Chapter 21
Context and Collaborative Work: A Context-Sensitive Intervention Approach for Collaboration in Dynamic Environment

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Abstract The context of complex design and engineering processes is characterized by dynamic requirements, like changing process goals or group constellations. To deal with these dynamics in a virtual environment, a context-sensitive collaboration support system needs to consider a changing context and provide virtual teams with the support they need. Such elastic collaboration support can range from a fixed process and tool configuration to an open collaboration environment that enables groups to interact in a self-organized way. In this chapter, research about a context-sensitive intervention approach is described that intends to support elastic collaboration in dynamic environments. Based on a review of existing theories on collaboration performance, the use of contextual process information to monitor group performance during collaboration is discussed. Thereby, a rule concept is introduced to derive interventions for elastic collaboration processes compared to existing approaches for context modeling in collaboration.

21.1 Introduction

As systems and products become more complex, organizations work collaboratively in virtual teams across-organizational borders to improve their product lifecycles. However, collaboration in virtual teams faces new challenges that make it more difficult to manage them than face-to-face collaboration (Nunamaker Jr. et al. 2009). Besides the loss of non-verbal cues, different work processes and cultures between the team members represent a challenge for the design of technological support. In this context, the use of product data streams to effectively and collaboratively develop and monitor cross-organizational products has become a major research topic (SmartVortex 2014). One major requirement for such developing and monitoring

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support is to provide intelligent support for the selection and appropriation of collaboration support tools based on a team's current interaction and process phase and the availability and accessibility of information (Janeiro et al. 2012a).

An application of such an intelligent support tool could be a cross-organizational product like a wheel loader that contains sensors to monitor the performance of the engine. Telemetric data such as the position of the machine, fuel level measures, engine vibrations and temperature could be analyzed to detect a machine degradation. To avoid a machine breakdown, an intelligent collaboration support tool can mobilize a cross-organizational expert team to quickly analyze and understand machine problems, and to identify solutions during the machine runtime. The virtual team has to identify machine failures, malfunctioning components, its causes and consequences, and define action plans. As telemetric data can change during the maintenance process, virtual teams collaborate in a dynamic environment where the original goal of the session can change, and the time planned and the available data can suddenly vary (Janeiro et al. 2012a). As result, the collaboration process needs to be constantly redesigned during the collaboration session.

In face-to-face collaboration, a team leader can provide process support by monitoring the collaboration process and redefining the goals and objectives of the team as well as to outline the procedures, activities, and tasks to accomplish these goals (Sarin and McDermott 2003). To deal with these types of dynamics in a virtual environment, teams need technological support that provide flexible features to monitor the context of a collaboration process as well as to adapt the process to the new situation. Depending on the expertise of the team members for the collaboration process, such support can range from prescribed collaboration processes and tools for inexperienced teams to emergent collaboration support in which the support system just gives recommendations on how to improve the process or on which tools to use (Janeiro et al. 2012a).

Current context-aware systems for collaboration make use of contextual information to provide awareness support (Ardissono and Bosio 2012; Ferscha et al. 2004) or to adapt the collaborative workspace (Terveen 1995; Haake et al. 2010). However, less research has focused on the relationship between group performance of a collaboration process and the need for process adaptation. In this chapter, it is assumed that contextual information of a collaboration process can be used to monitor the performance of a group in prescribed as well as emergent collaboration support environments. Therefore, a framework of group performance is introduced and its application to derive process adaptations is discussed. Based on a semantic model for dynamic collaboration processes the application of contextual information is illustrated by a rule concept. The resulting context-sensitive intervention approach is compared to existing approaches in collaboration and its application to design context-aware collaboration systems is discussed.

21.2 Background

Different approaches exist to define the concept of collaboration. In the Oxford dictionary collaboration is defined as the 'the act of working with another person or group of people to create or produce something'. From a computer science perspective, collaboration can involve humans as well as computational agents, who use technological support in 'a process in which two or more agents work together to achieve a shared goal' (Terveen 1995). A more specific definition is given in behavioral science, where collaboration 'occurs when a group of autonomous stakeholders of a problem domain engage in an interactive process, using shared rules, norms, and structures, to act or decide on issues related to that domain' (Wood and Gray 1991).

In this chapter, the focus is on collaboration as 'an interactive process in which a group of individual group members uses shared rules, norms, and structures to create or share knowledge in order to perform a collaborative task'. Thereby, collaboration can make use of technological support to provide an environment that supports shared rules, norms, and structures of an organization. In the context of virtual teams and cross-organizational collaboration, it is further assumed that collaboration takes place in a dynamic environment, which is characterized by changing requirements and resources such as a changing process goal, available time or group constellation. As a result, technological support needs to be aware of a collaboration context to provide groups with the support they need. Such technological support can be a context-aware system, which 'uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task' (Dey 2001). Thereby, context-aware applications can support the presentation of information and services to a user, the automatic execution of a service for a user or the tagging of context information to support later retrieval (Dey 2001).

Several context-aware systems focus on physical context elements such as user's location, time and activity (Ardissono and Bosio 2012; Ferscha et al. 2004). However, less research has been done on using context to predict group performance. Research on groupware systems (Dennis et al. 1988; Nunamaker et al. 1991) indicates that a collaboration process and its outcome are affected by different factors like group characteristics, task complexity, technology used or organizational culture. Today, different social psychological theories (Tajfel 1974; Janis 1982; Karau and Williams 1993; Diehl and Stroebe 1991; Gallupe et al. 1992) describe and predict the influence of such contextual factors on group behavior and performance. In this chapter, it is assumed that by monitoring group performance a context-aware system can provide new services to handle negative group behaviors such as groupthink (Janis 1982) or social loafing (Karau and Williams 1993) and thereby improve group performance.

21.3 Group Performance in Dynamic Collaboration Processes

This section introduces a framework for group performance in dynamic collaboration processes. The framework is used to illustrate the complexity of a collaboration process. It discusses the factors that define the context of a collaboration process

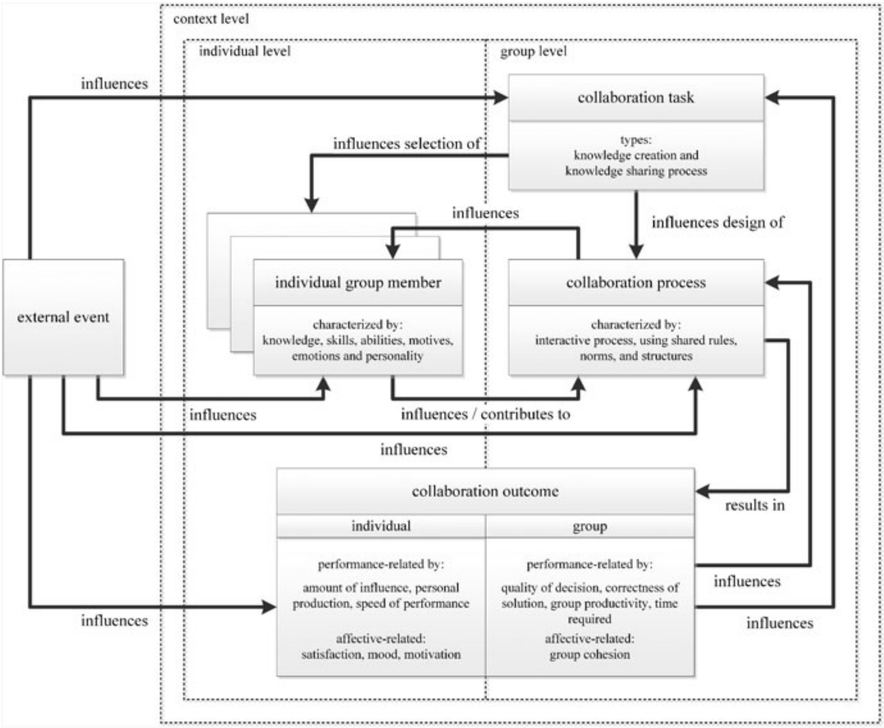

Fig. 21.1 A general framework of group performance in dynamic collaboration processes (adapted from Hackman 1987)

and influence its performance. Based on the input-process-output framework for analyzing group behavior and performance by Hackman (1987), the framework consists of the elements collaboration task, individual group member, collaboration process, collaboration outcome and external event (see Fig. 21.1).

Similar to Hackman (1987), in this chapter it is assumed that performance in collaboration can be observed from an individual and group level. In the center of Fig. 21.1 individual group members form a group for collaboration and represent the individual level. The composition of the group is influenced by the collaboration task, which defines the necessary resources to complete a task. These resources can represent knowledge, skills, and abilities (KSAs) of individual group members as well as their motives, emotions and personality.

During the collaboration process, individual group members interact with the environment by making use of external resources such as task related information or technological support. From a group level perspective, individual group members contribute different resources in an interactive process to the group. The design of the interactive process is influenced by the collaboration task, which defines the shared rules, norms, and structures to generate a collaboration outcome.

The outcome of a collaboration process can be classified into the dimensions performance-related and affective-related. On the individual level, performance of an individual group member can be represented in different ways such as the amount of influence of an individual during a decision-making process, the number of contributions in a discussion or the personal speed of performance. The affective-related outcome can be defined by psychological factors like satisfaction, mood or motivation of an individual group member. On the group level, performance of a group can be represented by factors like the quality of a decision, the correctness of a solution, the group productivity or the time required to achieve an intended goal. The affective-related outcome can be group cohesion.

From the literature, the context of a collaboration process can be defined in different ways. Schilit and Theimer (1994) refer to context as location information that enables context-aware systems 'to adapt according to its location of use, the collection of nearby people and objects, as well as the changes to those objects over time'. Dey (2001) proposes that context is 'any information that can be used to characterize the situation of an entity'. Bazire and Brézillon (2005) define context as a 'set of constraints that influence the behavior of a system (a user or a computer) embedded in a given task'. Thereby, they consider that 'context can be specified for a given situation by the answering of the following questions: Who? What? Where? When? Why? and How?'.

From a context perspective, in this chapter it is assumed that the collaboration context describes the current status of the collaboration task, individual group member, collaboration process, collaboration outcome. During a collaboration process, these elements can influence each other, which lead to a change of the collaboration context over time. From, e.g., a social psychological perspective, the production blocking effect (Diehl and Stroebe 1991) describes the possible negative effect of a process design that hinder the individual group members to share contributions the moment they occur. In this situation, the collaboration process influences the collaboration outcome by reducing the number of contributions as well as the motivation and mood of the individual group members. Another example is given by the social loafing effect (Karau and Williams 1993), which describes the tendency of individual group members to expend less effort in a collaboration process when they believe their contributions to be dispensable and not needed for group success. This effect could increase with the number of individual group members and a collaboration process design that provides anonymity. The composition of the group itself can influence the collaboration process and as a result the performance of the collaboration process. The social identity theory (Tajfel 1974), e.g., proposes that individual group members tend to classify themselves and others into various social categories, which represent attitudinal, emotional and behavioral similarities between the self and in-group members. Milliken et al. (2003) argue that individual group members who strongly identify with their group are more likely to participate actively than they would in groups with which group identification is low. In connection with group diversity, the evaluation apprehension effect (Gallupe et al. 1992) describes that the fear of negative evaluation may further cause individual group members to withhold their contributions during the collaboration process.

With regard to virtual teams and cross-organizational collaboration, a change in the collaboration context can stem from different external events that are not traditionally considered in collaboration process design. These events originate in the complexity and unpredictability of a collaboration process, which can lead to a change of the collaboration task, the group constellation and the process design itself (Janeiro et al. 2012a). During, e.g., a collaborative maintenance process of an industrial machine, the detection of changed machine parameters, such as a critical temperature rise of the machine, can lead to a change of the collaborative task. Instead of identifying the failure cause, the individual group members now need to prevent a breakdown of the machine. In such a dynamic situation, the resources such as the time available might change, which requires process adaptation. As a collaboration process is designed for a specific group of individual group members, a change of the collaboration task and the process design might also require different individual group members to achieve an intended goal.

To sum up, the introduced framework illustrates the contextual factors that influence the performance in collaboration. In this chapter, it is assumed that these contextual factors can be used by context-aware applications to provide collaborating teams with the support they need.

21.4 Concept of Interventions

A change in the collaboration context can lead to a need to adapt the collaboration process to the new situation. In face-to-face collaboration, a facilitator can monitor the collaboration process and perform interventions to help the group and solve its problem. A key skill for a facilitator is to make effective interventions to ensure that the collaboration process fits to a given collaboration context. From the literature, an intervention can take place in three stages (Westley and Waters 1988):

- *Stage 1: to recognize symptoms of a process problem*—The recognition process is characterized by analyzing the behavior of the individual group members. In face-to-face collaboration, this can be done by analyzing the contributions, the body language as well as the interaction of the group.
- *Stage 2: to interpret the syndromes*—To identify the underlying pattern of given syndromes, the facilitator needs knowledge about theories on group behaviors as well as expertise with group dynamics. During this identification process, a list of generic problem syndromes can support a facilitator (for example the generic meeting problem syndromes by Westley and Waters 1988)
- *Stage 3: to make an intervention*—To deal with a process problem, a facilitator can choose between action and interpretation interventions. Action interventions directly manipulate the collaboration process (for example to change the group constellation if expert knowledge is needed; or to prevent interruptions of an individual group member). By using an interpretation intervention, a facilitator communicates the observed patterns to the group to improve awareness and help the group to solve the problem on their own.

Compared to face-to-face collaboration, virtual teams face the challenge that the used technology often reduces or eliminates visual communication channels such as facial expressions or body language. To make use of the concept of interventions, a support technology needs to provide services to monitor and analyze contextual information of a collaboration process as well as to adapt the process.

Elastic collaboration support is needed in highly dynamic processes, such as complex design and engineering processes where external events can lead to an unpredictable change in the collaboration context (Janeiro et al. 2012b). Depending on the expertise of the individual group members, such support ranges from prescribed collaboration to emergent forms of collaboration (Janeiro et al. 2012b). On the one extreme, prescribed collaboration supports individual group members with less expertise in collaboration by predefining process as well as support tools. Here, a support technology provides support by monitoring the collaboration context and providing interventions based on predefined rules. On the other extreme, emergent collaboration supports expert groups that do not need guidance and coordination during collaboration. Here, the individual group members use the support technology to monitor the collaboration context and to adapt the process to new situations. A context-aware system can support such elastic collaboration by providing a service to monitor the collaboration context. Based on a rule concept, such a system can further provide services that provide action as well as interpretation interventions. However, to make this possible, a modeling approach is necessary to describe the context of a dynamic collaboration process.

Several context-modeling approaches exist that make use of contextual information to represent awareness information (Reiter et al. 2013) or to recommend services and tools (Wang et al. 2006; Vieira et al. 2005). For example, Reiter et al. (2013) introduce a conceptual context approach that uses data from a business process model to describe the communication context of an individual group member during collaboration. Here, a collaboration context is characterized by the dimensions: Task (the activity in a process model), Location (the workplace of an activity), Presence (the availability of an individual for communication in relation to a location or task), and Relation (the relationship between the individuals). As common business process models are usually not designed in such granularity to provide detailed information about the individual group members or the services, such context modeling approaches are less suitable to monitor the performance of emergent collaboration, where individual group members coordinates themselves. More contextual information about collaboration can be described by an ontological approach (Vieira et al. 2005; Wang et al. 2006). Such approaches divide the collaboration context into subclasses such as Physical Context, Organizational Context and Interaction Context (Vieira et al. 2005) or relate contextual information to Person, Task, Interaction, Artifact, Tool, Collaboration Control, Environment and History (Wang et al. 2006). However, they do not provide a concept to describe the process workflow, which is needed to monitor the performance of prescribed collaboration. Therefore, a new modeling approach is necessary to define a collaboration process as well as to express contextual process information.

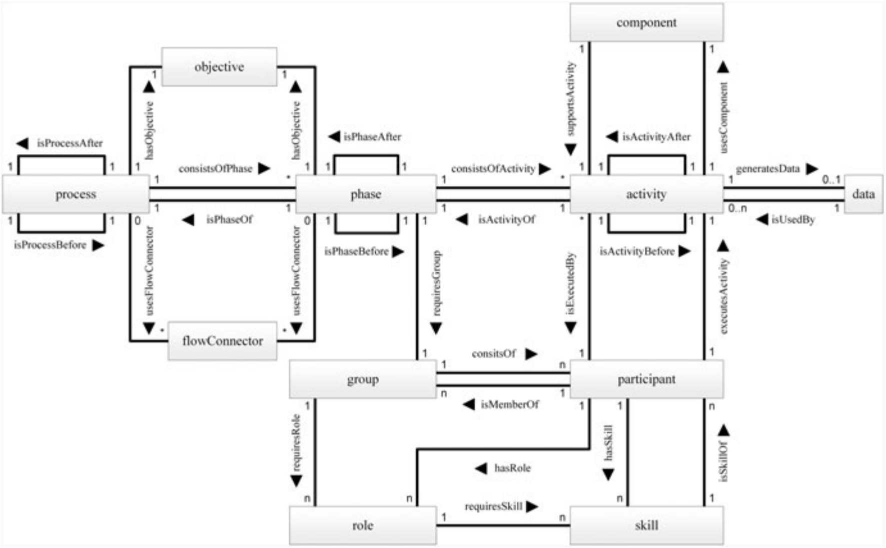

Fig. 21.2 A semantic model for dynamic collaboration processes

21.5 A Semantic Model for Dynamic Collaboration Processes

The following section introduces a semantic model that combines properties of a process definition language to express the workflow of acollaboration process with given ontology-based approaches to capture contextual process information.

Figure 21.2 illustrates a first approach for such a semantic model by the key concepts and their relations. In this model, the concept participant describes an individual group member who participates in a collaboration process. The concept participant has certain skills that can be a prerequisite of a role in a process. Similar to Haake et al. (2010), the concept role is used to abstractly denote a set of behaviors, rights and obligations of a process participant. A participant can be assigned to a group in a specific role. Besides the concept role, the concept skill is used to distinguish different participants and thus to be able to define requirements for the participants of a process. The concept process describes a collaboration process in which a group uses shared rules, norms, and structures to create or share knowledge. Similar to Oliveira et al. (2007), a process has an objective, defining its main purpose or collaboration task. How a group moves through this process to create an intended state in the process can be prescribed by work tactics of a group, similar to the concept of a collaboration pattern (Pattberg and Fluegge 2007). The semantic model represents these stages in a process by the concept phase and relating this concept to a group. During a phase, a group of participants moves through a sequence of activities. Similar to concepts like participation (Oliveira et al. 2007) or action (Haake et al. 2010), the concept activity represents an atomic activity that is executed by a participant using external resources such as a software tool represented by the concept component. To control the collaboration process and allow the representation of parallel phases, the concept flowConnector is used to implement given workflow patterns such as parallel split, exclusive choice or simple merge (van der Aalst et al. 2003).

The resulting semantic model expresses information about a collaboration process in different ways. By using properties of a process definition language, the model can prescribe as well as log the workflow of a collaboration process. The workflow of a problem solving process can, e.g., be prescribed by relating a process entity to phase entities such as 'problem definition', 'solution search', 'solution generation', 'solution evaluation' and 'solution implementation' (Knoll et al. 2013). As each phase can require a different group composition, a phase entity is related to a group entity, which requires participants with specific roles. Each phase itself defines an abstract sequence of possible activities related to predefined components. For example, the activity entity 'to generate a solution' can be related to the component entity 'brainstorming'. An activity sequence defines the possible interaction of a participant with a component. For example, a component entity 'brainstorming' could provide support for the activity sequences AS1: {to view; to create} and AS2: {to view; to create; to comment}. Thereby, the activity sequence AS1 represents a common brainstorming process, whereas the activity sequence AS2 allows brainstorming participants to comment existing contributions.

During a collaboration process, a process log can be created by documenting the executed activities in the process as a relation between the concepts phase, participant, component, activity and data. As it cannot be known before process start, through which phases a group passes, the process log is initialized as a process entity that relates a phase entity to a group entity. During collaboration, the process log relates a participant entity to an executed activity entity, which is defined by the supported activities of a used component. The process log can be refined by searching for patterns or comparing a process log to a predefined collaboration process. Thereby, a specific combination of used components or a specific activity sequence over a period of time can give insights on rules, norms, and structures the group used during collaboration that can be represented as a phase entity.

Besides the workflow of a collaboration process, the semantic model can express contextual process information by using properties of the given ontology-based approach. For example, the semantic model provides contextual information about the individual group members by the properties and relations of the concepts participant and skill. Similar to Wang et al. (2006), this information can be improved by connecting the Friend of a Friend ontology (FOAF 2010) to the concept participant to describe the individual group members, their activities and their relations to each other in more details. Contextual information about a collaborative task is given by the concept objective, which defines the goal for a phase or the whole collaboration process. This information can be improved by relating the concept process to an ontology such as the organization ontology (Organization Ontology 2013) that described organizational structures of an organization in which collaboration processes occur.

21.6 A Context-Sensitive Intervention Approach

In this section, the application of the semantic model to define context-sensitive interventions for context-aware systems that support collaboration in dynamic environments is discussed. Assuming that contextual information of a collaboration processes can be used to monitor the performance of a group during collaboration, such information can be used to define interventions as of event-condition-action (ECA) rules (Goh et al. 2001). The semantics of an ECA rule (ON event IF condition DO actions) is defined as follows:

- *Event*: The concept of an event specifies the situation in which a rule is used to coordinate the use of possible interventions that are related to this situation.
- *Condition*: The concept of a condition defines a logical test that, if satisfied or evaluated to be true, causes the action to be carried out. The expression of a condition can make use of given logical operations and can refer to the concepts of the semantic model. With regard to the concept of interventions (Westley and Waters 1988), a condition combines the stages of an intervention to recognize and interpret symptoms of a process problem.
- *Action*: The concept of an action defines a change or update in a collaboration process. Thereby, the concept of action can support collaboration by adapting the collaboration process (action intervention) or by providing awareness information to the individual group members (interpretation intervention).

Related to Niederman et al. (2008), context-sensitive interventions can be defined at different levels:

- *Design level*: These interventions guide individual group members in choosing appropriate tools, techniques, and participants to structure a collaboration process that is effective in achieving an intended goal.
- *Execution level*: These interventions guide a group step-by-step through the collaboration process and adapt its workflow if needed.
- *Activity level*: These interventions analyze the structure of activities of a collaboration process and provide support to adapt these activities to stimulate effective, efficient and rigorous problem solving.
- *Behavior level*: These interventions focus on behavior of a group during a collaboration process to stimulate positive and prevent negative group behaviors.

A possible application of the ECA rule approach is the design of a context-sensitive interpretational intervention for the social loafing theory (Diehl and Stroebe 1991). This theory describes the tendency of participants to expend less effort when they believe their contributions are dispensable and not needed for group success. The effect increases with increasing group size and can be reduced when participants believe that they are being evaluated as individuals rather than collectively as a group. As group size affects this group behavior, a context-sensitive intervention rule can be related to the number of individual group members in a collaboration process. Furthermore, indicators such as the number of contributions or the time between two contributions can be monitored during the process. A possible condition

```
01    interpretationIntervention reduceSocialLoafing (Activity a)
02    componentset c = a.isActivityOf().consistsOfActivity().usesComponent()
03    ON
04              a.activityType == 'navigate'
05    IF
06    a.isActivityOf().phaseType == 'solutionGeneration' AND
07    a.isActivityOf().requiresGroup().getGroupSize() > 7 AND
08    checkIdeaFlowDeviation(c, 'brainstorming', 2 ) == TRUE
09    DO
10    provideRecommendation( "The system detects a possible social loafing effect.
11    Please keep in mind that every contribution is valuable and needed to find a
12    solution for the problem situation. If a participant needs helps please do not
13    hesitate to ask other participants for help.")
```

Fig. 21.3 Syntax of the context-sensitive interpretational intervention: reduceSocialLoafing

for an intervention can be the situation that a group has a constant contribution flow instead of one individual group member with a high time factor between two contributions. At a certain discrepancy level between individual contribution rate and average group contribution rate, an interpretation intervention can inform the group about this situation and suggest approaches to overcome this situation.

Figure 21.3 represents the syntax of an interpretational intervention rule to monitor and reduce social loafing. The rule makes use of the semantic model for dynamic collaboration processes (shown in Fig. 21.2) to monitor the workflow of a collaboration process and capture contextual process information. During a collaboration session, the relations between the concepts of the semantic model define a collaboration data stream. By monitoring the collaboration data stream the interpretational intervention rule is triggered by the execution of an activity of the activityType: 'navigate' (see Fig. 21.3, Line 04), which represents the situation in the workflow in which the group activates a new phase of a collaboration process. With regard to the introduced semantic model, the rule checks the conditions if the related phase of the event activity is of the phaseType: 'solutionGeneration' (see Fig. 21.3, Line 06) and if the active group involves more than seven participants (see Fig. 21.3, Line 07). Furthermore, the rule uses the function 'checkIdeaFlowDeviation()' (see Fig. 21.3, Line 08) to check whether the group uses the component: 'brainstorming' and if the deviation between the individual idea flow rate and the average group idea flow rate is more than two minutes. In the data stream, the relation between the concepts 'activity' and 'component' (shown in Fig. 21.2) represents the used component. Furthermore, the function uses the relation between the concepts 'participants', 'activity' and 'data' to calculate the idea flow deviation. If the conditions are true, a context-aware system can provides a popup window to the participants with awareness information (shown in Fig. 21.3, Line 10–13).

21.7 Related Work and Discussion

The introduced context-sensitive intervention approach represents a possible application of a semantic model that combines properties of a process definition language to express the workflow of a collaboration process with given ontology-based approaches to capture contextual process information.

In the research field on context, different approaches exist to control the physical actions of a human or computational agent situated in a simulation or in the real world. For example, the context-based reasoning approach decomposes knowledge about human behaviors into a hierarchy of contexts to represent human performance during a process (Gonzalez et al. 2008). At the top of the context hierarchy, a mission context provides knowledge on a process and a sequence of control contexts that could be implemented by an agent during the process. Thereby, a control context contains the actions and procedures relevant to a specific situation as well as transition rules to recognize when a transition to another control context is required. In this context, Gonzalez et al. (2008) introduced a formal description to express the behavior of an agent in a process in a context-based reasoning model. Furthermore, Barrett and Gonzalez (2011) extend the context-based reasoning approach to formalize collaborative behaviors. The resulting collaborative context-based reasoning approach is based on the concepts of the joint intention theory and express the communication among the agents.

As the design process of a context model has to include the experience of human experts to model the necessary knowledge associated, the given approaches seem to be suitable to express well-known collaboration processes. The introduced context-sensitive intervention approach can make use of the hierarchically approach to structure and organize process interventions with regard to the possible collaboration contexts of a process. Thereby, concepts of the semantic model for dynamic collaboration processes can be used to describe a context in a machine-readable description, which can be used by a context-aware system to monitor the collaboration context and adapt the process if needed. However, to monitor collaboration in dynamic environments, where external events can lead to an unpredictable change in the collaboration context, context models need to be adapted and extended to new situation, which evolve during collaboration.

In this chapter, it is assumed that the semantic model can be used to log the context of a collaboration process. Such a process log can be used by experts in collaboration to search for patterns or to compare a given collaboration context to predefined context models. As each collaboration process is unique, context-sensitive interventions must be adapted to be efficient in another collaboration context. Here, the formalism of a contextual graph Brézillon (2007) seems to be a suitable approach to represent and compare similar collaboration processes. To express experience in decision-making, a contextual graph represents a task realizing, and paths correspond to different practices developed by experts for realizing the task. The formalism further allows the incremental enrichment of experience by the refinement of existing practices. This property of a contextual-graph could be used to represent expert knowledge about process interventions. During the analysis of process logs of similar collaboration tasks, experts in collaboration can use a contextual graph to document possible identified process problems. Contextual nodes can be used to express differences between similar collaboration processes such as the initial collaboration context as well as distinctive changes of the collaboration context during the process. Experts can further use action elements to document possible context-sensitive interventions that correspond to a given contextual node. These interventions represent the experience of the experts for a specified context and make use of the introduced ECA approach to define conditions that can be evaluated by a context-aware system. The resulting contextual-graph can be improved over time by the refinement of possible new contextual nodes as well as context-sensitive interventions.

To sum up, in this chapter research about a context-sensitive intervention approach is described that intends to support elastic collaboration in dynamic environments. Based on a review of existing theories on collaboration performance, it is discussed how contextual process information can be used to monitor group performance during collaboration. A first approach of a semantic model is introduced that can be used to capture, share and reuse information about a process definition and contextual information. An application of the semantic model is discussed to define context-sensitive intervention for collaboration processes. Here, the ECA rules concept is used to describe the relation between an intervention and a specific collaborative situation.

Finally, more research is needed to understand the relation between these indicators and the performance of a group in a specific situation. Currently, the semantic model is deployed in a context-aware system for collaboration (Janeiro et al. 2013) to evaluate the semantic model and possible intervention rules. Resulting knowledge can then be used to improve the existing semantic model and to provide new services to handle negative group behaviors in collaboration processes.

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References

Ardissono, L., Bosio, G.: Context-dependent awareness support in open collaboration environments. User Model. User-Adap. Inter. **22**(3), 223–254 (2012). doi:10.1007/s11257-011-9100-1

Barrett, G., Gonzalez, A.J.: Effective agent collaboration through improved communication by means of contextual reasoning. Int. J. Intell. Syst. **26**(2), 129–157 (2011). doi:10.1002/int.20458

Bazire, M., Brézillon, P.: Understanding context before using it. In: Dey, A., Kokinov, B., Leake, D., Turner, R. (eds.) Modeling and Using Context. Lecture Notes in Computer Science, vol. 3554, pp. 29–40. Springer, Heidelberg (2005)

Brézillon, P.: Context modeling: task model and practice model. In: Kokinov, B., Richardson, D.C., Roth-Berghofer, T.R., Vieu, L. (eds.) Modeling and Using Context. Lecture Notes in Computer Science, vol. 4635, pp. 122–135. Springer, Heidelberg (2007)

Dennis, A.R., George, J.F., Jessup, L.M., Nunamaker Jr., J.F., Vogel, D.R.: Information technology to support electronic meetings. MIS Quart. **12**(4), 591–624 (1988). doi:10.2307/249135

Dey, A.K.: Understanding and using context. Pers. Ubiquit. Comput. **5**(1), 4–7 (2001)

Diehl, M., Stroebe, W.: Productivity loss in idea-generating groups: tracking down the blocking effect. J. Pers. Soc. Psychol. **61**(3), 392–403 (1991). doi:10.1037/0022-3514.61.3.392

Ferscha, A., Holzmann, C., Oppl, S.: Context awareness for group interaction support. In: Proceedings of the 2nd International Workshop on Mobility Management Wireless Access Protocols (Co-located with Mobicom 2004 Conference). Philadelphia, PA, USA, 26 September–01 October 2004

FOAF: The FOAF vocabulary specification. http://xmlns.com/foaf/spec/ (2010). Accessed 03 Oct 2013

Gallupe, R.B., Dennis, A.R., Cooper, W.H., Valacich, J.S., Bastianutti, L.M., Nunamaker Jr., J.F. : Electronic brainstorming and group size. Acad. Manage. J. **35**(2), 350–369 (1992). doi:10.2307/256377

Goh, A., Koh, Y.K., Domazet, D.S.: ECA Rule-Based Support for Workflows. Artif. Intell. Eng. **15**(1), 37–46 (2001). doi:10.1016/S0954-1810(00)00028-5

Gonzalez, A.J., Stensrud, B.S., Barrett, G.: Formalizing context-based reasoning: a modeling paradigm for representing tactical human behavior. Int. J. Int. Syst. **23**(7), 822–847 (2008). doi:10.1002/int.20291

Haake, J.M., Hussein, T., Joop, B., Lukosch, S.G., Veiel, D., Ziegler, J.: Modeling and exploiting context for adaptive collaboration. Int. J. Coop. Inf. Syst. **19**(1&2), 71–120 (2010). doi:10.1142/S0218843010002115

Hackman, J.R.: The design of work teams. In: Lorsch, J.L. (ed.) Handbook of Organizational Behavior, pp. 315–342. Prentice Hall, Englewood Cliffs (1987)

Janeiro, J., Knoll, S.W., Lukosch, S.G., Kolfschoten, G.L., Brazier, F.M.T.: Designing collaboration support for dynamic environments. In: Proceedings of the International Conference on Group Decision and Negotiation 2012, Recife, Brazil (2012a), 20–24 May 2012

Janeiro, J., Lukosch, S.G., Brazier, F.M.T.: Elastic collaboration support: from workflow-based to emergent collaboration. In: Proceedings of the 17th ACM International Conference on Supporting Group Work, Sanibel Island, FL, USA (2012b), 27–31 October 2012

Janeiro, J., Lukosch, S.G., Radomski, S., Johanson, M., Mecella, M.: Supporting elastic collaboration: integration of collaboration components in dynamic contexts. In: Proceedings of the ACM SIGCHI Symposium on Engineering Interactive Computing Systems, London, UK, 24–27 June 2013

Janis, I.L.: Victims of Groupthink: A Psychological Study of Foreign Decisions and Fiascoes. Houghton-Mifflin, Boston (1982)

Karau, S.J., Williams, K.D.: Social loafing: a meta-analytic review and theoretical integration. J. Pers. Soc. Psychol. **65**(4), 681–706 (1993). doi:10.1037/0022–3514.65.4.681

Knoll, S.W., Janeiro, J., Lukosch, S.G., Kolfschoten, G.L.: A semantic model for adaptive collaboration support systems. In: Hussein, T., Paulheim, H., Lukosch, S.G., Ziegler, J., Calvary, G. (eds.) Semantic Models for Adaptive Interactive Systems, pp. 59–81. Springer, London (2013)

Milliken, F.J., Bartel, C.A., Kurtzberg, T.R.: Diversity and creativity in work groups: a dynamic perspective on the affective and cognitive processes that link diversity and performance. In: Paulus, P.B., Nijstad, B.A. (eds.) Group Creativity: Innovation through Collaboration, pp. 32–62. Oxford University Press, New York (2003)

Niederman, F., Briggs, R.O., de Vreede, G.J., Kolfschoten, G.L.: Extending the contextual and organizational elements of adaptive structuration theory in GSS research. J. Assoc. Inf. Syst. **9**(10), 633–652 (2008)

Nunamaker Jr., J.F., Dennis, A.R., Valacich, J.S., Vogel, D., George, J.F.: Electronic meeting systems to support group work. Commun. ACM **34**(7), 40–61 (1991). doi:10.1145/105783.105793

Nunamaker Jr., J.F., Reinig, B.A., Briggs, R.O.: Principles for effective virtual teamwork. Commun. ACM **52**(4), 113–117 (2009). doi:10.1145/1498765.1498797

Oliveira, F.F., Antunes, J.C.P., Guizzardi, R.S.S.: Towards a collaboration ontology. In: Proceedings of the 2nd Workshop on Ontologies and Metamodeling in Software and Data Engineering (Co-located with SBES/SBBD 2007), Pessoa, Brazil, 17 October 2007

Organization Ontology: The Organization Ontology Specification. http://www.w3.org/TR/vocab-org/ (2013). Accessed 03 Oct 2013

Pattberg, J., Fluegge, M.: Towards an ontology of collaboration patterns. In: Proceedings of the 5th International Workshop on Challenges in Collaborative Engineering, Cracow, Poland, 11–13 April 2007

Reiter, M., Houy, C., Fettke, P., Loos, P.: Context-sensitive collaboration in service processes through the integration of telecommunication technology and business process management. In: Proceedings of the 46th Hawaii International Conference on System Sciences, Wailea, Maui, HI USA, 07–10 January 2013

Sarin, S., McDermott, C.: The effect of team leader characteristics on learning, knowledge application, and performance of cross-functional new product development teams. Decision Sci. **34**(4), 707–739 (2003). doi:10.1111/j.1540–5414.2003.02350.x

Schilit, B., Theimer, M.: Dissemination active map information to mobile hosts. IEEE Network **8**(5), 22–32 (1994). doi:10.1109/65.313011

SmartVortex: The SMART VORTEX project. http://www.smartvortex.eu/ (2014). Accessed 01 May 2014

Tajfel, H.: Social identity and intergroup behaviour. Soc. Sci. Inform. **13**(2), 65–93 (1974). doi:10.1177/053901847401300204

Terveen, L.G.: An overview of human-computer collaboration. Knowl-Based. Syst. **8**(2–3), 67–81 (1995). doi:10.1016/0950-7051(95)98369-h

van der Aalst, W.M.P., ter Hofstede, A.H.M., Kiepuszewski, B., Barros, A.P.: Workflow patterns. Distrib. Parallel Dat. **14**(1), 5–51 (2003). doi:10.1023/A:1022883727209

Vieira, V., Tedesco, P., Salgado, A.C.: Towards an ontology for context representation in groupware. In: Fuks H., Lukosch S.G., Salgado A.C. (eds.) CRIWG 2005: Groupware: Design, Implementation, and Use. 11th International Workshop, Porto de Galinhas, Brazil, 25–29 September 2005. Lecture Notes in Computer Science (Information Systems and Applications, incl. Internet/Web, and HCI), vol. 3706, pp. 367–375. Springer, Heidelberg (2005)

Wang, G., Jiang, J., Shi, M.: A context model for collaborative environment. In: Proceedings of the 10th International Conference on Computer Supported Cooperative Work in Design, Nanjing, 3–5 May 2006

Westley, F., Waters, J.A.: group facilitation skills for managers. Manage. Learn. **19**(2), 134–143 (1988). doi:10.1177/135050768801900207

Wood, D.J., Gray, B.: Toward a comprehensive theory of collaboration. J. Appl. Behav. Sci. **27**(2), 139–162 (1991). doi:10.1177/0021886391272001