMN (OMG, 2009) - the grammar that has enjoyed a wide uptake in industry practice (Recker, 2010b). Figure 1 gives an example of a BPMN process model that depicts start and end conditions, tasks, and relevant conditions specifying the order of execution.

Process modeling grammars are implemented, and used, as a part of a process modeling tool suite (Ami and Sommer, 2007). These tools typically provide a graphical model editor and complementary functionality enabling simulation, reporting, analysis, or even execution of the stored process models (Recker *et al.*, 2010).

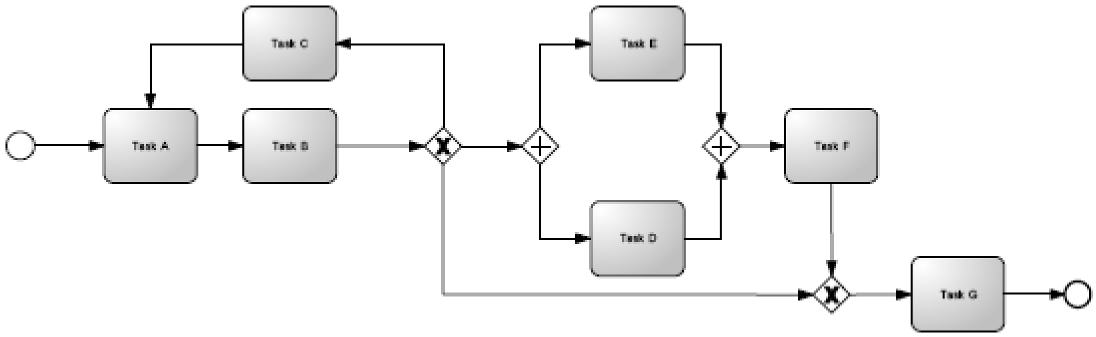

Figure 1: Example of a process model created with BPMN

Perusing grammar and tools, the *process of process modeling* typically consists of the three stages elicitation, modeling and verification (Frederiks and van der Weide, 2006), as depicted in Figure 2. While this framework was originally intended for information/data modeling processses, the general stages in principle also hold for other modeling processes such as process modeling.

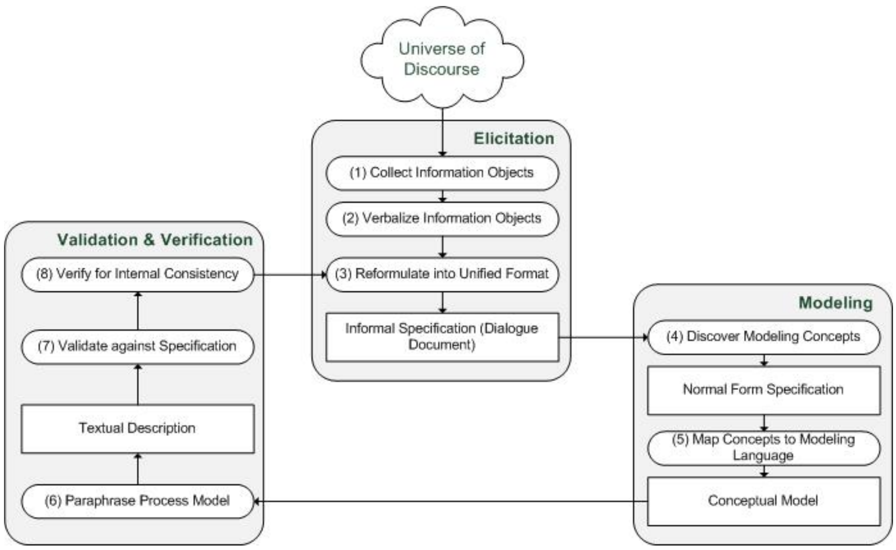

Figure 2: The process of modeling (Frederiks and van der Weide, 2006)

During *elicitation*, a natural language (e.g., textual) description of the problem domain is developed by collecting relevant information objects (e.g., documents or diagrams), which are then verbalized using a common language. Finally, this verbalization is reformulated using some unified language (e.g., on basis of a common business object terminology) as an informal specification. During *modeling*, the dialogue document is transformed into a formal specification (i.e., a process model) by mapping the components of the informal specification onto modeling concepts and relationships provided by the chosen modeling grammar and tool. Last, during *validation and verification*, the model is paraphrased in natural language in order to be able to validate the resulting text against the natural language description created during the elicitation stage. Finally, the produced process model has to be verified for internal correctness (Mendling, 2008).

Collaboration in Process Modeling

Traditionally, the process of process modeling has been conceptualized as a single-person activity. This perspective highlights the view of one person being responsible for the whole process of modeling, i.e., to elicit domain knowledge, create a conceptual model, and finally verify the model. In academic settings, this single-person perspective is often used to train students in the competencies of both domain expertise and method expertise.

In corporate reality, however, single-person process modeling hardly describes a realistic perspective. This is because, firstly, it requires one person to undertake all activities necessary in the process of modeling (see Figure 2). However, method and domain expertise are typically distributed amongst different staff members in an organization (Khatri *et al.*, 2006). Secondly, often, knowledge about organizational procedures is widely distributed within an organization (den Hengst, 2005), which makes it necessary to include many domain experts in the process of modeling, whose knowledge then needs to be elicited and consolidated. Furthermore, other stakeholders might have a strong interest in attending the process of modeling, e.g., for controlling or monitoring purposes, as project sponsors, or other stakeholders with vested interests (Rosemann, 2006). Lastly, the integration of multiple stakeholders in the process of modeling is also important for the validation and verification stage, as a single person would be a potential source for modeling errors and subjective bias.

Therefore, more recent perspectives have emerged that describe process modeling as a goal-driven multi-stakeholder dialogue (Hoppenbrouwers *et al.*, 2009) or a negotiation process (Rittgen, 2007). In these views, the participating actors can broadly be classified into either domain experts who generate and validate statements about the domain, or business/process analysts who create and verify formal models. Rittgen (2007) further argues that information is created through a social and communicative process of modeling, and roles within the group develop parenthetically. Each participant can contribute to all phases of the process, although the level of participation may vary with the participant's organizational role and level of knowledge.

Viewing process modeling as a collaborative activity that includes dialogue and negotiation as part of the information elicitation, modeling, and verification stages is obviously conducive to settings of multi-national, multi-organizational or otherwise distributed processes where relevant domain or method experts work in a separated manner from different, sometimes remotely placed locations. In such settings, acts of dialogue or negotiation are difficult to perform due to the distribution of relevant process stakeholders and organizations therefore look for technology to provide support for collaboration in the process of modeling (Brown et al., 2011). We review essential features of such technology in the following.

B) Relevant Levels of Collaboration and Relevant Technology Support

Collaboration as Social Interaction

We argue that the characteristics of collaboration (distributed participants around the globe) pose a number of requirements to the modeling process and its tool support. Looking at how advanced technology might support collaborative modeling, we note that collaborative technology has already been applied and examined in related areas such as design or learning. For example, Susman et al. (2003) synthesized and extended existing theories on the appropriation of collaborative technologies in new product development by "recognizing misalignments between technology, task, organization and the group." Marjanovic (1999) validated an interactive methodology for learning and teaching in a synchronous electronic collaborative environment emphasizing the necessity of understanding collaborative processes in order to design better methodologies.

Accordingly, collaborative process modeling can be seen as a social interaction between several people, while they jointly conduct the process of modeling in form of a social entity. The modeling team shares the common goal of creating a process model, and furthermore the common understanding of how the process of modeling is structured and how they can individually contribute to this process. When such social interactions occurs in geographically distributed settings (i.e., when participants are temporally and/or geographically dispersed), technology is required to support for levels of interaction, viz., awareness, communication, coordination, group decision making and team-building (Malone and Crowston, 1994). Table 1 describes these levels of interaction and their relevance to collaborative process modeling.

Table 1: Levels of social interaction in collaborative process modeling. Extended from (Malone and Crowston, 1994)

Level	**Components**	**Description**	**Example in process modeling**
Awareness	Actors, objects	seeing the same physical objects, or accessing shared concepts	Recognizing all process stakeholders; accessing relevant documentation about procedures or stakeholders, viewing the model (draft)
Communication	Send, receives, messages, languages	establishing a common language, selecting receiver (routing), transporting message (delivering)	Defining a shared business vocabulary, allowing interactive discussion, enabling chat/live conferencing
Coordination	Goals, activities, actors, resources, inter-dependencies	identifying goals, ordering schedules, assigning tasks to resources, synchronizing work	Organizing a modeling workshop, setting agenda, implementing discussion or decision rules
Group decision-making	Actors, goals, alternatives, evaluations, choices	proposing alternatives, evaluating alternatives, making choices (e.g. by authority, consensus, or voting)	Reaching decisions during information elicitation, model construction or model verification
Team-building	Actors, goals, activities	Sharing a common understanding of working, the responsibilities for tasks and outcomes, as well as common documents and artifacts	Building a process modeling team or teams responsible for selected business processes

Awareness aims at reducing uncertainty and enabling spontaneous coordination in collaborative situations that incorporate mutual dependencies between the team members. Awareness allows team members to answer question regarding the in-time completion of work tasks by other team members or the availability of other members for further enquiries (Gross and Koch, 2007). Awareness denotes the provision of mutual information for all members of a social entity about each other and hence is an important aspect of successful social interaction. Awareness is maintained by tracking information about the participants' location, their activities and intentions, and the interaction history. In general, awareness can be classified in four types of information requests (Gutwin and Greenberg, 2002):

- **Informal awareness** comprises information about the presence, activities, and intentions of other group members, as well as the personal and electronic ubiquity of other people.
- **Group-structural awareness** relates to information about the structure of the group, including information about group members, their roles and responsibilities, as well as their positions and status.
- **Social awareness** involves information about other members' interests, their attention, and emotional condition. This typically includes aspects like eye contact, facial expressions, and body language.
- **Workspace awareness** covers information about the interaction of and with other members inside a common workspace, e.g. a modeling tool. This also incorporates information about workspace artifacts, i.e. user attendance, user identities, user activities, user intentions, and others.

Communication is a prerequisite for coordination that requires mutual agreements and builds on the concept of awareness. Human communication is a dynamic and highly complex process that incorporates the transfer of verbal and non-verbal expressions within a dialogue from a sender to a receiver (Gross and Koch, 2007). Communication is typically seen as a process of encoding information by a sender, who is then transferring a message to a receiver via some medium. The receiver decodes the message and may give feedback to the sender. Encoding and decoding of information happen on the basis of a communicative commonality, e.g., the English language, and can include speech, body language, facial expressions, media, sound, writing, and others. Messages sent from a sender to a receiver contain four aspects which play an important role in the process of creating and understanding a message (Gross and Koch, 2007):

- **Content**: Includes the actual information supposed to be transferred to and interpreted by the receiver.
- **Appeal**: Includes implicit wishes of the sender and how they are understood by the receiver.
- **Relationship**: Includes the relationship between the sender and the receiver, respectively how the receiver of the message understands the relationship.
- **Self-Revelation**: Includes the revelation of feelings, respectively the understanding of revealed feelings by the receiver.

Communication can further be categorized by the aspects of direction (direct versus indirect) and synchronicity (synchronous versus asynchronous). Direct communication describes social interaction at which the sender already knows who receives the message. Indirect communication comprises the storage of messages, which can be discovered by potential receivers at any given time after storage. Synchronicity describes the temporal aspect of communication; while synchronous communication requires both sender and receiver to be present at the same time, asynchronous communication does not require presence and availability at the same time and thus implies conversations that evolve over a period of time.

Coordination of group activities is of major significance for collaborative settings. Coordination comprises a concept of structuring and facilitating transactions between interdependent components (Chandler Jr., 1969). In their coordination theory, Malone and

Crowston (1994) identify basic components in coordinative settings. These components comprise the

(1) identification of the goals of a coordinative effort,

(2) mapping of goals to activities, e.g., by decomposing goals,

(3) selection of actors and the assignment of activities, and

(4) management of interdependencies between the activities in order to support goal-relevant relationships between the activities.

In order to handle problems arising from the interdependency of activities during the modeling process (e.g., between modeling and verification, or between elicitation and modeling), group members have to spend time on organizing the coordination of these activities (Hahn *et al.*, 2010). This is because the loss of time incurred by coordination is offset by the organizational productivity gained through the efficient coordination of joint tasks (Malone and Crowston, 1994).

Group decision making is relevant to collaborative settings in which multiple people working together combine their knowledge, making use of communication and awareness, and attempt to identify suitable solutions for complex problems. Group decision making is used in settings in which problem solution is considered to be too critical for a single individual (DeSanctis and Gallupe, 1987). Support in group decision making aims at providing guidance in the process of decision making, i.e., altering the communication process in a way that well-proven patterns of decision making (formalized decision procedures) are implemented and facilitated. Group decision support should provide new possibilities to the group for making decisions.

Last, *team-building* is the process of creating social entities that share a common understanding of working and assume shared responsibilities for tasks and outcomes of group work. The organization of individuals in social entities aims at working together collaboratively and requires the establishment of all introduced aspects of social interaction; awareness, communication, and group decision making. One of the main challenges in team building appears to be the support of both formal and informal interactions, and the overlapping and interaction of individual and cooperative work (Schmidt and Rodden, 1996). The importance of support for team building depends on the organizational setting, e.g., modeling groups that communicate or share objects electronically can be expected to benefit from team building support.

Technical Support for Collaboration

Much technical support for collaboration has been described under the term of computer supported collaborative work (CSCW) (Easley *et al.*, 2003). These technologies are typically classified using a time-space taxonomy that distinguishes between communication that occurs at the same space or concurrently at different spaces, and communication that occurs in the same time (synchronously) or in different times (asynchronously) (DeSanctis and Gallupe, 1987). We have no intention of reviewing the ample literature on CSCW and instead only discuss technology support for the above introduced five aspects of collaboration, viz., awareness, communication, coordination, group decision making and team building.

Technical support for awareness especially makes sense in situations in which group members are geographically dispersed and require information about users, artifacts, and tasks associated with the work of the group (Dourish and Bellotti, 1992). Technologies that provide awareness support include presence awareness systems (e.g., instant messaging systems or media spaces that provide information about logging, user status notifications, and exchange of text, audio or video), proprietary awareness systems (systems that capture awareness information such as emotions, task histories or gestures only within a single application), and integrated awareness environments (systems that integrate awareness information from several other applications, e.g., event-notification or context-based systems) (Gross and Koch, 2007).

Technical support for communication originates from the support for telephone and mail exchange and to cover span systems for synchronous communication (systems like chats, multi user dialogues, and audio or video conferences that allow users to exchange messages which are transferred immediately while recording the input and allow the receiver of the message to answer at the same time) and those for asynchronous communication such as email or text messages. Instant messaging can be used both in a synchronous and asynchronous manner.

Technical support for coordination aims at providing mechanisms that support the adjustment of group activities. This technical support for coordination can be either explicit or implicit. Explicit coordination support circumscribes the full automation of coordinative tasks by a software system, so that human users have to follow the system's instructions. In contrast, implicit coordination involves semi-automated coordination and circumscribes the provision of awareness information which can be used by the system's users in order to better coordinate their group tasks (Gross and Koch, 2007). Coordination systems in use include; workflow systems that pass tasks from one participant to another in order to ensure the required human contribution and that the correct sequence of the activities is followed, communication-oriented systems that typically aim at improving the communication of a group by modeling organizational structures and implementing a conversation in the form of an email exchange between the participants and corresponding rules that define default responses, or form-based systems that use semi-structured messages that are created in a decentralized way and can be connected with rules which define how to process incoming forms.

Technical support for group decision-making aims at facilitating the process of making decisions in a group of participants by structuring and recording the decision process. There are systems that facilitate either asynchronous or synchronous support for group decision making, i.e., systems that allow users asynchronous (alternating) or synchronous (concurrent) communication for making decisions. There are also other systems, such as communication-driven decision support systems, that are basically groupware that support electronic communication, scheduling, document sharing, and other activities that enhance decision support.

Technical support for team building comprises software that guides the organization of teams for different application scenarios. Most tools in this area are group editors (for editing of texts, graphical models, and other design artifacts) or shared workspaces that allow a group of users to jointly administrate shared documents. More advanced technologies further enable community or team building using virtual spaces (Benford *et al.*, 2001) with digital characters such as avatars. Team building can further be supported through social software, web-based software that supports human communication, interaction, and collaboration by making use of capabilities and contributions of a network of users (Koschmider *et al.*, 2010).

3. A Framework for Analyzing the Collaboration Features in Process Modeling Tools

Having reviewed process modeling as a collaborative activity and identifying important levels of collaboration as a social interaction and the corresponding available technologies, we now set out to define a framework that allows us to examine and compare existing process modeling tools with respect to the support they provide for collaborative process modeling. The framework builds on the components of the process of modeling as identified by Frederiks and van der Weide (2006), and integrates them with aspects of collaboration by Malone and Crowston (1994), and is displayed graphically in Figure 3.

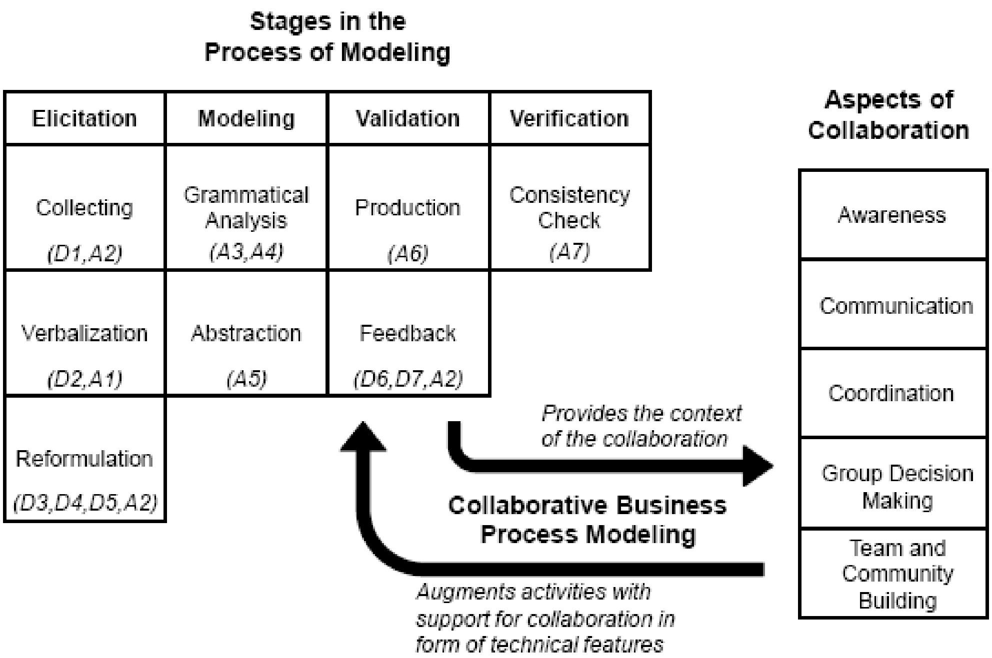

Figure 3: Interrelations between stages of modeling and aspects of collaboration

We start with the perspective of the process of modeling as discussed in Frederiks and van der Weide (2006). Figure 3 shows its components from elicitation to verification from left to right, along with the required skills of analyst (A) and domain expert (D). The roles of the domain expert and the analyst are recursively defined via an according set of competencies. For instance, D1 refers to the fact that a domain expert can provide a complete set of information objects while the corresponding skill A2 emphasizes that the analysts should be able to validate a set of sample sentences for consistency. Both these skills complement each other in the collecting step of elicitation. While particular scenarios of process modeling provide additional role definitions, one can argue that these two basic roles capture the various skills that are assigned in an abstract way to any domain expert or analyst involved in a process modeling project. In a collaborative, distributed setting, it may simply be that different participants provide these skills, and thus occupy these roles.

The stages in the process of modeling together with the related competencies are particularly relevant to collaborative process modeling, as they provide the *context of the collaboration*. These stages are all subject to considerations about aspects of collaboration, as highlighted by the arrow pointing rightwards. Accordingly, if we consider the collecting step again, we can consider this step from a perspective of awareness, communication, coordination, group decision making, or team and community building.

Second, we can discuss the framework from right to left, from the perspective of collaboration. From this view, collaborative business process modeling can be examined with respect to the collaboration aspects it implements. Further, the aspects of collaboration can be supported by technical features in order to augment the activities of the people participating in the process of modeling (captured by the arrow pointing leftwards). In this view, Figure 3 combines the stages of Frederiks and van der Weide (2006) with the aspects identified by Malone and Crowston (1994).

4. Framework Application

A) Tool Sample

We now apply our framework to three examples of applications that purport to support collaborative process modeling. To cover a broad spectrum of different modeling tool variants, we selected three different types of systems: an academic prototype, a specialized web-based niche product, and a tool from the market leader for BPM solutions (Hill *et al.*, 2007).

The evaluation of a broader base of applications is not feasible within the scope of this paper. We do not claim the following tool sample to be exhaustive or complete yet argue an approximate representativeness of our sample for tools currently in use for process modeling (Recker, 2010b; Fettke, 2009). We introduce the three selected tools in the following.

1. **Collaborative Modeling Architecture (COMA)**

   The Collaborative Modeling Architecture (COMA) is a free prototype for collaborative business process modeling developed by Rittgen (2010). This tool implements a solution for the process of modeling from a group negotiation perspective (Rittgen, 2007) and supports five UML diagrams: Class Diagrams (for information modeling); Activity Diagrams (for process modeling); Use Case Diagrams (for requirements modeling); Sequence Diagrams (for real-time modeling); and State Diagrams (for software development). The COMA tool is available as a Microsoft Visual C++ installer or VBA.NET add-in for Microsoft's Visio 2007, and explicitly supports the negotiation of models by allowing four basic activities of negotiation: propose, support, challenge, and accept; as well as the decision on the acceptance of proposals based on two social rules. Either the group of modelers has a facilitator who makes the decision (rule of seniority), or a team without a facilitator provides all modelers with a vote of the same weight (rule of majority). Interestingly, activities featuring direct communication or discussions are not supported by the COMA tool, so that all communication relies on face-to-face conversations, i.e. all group members have to be located in the same place (Rittgen, 2009b).

2. **Signavio Process Editor**

   The Signavio Process Editor is a web-based collaborative process modeling solution that allows users to model business processes with the modeling standards BPMN or EPC perusing a web browser. The process models are stored in a central model repository, and are accessible to users via the assignment of access rights. The process models are available via a unique URL in the Web; when opening such an URL, not only the model itself but the whole modeling tool is loaded and executed in the Web browser. Originating from the open source BPM platform Oryx, which was developed at the Hasso Plattner Institute of the University of Potsdam (Germany) (Decker *et al.*, 2008), the Signavio Process Editor is a further development of the platform towards the provision of a professional solution for business customers. The Signavio Process Editor does not require a desktop installation, but instead is executed with the Mozilla Firefox web browser, and is available in two commercial versions; a software-as-a-service version hosted by Signavio, and an enterprise version that can be hosted by the customer itself.

3. **Software AG ARISalign & ARIS Community**

   Software AG's ARIS collaborative tool consists of two web-based software platforms, ARISalign and ARIS Community. These two platforms focus on the community aspect of collaborative modeling of business processes, as well as the exchange of information and shared discussions of all BPM-related topics. ARISalign is a web-based collaborative process modeling solution that allows users to model, discuss, and improve business processes by combining social networking tools with intuitive tools for process design and modeling. Just like the Signavio Process Editor, ARISalign does not require a desktop installation but instead is loaded and executed in a Web browser. ARIS Community is an online portal for process modeling users and experts that creates a community for people with an interest in BPM. Among other features, the ARIS Community helps exchange information, supports discussions, and provides training materials and best practice documentations. Both ARISalign and ARIS Community can be used free of charge.

B) Application

In a second step, we applied the framework developed above to the selected sample of modeling tools, to gauge the provision and use of technology to support collaboration in process modeling. In our evaluation, we examined how each of the five levels of collaboration can be enabled through features available in the respective tool. In other words, in each tool we identified those tool features that facilitated one aspect of collaboration (instead of identifying all tool features and mapping those to a collaboration aspect). Table 2 summarizes the results from our qualitative evaluation.

C) Findings and Discussion

The data displayed in Table 2 allows us to draw a number of tentative conclusions; firstly, about the tools we inspected, and secondly, about the levels of collaboration required and supported in process modeling.

First, regarding the selected tools, our evaluation reveals that each tool provides a different focus on collaboration. The COMA tool focuses on providing support for the collaborative aspects of *coordination* and *group decision making*, while neglecting the aspects of *awareness* and *communication*. Team building is supported by basic repository functionality only. The implementation of the COMA tool clearly mirrors the intended motivation for development – process modeling as an act of negotiation (Rittgen, 2007; Rittgen, 2009a), which, in turn, results in a more active participation of the stakeholders, as well as providing technical support for the facilitation of the process of modeling from this perspective.

Table 2: Summarized results from framework application

Tool / Collaboration Aspect	*COMA*	*Signavio*	*Software AG ARIS*	
			ARISalign	*ARIS Community*
Awareness	not implemented: participants must be located in the same place	subscription for email notifications	network activity overview, detailed project feed	subscription to event notifications, overview of network activity
Communication	not implemented: only face-to-face conversations are possible	invitation emails, commenting	message center allows text messaging with users, discussion groups	comments in web forums and blogs, posting on profile walls, text messages with contacts
Coordination	pre-specified workflow according to an identified pattern of negotiation, facilitated by a tool-specific methodology	change history, search function, central dictionary	search function, link between whiteboard and process modeling tool	search function, categorization of articles, rating systems (popularity), shared group calendars
Group decision-making	negotiation component approach that makes use of the underlying coordination method and the application of social rules	invite people for commenting on elements of models	discussion groups (web forums) where documents can be attached	discussion forums (where process models can be attached), user polls
Team-building	repository with versioning of process model proposals	central model repository with version control, access right management, model publishing (embedding, process portals, mashups)	social network (with profiles, searching, connections), integration of other existing networks, project access control and roles	social network (with profiles, searching, connections), mashup zone

The Signavio Process Editor does not provide specific features such as COMA and instead addresses all five aspects of collaboration we considered. Notably, the editor provides some advanced features that support the aspect of team and community building (e.g., access right management or model publishing). The aspects of awareness, communication, and group decision making are each covered by one or two features only. This could be either the result of a very selective developers' decision, or otherwise reflects the developers' uncertainty about adequate support.

ARISalign and ARIS Community provide technical support for each of the five aspects of collaboration. In contrast to the COMA tool and the Signavio Process Editor, these applications offer multiple dedicated social features that can be used for supporting the aspects of awareness and communication (e.g., subscriptions, network activity overviews, discussion groups, and so forth). While ARISalign does not explicitly support the aspect of coordination, ARIS Community offers a broader range of social features for coordination support (e.g., categorization, rating, and shared resources). The integration of social network approaches in both ARISalign and ARIS Community highlights the focus of these applications on the collaborative aspect of team and community building.

Second, regarding the levels of collaboration supported in process modeling, inspection of Table 2 suggests that the different aspects of collaboration are supported in different ways and to different extents across the three tools considered. This perspective allows us to compare the actual provision of collaboration features in current BPM tools with a theoretical provision (i.e., what could be possible):

Examining the support for awareness among the introduced applications, we note that all tools considered only provide a small range of social features. It appears that support is available in form of subscriptions for notifications, network activity overviews, and project feeds. Keeping in mind the four different types of awareness we notice that not all types of awareness are equally supported. While technical support for informal and group structural awareness is partly provided, social awareness and workspace awareness are only sparingly supported by the examined applications. However, inadequate awareness support incorporates the risk of not being able to deal with uncertainty and impairing spontaneous coordination in cooperative situations. The examined applications do not provide functionality to customize the awareness support with the user's need for information and privacy, suggesting a potential for further extension of the application with features that support other aspects of awareness. In the context of collaborative modeling, especially instant messaging and web feeds like RSS (which could not only provide information on an activity level, but also on a model or object level) could be promising additional features. These additions could easily be integrated into existing applications, and significantly improve the awareness about the presence of other participants as well as the shared workspace and its objects.

Communication appears to be supported by various features, including emailing, commenting on process models and profile walls, and writing entries in discussion groups, web forums, and blogs. While this is a wide range of communication alternatives, all these features rely on written messages that are exchanged between users. Therefore, collaborative modeling tools could potentially benefit from further features that provide support for other forms of communication (especially audio and video conferencing, the integration of VoIP and traditional telephony, and the exploitation of mobile devices) – as noted in the study by Hahn et al. (2010). This could improve both the availability of participants as well as their willingness to communicate with each other.

The examination of the introduced applications shows that available tools integrate a range of features to support coordination. Among these features are search functions, change histories, shared glossaries, shared group calendars, rating and categorization features, and others. Interestingly, these features facilitate the coordination *within* a group, but do not provide any guidance for group coordination. Thus, users remain completely free to decide if they want to make use of these features. Such features may certainly provide support for issues of group coordination, but they do not provide support for meta planning (the planning and implementing a coordination workflow, i.e., a methodology for coordinating a group). This feature is only implemented in the COMA tool, which offers a tool-specific methodology that guides each user's activity following the paradigm of negotiation models (Rittgen, 2007). To extend the current level of support offered, especially the provision of shared resources (wikis, blogs, calendars, et cetera), and corresponding methodologies and rules for their usage, are promising additional features.

The support for group decision making is basically limited to discussion groups (web forums) and commenting functionality. These features may support the aspect of group decision making, but are actually rather communication channels which, however, are useful in the context of group decision making. An exception is the COMA tool, which provides a group negotiation component and thus especially focuses on providing support for group decision making. A lack of decision support for groups makes it difficult for participants to identify suitable solutions for complex problems and adapt well-proven patterns of decision making.

Also, the process of decision making may be nontransparent to other stakeholders, due to missing structure and traceability. Hence, collaborative modeling tools could potentially benefit from the integration of further features for project management, probability assessment, opinion making, or statistical calculations, as well as features that support group negotiation (DeSanctis and Gallupe, 1987). Such support would provide functionality that directly facilitates the identification of suitable solutions and would thus reduce uncertainty and noise in decision making. Finally, the provision of a playback feature for recapitulating collaborative activities (instead of pure logging functionality) could be advantageous for making the decision making process more transparent.

Team building is supported by various features across the three tools considered, including central model repositories with version control functionality, access right and user roles management, and social network implementations. Also present are specialized features for publishing and re-assembling functionality provided by the application platforms. Our data suggests that current tools focus on the provision of shared workspace functionality (the joint administration of shared documents) as well as the provision of virtual rooms for knowledge management (that support the generation and exchange of knowledge) in the form of social networks. Interestingly, group editors which allow the synchronous and concurrent creating and editing of documents and process models do not seem to be greatly supported in practice. In terms of further extending the support, existing applications may adopt ideas from the well established field of groupware applications, especially in the growing area of social software (Koschmider *et al.*, 2010). The examples of ARISalign and ARIS Community show that some vendors have already taken steps in this direction.

5. Conclusions

A) Contributions

In this paper we reported on the development and application of a framework suitable for collaborative process modeling tool analysis. We have suggested process modeling to be a collaborative activity that includes dialogue and negotiation, and conceptualized this collaboration as a social interaction process. We then reviewed available technology to support five levels of social interaction, and mapped out a framework that allows us to examine the current state-of-the-art in support for collaborative process modeling. We examined three different collaborative process modeling tools to demonstrate the utility of our framework.

B) Limitations

Our research bears some limitations. First, the specific focus of this paper on the features supporting collaboration as social interaction neglects other important and relevant challenges in collaboration, such as security, mobility, cross-cultural effects and others. There is related work to that effect (e.g., Straub, 1990; vom Brocke and Sinnl, 2011) that can be leveraged to extend our work in these directions. Second, our discussion of the developed analytical framework is limited by the number of reviewed tools, which allowed gaining some initial insights but does not replace a comprehensive market review. However, this limitation also provides an opportunity to further extend our study by reviewing a larger set of features and/or tools.

C) Implications

We identify two sets of implications from our analytical study. On a practical level, our work identifies a set of collaboration features available in modern technology that appears suitable for inclusion in process modeling tool solutions. These findings are of interest primarily to the community of process modeling tool vendors, and allow them to identify the most appropriate tool extensions. Second, our review also informs process modelers and their project and team leaders about the features available in current tool solutions, and how they can be appropriated in the process of modeling. These findings can lead to more effective and efficient use of process modeling technology.

On a theoretical level, we set out and define process modeling as a social interaction process that requires awareness, communication, coordination, group decision-making and team-building support. Most of the current research examines process modeling grammars (e.g., Recker *et al.*, 2011) or tools (e.g., Ami and Sommer, 2007), while other research addresses complementary aspects such as labeling (e.g., Mendling *et al.*, 2010). While some work has addressed the communication (Bandara and Rosemann, 2005) and coordination aspects (Rittgen, 2007; Rittgen, 2009b) in process modeling processes, examinations of aspects of awareness, group decision-making, and team-building are still outstanding. Our study therefore provides important directions to inform a broader research agenda on collaborative process modeling as well as on the process of process modeling.

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