Collaboration Process Design for Ideation in Distributed Environments

Approaches to Support Collaborative Ideation in Global Virtual Groups using Technological Support

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Abstract

Die vorliegende Arbeit betrachtet das Forschungsgebiet der Entwicklung von kooperativen Gruppenprozessen und verfolgt zwei Forschungsziele: die Verbesserung von kooperativen Ideenentwicklungsprozessen im Innovationsprozess, sowie die Entwicklung von technischen Lösungen zur Unterstützung von kooperativen Ideenentwicklungsprozessen in virtuellen Gruppen.

Zur Verbesserung von kooperativen Ideenentwicklungsprozessen im Innovationsprozess stellt die Arbeit einen neuen Entwicklungsansatz vor, der neben den sozialen und interaktiven Prozess einer Gruppe, deren kognitiven Ideenentwicklungsprozess berücksichtigt. Die Arbeit stellt hierzu eine Untersuchung über den Einfluss bestehender Kreativitätstechniken auf den kognitiven Ideenentwicklungsprozess einer Person vor. Die Forschungsergebnisse zeigen, dass bestehende Kreativitätstechniken drei grundlegende mentale Prinzipien verwenden, die durch die Verwendung von externen Reizen den kognitiven Ideenentwicklungsprozess einer Person leiten bzw. unterstützen können. Die Arbeit sieht in diesen mentalen Prinzipien einen interessanten Ansatz, um den Ideenentwicklungsprozess im Innovationsprozess effizienter zu gestalten, da durch die gezielte Verwendung von mentalen Prinzipien die Entwicklung bestimmter Ideen unterstützt werden kann. Untersuchungen zeigen aber das bestehende Entwicklungsansätze diese mentalen Prinzipien nur bedingt unterstützen. Die Arbeit führt daher einen neuen Ansatz zur Entwicklung von kooperativen Ideenentwicklungsprozessen ein. Dieser Ansatz kombiniert verschiedene Entwurfsmuster zur Gestaltung eines kooperativen Gruppenprozesses, zur Unterstützung des kognitiven Ideenentwicklungsprozesses, sowie zur Gestaltung eines Umfelds dar, welches den kooperativen Ideenentwicklungsprozess unterstützt. In diesem Zusammenhang untersucht die Arbeit den Einfluss von Reizen auf den kognitiven Ideenentwicklungsprozess, um Regeln zur Verwendung der mentalen Prinzipien zu entwickeln.

Zur Unterstützung von kooperativen Ideenentwicklungsprozessen in virtuellen Gruppen stellt die Arbeit eine technische Lösung in Form einer Groupware Technologie vor, die sich flexibel an verschiedene kooperative Prozesse anpasst und die Teilnehmer bei der Durchführung eines Prozesses unterstützt. Die Arbeit sieht in einer formalen, maschinenlesbaren Beschreibungssprache für kooperative Gruppenprozessen einen interessanten Ansatz zur Entwicklung einer solchen technischen Lösung. Hinsichtlich der Unterstützung von virtuellen Gruppen muss diese Beschreibungssprache detaillierte Anweisungen zur Koordination und Moderation eines Gruppenprozesses enthal-

ten. Bestehende Ansätze zur Prozessbeschreibung zeigen jedoch Schwachstellen hinsichtlich der Eindeutigkeit von Prozessschritten auf. Die Arbeit führt daher das Konzept eines ThinXel als atomare Aktivität eines Teilnehmers ein und kombiniert dieses Konzept mit bestehenden Konzepten, um die Aktivitäten einer Gruppe und deren Verlauf in einem kooperativen Prozess zu beschrieben. Die resultierende Beschreibungssprache unterstützt zwei Darstellungsarten: eine grafische Prozessdarstellung zur Unterstützung des Entwicklungsprozesses eines kooperativen Gruppenprozesses, sowie eine semantische Prozessdarstellung zur formalen Beschreibung des kooperativen Workflows in einer maschinenlesbaren Form. Diese semantische Prozessdarstellung stellt weiterhin detaillierte Konfigurationsinformationen zur Verfügung. Beide Darstellungsarten können zur Beschreibung von kognitiven Ideenentwicklungsprozessen genutzt werden.

Als eine mögliche technische Lösung zur Unterstützung des kooperativen Ideenentwicklungsprozesses in virtuellen Gruppen wird ein webbasierter Prototyp auf der Basis eines Workflow Management Systems vorgestellt. Die Arbeit stellt einen Algorithmus zur Führung der Teilnehmer durch einen beschriebenen kooperativen Gruppenprozess vor. Dieser Algorithmus nutzt die formale Beschreibungssprache zur Berechnung der aktuellen Position eines Teilnehmers in einem definierten Prozess und ermöglicht die automatische Anpassung des Systems, durch das Auslesen der Konfigurationsinformationen der aktuellen atomaren Aktivität. Der Nutzen eines solchen technischen Lösung wurde in verschiedenen Anwendertests im universitären Umfeld untersucht. Die Forschungsergebnisse unterstützen die Annahme das ein solches System kooperative Ideenentwicklungsprozesse auch im virtuellen Umfeld unterstützen kann.

Contents

List of Figures

List of Tables


introduction
research approach
collaboration process design
process
collaboration
innovation
design science
structure of the thesis
design
research
innovation process
approach
support
ideation
thesis
environment
organisations
virtual
pre-development
interested
chapter
technological
researchers
introduces
provide
modelling
processes
phase
need
used

Chapter 1

Introduction

1.1 Overview

The research focus of this thesis lies in the field of collaboration process design and pursuses two objectives. One objective is the improvement of the collaboration process design for ideation processes that support the pre-development phase of an innovation process. To reduce uncertainties in this phase, the thesis introduces an engineering approach for the design of collaborative ideation processes that support the generation of predictable results. This design approach aims at organisations and researchers who are interested in the design of collaborative ideation processes in a face-to-face as well as virtual environment.

Another research objective is related to the need for technological support to improve collaborative ideation processes in a virtual environment. The thesis introduces a new modelling approach that formalises a collaboration process into a machine-readable process description. This formalisation can be used to design adaptable groupware technologies that provide functionalities and methods to support the design, configuration and execution of a collaboration process in a virtual environment. Contributions of this modelling approach are aimed at researchers and organisations who are interested in collaboration in global virtual groups using technological support.

In order to understand the motivation of this research, this chapter discusses the need for collaboration and its challenges for organisations. A research approach is presented which is used to close given research gaps. The chapter ends with an overview of the thesis structure to provide support for the readers.

1.2 Need for collaboration and resulting challenges

Today's world is characterised by rapid changes in cultures, ecologies, economies, governments and technologies which influence our life in positive and negative ways. For example, technological changes like the introduction of the World Wide Web have improved the quality of life by offering information, entertainment and communication across the globe. At the same time, changing demographics and increasing urbanisation have lead to global challenges like the management of world's water supplies or the achievement of climate stability.

In this world, profit and non-profit organisations operate in a global economy, which is characterised by the liberalisation of markets and an ever growing number of new products and services. Their competitive positions are influenced by changing circumstances like the introduction of new or improved products by competitors or the expiration of their patent protections. To remain competitive, organisations require a steady portfolio of new products and market strategies. The management of an existing portfolio can be supported by an innovation process; a multi-stage process that combines a variety of techniques and methods to analyse market situations, define strategic goals, and generate and implement ideas for new products and market strategies [Cooper, 1988].

The overall performance of an innovation process depends on the extent to which given knowledge resources of an organisation can be used to create new values for the organisation [von Krogh, 1998]. Besides documented and expressed in words, graphics, and numbers, knowledge is held by employees and customers of an organisation. During the pre-development phase of the innovation process, which ranges from the generation of ideas to either their approval for development or its termination, organisations can use this knowledge for the creation of new ideas and concepts for product improvement and product generation. However, this pre-development phase can be a weak link in the innovation process because 'deficiencies here -poor ideas, too few ideas, and poor screening- result in costly problems in later stages of the process' [Cooper, 1988, pg. 241]. The challenge to design an appropriate pre-development phase is increased by different innovation goals of an organisation, such as the need to design radical or incremental innovations [Herstatt et al., 2004].

During the innovation process, organisations try to obtain synergy effects between their employees and customers by using collaboration. By definition, collaboration is a group process where participants work together to achieve a shared goal [Terveen, 1995]. During the pre-development phase, organisations use collaboration to improve their problem solving and decision making processes. However, the design of an efficient collaboration process can be a challenge for organisations. Research [Dennis et al., 1988, Nunamaker Jr. et al., 1991] indicates that collaboration and its outcomes are affected by different internal and external factors like the characteristics of the participants, the task, the context, and the technology used. Different theories exist that describe and predict the influence of these factors on group behaviour and performance in relation to group communication [Poole and Hollingshead, 2005], group participation [Diehl and Stroebe, 1991, Karau and Williams, 1993, Csikszentmihalyi, 1997] and group cohesiveness [Irving, 1983, Edmondson, 1999]. To handle negative group behaviour and support group performance in collaboration, organisations need shared rules, norms and structures for the design and execution of a collaboration process.

Collaboration support consists of tools, processes and services that support groups during the design and execution of collaboration. With regard to the pre-development phase of an innovation process, idea generation techniques can be used as best work practices to guide the collaborative ideation process of a group [Santanen et al., 2004]. Because organisations may have different strategic goals, such as developing radical, incremental, market or technical innovations [Herstatt et al., 2004], the ideation process needs to be capable of generating different types of ideas. Today, organisations can make use of more that one hundred idea generation techniques to support the generation of ideas [Higgins, 1994, VanGundy, 1988, 2005]. However, most idea generation techniques are generic, i.e. they are presented in a non-problem-specific form, which provides no clear guidelines for the selection or use of a technique with regard to an innovation goal or given group characteristic. As a result, experience is necessary for the selection of an appropriate idea generation technique and the facilitation during the ideation process itself. To support the involved collaboration process, organisations can use professional facilitators who have expertise in design and execution of collaboration. However, economic and political factors can prevent organisations to hire external professional facilitators and to benefit from facilitation intervention [Kolfschoten, 2007].

Briggs et al. [Briggs et al., 2003] assume that the expertise needed for design and execution of a collaboration process can be reduced by packing and transferring knowledge about collaboration. They introduce Collaboration Engineering as a facilitation, design and training approach for collaboration work practices that can be executed without ongoing support from collaboration professionals such as facilitators. To reach this goal, Collaboration Engineering classifies collaboration into six key patterns of collaboration: Generate, Reduce, Clarify, Organize, Evaluate and Build Consensus [Briggs et al., 2006]. Each pattern stands for different reusable collaborative activities of a group that can be used over a period of time to move from a defined starting state to an intended end state of a group [Kolfschoten, 2007].

The concept of thinkLets was introduced as a design pattern to collect, create, document and test collaborative activities of a group [de Vreede and Briggs, 2005, Briggs et al., 2006]. Each thinkLet provides information for its selection and how to create a required pattern of collaboration by using a technology in a defined configuration. Research indicates that groups that are trained in using thinkLets can predictably and repeatably engender the pattern of collaboration that a given thinkLet is intended for, even without any facilitation expertise [de Vreede and Briggs, 2005]. Through this, Collaboration Engineering represents an interesting approach to support collaboration in the innovation process. Organisations could use thinkLets to structure their collaboration processes such as gathering concepts, structuring concepts or generating ideas.

Previous research [Kolfschoten and Santanen, 2007] analysed the use of thinkLets for the design of an ideation process and defined a set of four thinkLets for the pattern Generate: OnePage, LeafHopper, FreeBrainstorm and BranchBuilder. These Generate thinkLets provide different approaches to support ideation in the pre-development phase of an innovation process. However, given research makes no statement about the completeness of these approaches for the design of an ideation process. With regard to the huge number of given idea generation techniques, Generate thinkLets seem only to implement a small number of possible approaches to support ideation. Therefore, the thesis presents an analysis of given idea generation techniques to understand existing approaches for ideation support. Furthermore, the thesis combines the identified approaches for ideation support with the Collaboration Engineering approach and introduces a new design approach for collaborative ideation processes. The thesis uses the following research question:

> *How to improve the design of a predictable and suitable ideation process for the pre-development phase of the innovation process?*

Resulting knowledge of this research can be used to develop guidelines for the design and execution of the pre-development phase of an innovation process, which could reduce uncertainties in an ideation process by generating predictable results for a given innovation goal.

Besides the design of a collaboration process for ideation, this research focuses on technological support for collaboration. This is due to the fact that virtual groups; groups that work in distributed environments and use technological support for collaboration more than collaboration in face-to-face environment [Maznevski and Chudoba, 2000]; comprise an important structural component of many multinational organisations [Nunamaker Jr. et al., 2009]. In order to lower travel and facility costs, organisations use technological support to reduce project schedules or to involve customers in the innovation process. Technological support for collaboration is given by groupware technologies which offer a variety of local and web-based applications to structure collaboration activities and improve group communication [DeSanctis and Gallupe, 1987, Nunamaker Jr. et al., 1991]. Today, different web-based applications for collaboration exist that can be adapted in different ways to implement and support collaboration [Mittlemann et al., 2008]. However, most of these technologies are designed as closed systems, which can make it difficult for organisations to combine different technologies for collaboration without expertise in adapting and using a technology for collaboration.

Considering the possible complexity of a collaboration process, the successful configuration and use of groupware functionalities is fundamental to design predictable and efficient collaboration in virtual groups [DeSanctis and Poole, 1994, Dennis and Valacich, 1993]. With regards to the Technology Transition Model [Briggs et al., 1999], using technological support can lead to a high conceptual and perceptual load, if the user misunderstands the use of a groupware technology for collaboration. To reduce conceptual and perceptual load, a pattern approach can be used to transfer knowledge about the configuration and use of a groupware technology to less experienced users. For example, the concept of thinkLets provides information how to create a required pattern of collaboration by using the functionalities of a groupware technology in a defined configuration. However, design approaches like Collaboration Engineering document a collaboration process model as a paper-based handbook that needs to be closely connected to the used technology. This property reduces the transferability of a collaboration process model to other groupware technologies. As a result, other groupware technologies cannot benefit ad hoc from a given collaboration process model.

To improve the transferability of a collaboration process model to different groupware technologies, a machine-readable process description can be defined as an industry standard. This modelling language for collaboration can provide a foundation to design groupware technologies that support virtual groups in using and combining different technological support for collaboration. Therefore, the thesis analyses given modelling and pattern approaches for collaboration and introduces a new modelling approach that formalises a collaboration process into a machine-readable process description. This formalisation is further used to define a conceptual design for an adaptable groupware technology, which provides functionalities and methods for the design, configuration and execution of a collaboration process in a virtual environment. The thesis uses the following research questions:

> *How to formalise a collaboration process into a machine-readable process description?*
>
> *How to use a machine-readable process description to design an adaptable groupware technology that support collaboration in global virtual groups?*

Resulting knowledge of this research can be used to develop a conceptual design for a groupware technology, which can be used to analyse and design new artifacts to support the design, configuration and execution of collaboration in distributed environments.

1.3 Design science research approach

The thesis focuses on collaboration process design from a business management as well as technological perspective. The objective is to develop theoretical foundations to support collaboration in organisations by using technological support. As a result, a conceptual framework for information system research is used, which combines behavioural science and design science paradigms. Figure 1.1 provides an overview of this research approach; adapted from the Information System Research Framework [Hevner et al., 2004] and the Design Science Research Cycle [Hevner, 2007].

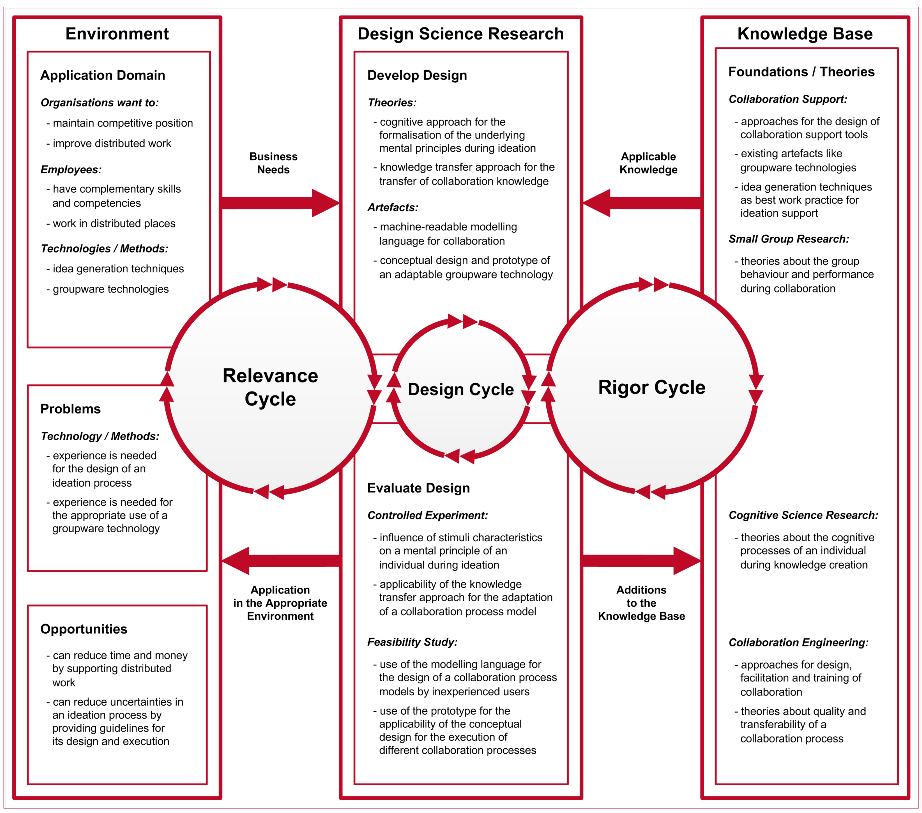

Figure 1.1: Design science research approach adapted from [Hevner et al., 2004, Hevner, 2007]

According to the objective of design science research, the research approach focuses on the development of technology-based solutions for given business needs which result from an organisational context. Three research cycles can be indicated during this design research [Hevner, 2007]:

- The *Relevance Cycle* - initiates design science research with an application environment, that can be defined for an organisation by the capabilities and characteristics of people within an organisation; the strategies, structure, culture, and business processes of an organisation; and the existing technological infrastructure of an organisation [Hevner et al., 2004]. Besides the identification of the business needs, the relevance cycle provides requirements for the research as well as input for the evaluation of the research results.

- The *Rigor Cycle* - uses prior research results from behavioural and design science to define a knowledge base for building and evaluating artifacts that meet the identified business needs. This knowledge base can be divided into foundations for the development phase and methodologies for the evaluation phase of an artifact [Hevner et al., 2004].

- The *Design Cycle* - involves research activities that iterate between the development and evaluation of an intended artifact, based on the environmental analysis and the knowledge base. Besides the development of artifacts as application in the appropriate environment, the design cycle can provide new contributions for the knowledge base [Hevner, 2007].

Based on the design science research approach, the research can be described by the Environment, the Knowledge Base and Design Science Research, which will be described in the next paragraphs.

1.3.1 Environment of this research

The environment of this research is characterised by the objective to improve the reusability and transferability of a collaboration process design for different groupware technologies. This objective could support organisations in the design and execution of collaboration in distributed environments. In this context, the research focuses on the pre-development phase of an innovation process as a field of application. This results from the fact that the design of a pre-development phase using technological support is still a business need for both profit-making and non-profit-making organisations, who need to maintain their competitive position.

The application domain for these organisations can be characterised by the use of collaboration as a business process to obtain business strategies; such as to maintain its competitive position by generating predictable ideas for new products and services or to improve work between people in distributed environments by using technological support. The collaboration process can be characterised as a process that involves people with complementary skills and characteristics. For example, during the pre-development phase of the innovation process, organisations use knowledge of engineers, designers and customers for the creation of new ideas for product improvement.

The technological infrastructure is characterised by groupware technologies that offer a variety of specific applications to structure collaboration activities and improve group communication. Considering the complexity of a collaboration process, the faithful configuration and use of a groupware technology can be a challenge for organisations with less experience in using technological support for collaboration. Furthermore, best work practices for ideation support such as idea generation techniques are generic and provide no clear guidelines for organisations for their use in the pre-development phase of an innovation process.

1.3.2 Knowledge base of this research

The knowledge base of this research is characterised by several research domains such as the cognitive, behavioural and design science, which provide theories and approaches for the design, implementation and evaluation of collaboration. For example, small group research [Poole and Hollingshead, 2005] provides theories that explain or predict group behaviour and performance during collaboration. Methods of cognitive science [Lubart, 2001] are used to develop and verify theories that explain the cognitive processes of an individual during knowledge creation and the influence of given methods for ideation support. Methods of behavioural and design science [March and Smith, 1995] are used to develop artifacts that improve technological support for collaboration. Further, this research focuses on given collaboration support approaches from the research field of Computer Supported Cooperative Work [Grudin, 1994] as a knowledge base that combines engineering approaches such as Software Engineering [Jacobson et al., 1992, Gamma et al., 1995] and Business Process Engineering [Scheer, 1998] with different pattern design approaches [Alexander et al., 1977, van der Aalst et al., 2003, Briggs and de Vreede, 2003, Schümmer and Lukosch, 2007].

1.3.3 Design science approach of this research

Based on the environment and the intended knowledge base, the design science approach of this research involves different iterative phases which are described in more details in the next paragraphs.

Literature review and requirement definition

The research analyses the pre-development phase of an innovation process from multiple perspectives. A cognitive science perspective is used to identify methods and theories to analyse the cognitive processes of an individual during ideation and to formalise the underlying principles of given idea generation techniques. From the perspective of behavioural science, collaboration is analysed with a focus on the behaviour factors that influence the collaboration process. The thesis uses a functional perspective [Poole and Hollingshead, 2005, Romano et al., 2007, Wittenbaum et al., 2004] on collaboration processes like ideation [Diehl and Stroebe, 1991, Nijstad et al., 2002] and group decision making [Poole and Hollingshead, 2005]. The resulting factors are used to define a quality construct for collaboration which is used to evaluate the artifacts of this research.

Based on the resulting knowledge base, the concept of thinkLets is analysed with regard to possible restrictions for the design of an ideation process. The results indicate that given Generate thinkLets provide only a small number of possible approaches for ideation support. Furthermore, no clear guidelines exist for the selection or appropriate use of a Generate thinkLet for possible given innovation goals of an organisation.

Literature on technological support for collaboration is analysed to identify given groupware technologies and approaches for their classification and comparability. A theoretical analysis of different groupware tools provides requirements for a groupware technology that supports collaboration in global virtual groups. Further, this research analyses different collaboration workshops to identify key concepts of a collaboration process that need to be described by a machine-readable process description. Resulting factors are combined with the concepts and methods of the Collaboration Engineering approach to define requirements for a Collaboration Modelling Language; a machine-readable process description that uses a pattern approach to describe the workflow of a collaboration process.

Design of theories and artifacts

The thesis uses methods of the behavioural and design sciences to develop artifacts [March and Smith, 1995, Hevner et al., 2004] that are both relevant and effective for the research objectives to improve the reusability and transferability of a collaboration process model to different groupware technologies and to improve the design of a predictable and suitable ideation process. As in research [Finke et al., 1992, Nijstad and Stroebe, 2006, Santanen et al., 2004, Welling, 2007], a creative cognition approach is used to specify and study the cognitive processes of an individual during knowledge creation. The thesis uses the cognitive approach to formalise the underlying mental principles of given idea generation techniques. Furthermore, the thesis combines the identified approaches for ideation support with the Collaboration Engineering approach and introduces an new design approach for collaborative ideation processes.

A user-centered design process [Jokela, 2002] is used to develop a machine-readable modelling language for collaboration as well as a conceptual design for an adaptable groupware technology that supports collaboration in global virtual groups. The resulting Collaboration Modelling Language makes a distinction between a logical and physical process model and provides different pieces of process information to define the workflow of a collaboration process. The thesis sees the quality of facilitation as a key issue for collaboration success and analyses the concept of thinkLets as a pattern approach for facilitation knowledge. The research shows that given abstract rules of a thinkLet can leave open the question which facilitation instruction should be used to achieve the intended actions that are needed to engender a pattern in collaboration. As a result, this research enhances the concept of a thinkLet by introducing a formal instruction element called thinXel. Further, this research introduced a knowledge transfer approach to transfer necessary knowledge for the adaption and execution of a collaboration process.

Based on the developed artifact of a Collaboration Modelling Language, this research develops a conceptual design of an adaptable groupware technology that provides functionalities to support the design, execution and data management of a collaborative process. A key value in this design is a Participant Flow Algorithm, which uses the properties of the modelling language to compute the activities of the participants during the collaboration process.

Evaluation of the artifacts

This research uses different design evaluation methods to evaluate the resulting artifacts. A controlled experiment is used to evaluate the underlying mental processes of an individual during knowledge creation. In this context the influence of stimuli characteristics on one mental principle is analysed in a controlled environment with a group of students.

A feasibility study is used to evaluate the possible application of the graphical representation of the Collaboration Modelling Language to design different collaboration process models. Here, a group of students is trained in the Collaboration Engineering approach and the graphical and semantical notation of the modelling language. The students are requested to use the modelling language during a one-semester undergraduate student project to develop collaboration process models for different scenarios. During the project different interviews have been conducted to analyse the used process models and the applicability of the modelling language for collaboration process design.

An expert evaluation and a functional test is used in a controlled experiment to evaluate the Knowledge Transfer Approach for the semantical representation of the Collaboration Modelling Language. During this experiment, a group of students use a software application to configure a logical process design according to a predefined task and group characteristic.

The conceptual design for an adaptable groupware technology is evaluated by a prototype that implements different collaboration processes. A feasibility study is done with different physical collaboration process models, which are executed by a distributed group of students.

1.4 Structure of the thesis

To provide support for the readers, this chapter ends with an overview of the structure that is used to present the research of this thesis and the resulting artifacts.

In *Chapter 2* the knowledge base of collaboration research is presented by concepts, theories and approaches which are needed to understand the research and the resulting artifacts. Besides giving an overview on collaboration and existing theories that describe and predict factors which influence the collaboration process, the chapter presents possible collaboration support like the Collaboration Engineering approach. The thesis discusses possible research gaps of the presented approaches for the design of an innovation process as well as for its use with given technological support for collaboration in global virtual groups.

Based on the knowledge base, *Chapter 3* focuses on the research question: *How to improve the design of a predictable and suitable ideation process for the pre-development phase of the innovation process?* A cognitive model for ideation is used to analyse the underlying mental principles of given idea generation techniques. The research results show that given idea generation techniques can be formalised and categorised into three mental principles which support cognitive processes for knowledge creation. The chapter argues why given Generate thinkLets do not support these mental principles. As a result, the thesis combines the identified approaches for ideation support with the Collaboration Engineering approach and introduces an new design approach for collaborative ideation processes. The chapter ends with a discussion how this new design approach can be used to reduce uncertainties in a collaboration process and to support the generation of predictable results.

In *Chapter 4* the thesis focuses on the research question: *How to formalise a collaboration process into a machine-readable process description?* The chapter presents requirements for a Collaboration Modelling Language; a machine-readable modelling language for collaboration processes. The concept of a thinXel is introduced as a formal instruction element that can be used to improve the given concept of thinkLets. The thesis presents a first approach of a graphical and semantical representation of a modelling language that uses the concepts of thinXel and thinkLet to describe the workflow of a collaboration process. In addition, a Knowledge Transfer Approach is presented for the transfer of necessary knowledge for the adaption and execution of a collaboration process for groups with low expertise in collaboration.

A conceptual design for an adaptable groupware technology is presented in *Chapter 5*. Based on the research question: *How to use a machine-readable process description to design an adaptable groupware technology that support collaboration in global virtual groups?*, the chapter discusses how the basic characteristics of Workflow Management Systems can be combined with the Collaboration Modelling Language to develop an adaptable groupware technology that support the design, adaptation, execution of a collaborative process. A Participant Flow Algorithm is presented which uses the properties of the modelling language to compute the activities of the participants during the collaboration process. The chapter closes with a discussion how the conceptual design can be used to support collaborative ideation in virtual groups.

The thesis closes in *Chapter 6* with a discussion of the research results and an outlook on further research.


knowledge base
collaboration research
theories on collaboration
technological support
global virtual groups
group participation
collaboration
collaboration process design
collaboration engineering
research gaps
group communication
group cohesiveness
thinklet
thesis design
groupware
technology
process
support
approach
used
discussed
theories

Chapter 2

Knowledge base of collaboration research

2.1 Overview

This chapter presents the knowledge base of collaboration research. Besides giving an overview on collaboration, basic theories on collaboration will be discussed, which describe and predict factors that influence group behaviour in collaboration.

The chapter focuses on the use of groupware technologies as a technological approach to support collaboration in global virtual groups. Collaboration Engineering is presented as a design approach to support the design and execution of collaboration processes that can make use of groupware technologies.

The chapter closes with a discussion about given research gaps in collaboration process design and the need for new approaches to improve collaborative ideation processes in global virtual groups.

2.2 Collaboration

2.2.1 Definition of collaboration

A focus point of this research is Collaboration, which can be defined as '*the act of working with another person or group of people to create or produce something*' [Dictionary, 2011]. More specific definitions for collaboration are given by different research fields. From behavioural science '*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, pg. 146]. Computer Science focuses on collaboration involving technological support and defines collaboration as '*a process in which two or more agents work together to achieve a shared goal*' [Terveen, 1995, pg. 1]. Here, the collaboration process can involve humans as well as computational agents. The thesis focuses on collaboration with regard to the research field of Collaboration Engineering and uses a definition by Kolfschoten who defines collaboration as '*a process in which participants joint effort toward a goal*' [Kolfschoten, 2007, pg. 3].

A number of issues can be considered that arise to this definition of collaboration. In order to obtain synergy effects, the collaboration process combines participants with complementary skills and knowledge. This process involves individual as well as group activities which can be guided by rules, norms, and structures. The resulting effort of each participant is dependent and based on the effort of others that will be shared with each other in an interactive process [Kolfschoten, 2007]. The thesis further assumes that the participants do not need to commit to the goal of the collaboration process but they need to agree to direct their effort to achieve a desired outcome. This assumption results from a view on an open innovation process; a collaborative process that tries to enrich the knowledge base of an organisation by integrating external knowledge, customers and suppliers [Gassmann and Enkel, 2004]. During this process, participants like customers will have different motivations to direct their effort to the collaboration process. However, not every customer will commit to the goal of an organisation to generate new products to maintain a competitive position.

With regard to the pre-development phase of the innovation process, the thesis will focus on collaboration as a knowledge creation and knowledge sharing process of an organisation. Resulting artifacts of this research should increase the quality of the outcome and the collaboration process itself.

2.2.2 Collaboration in global virtual groups

Over the years, the research focus on collaboration has changed from groups whose members work in the same place to geographically distributed virtual teams. This results from the fact that virtual teams comprise an important structural component of many multinational organisations to lower cost factors like travel and facility costs [Nunamaker Jr. et al., 2009]. Katzenbach and Smith [Katzenbach and Smith, 1993] define a team as a small group of participants with complementary skills who share a common goal for which they hold themselves mutually accountable. A global virtual team can be defined as a team, whose members are geographically dispersed and use technological support to work across space, time, cultural and organisational boundaries [Maznevski and Chudoba, 2000, Jarvenpaa and Leidner, 1999].

Besides global virtual teams, the thesis sees potential in distributed work of a group where participants do not hold themselves mutually accountable. With regard to the pre-development phase of the innovation process, a global virtual group can combine customers and engineers in an open innovation process to identify customer needs [Gassmann and Enkel, 2004]. During this process, customers move from being passive recipients of product development to a more active role. However, the resulting group of customers and engineers does not fulfill all requirements of a team (such as to share a common purpose and performance goal). As a result, this thesis focuses on collaboration in distributed groups that uses temporary technological support for collaboration.

2.2.3 Theories on collaboration

The collaboration process and its outcomes are affected by different internal and external factors like the characteristics of the group (such as group size, group proximity and the experience of the individual participant), the task (such as type and complexity of the task), the context (such as organisational culture and environment), and the technology used (such as the communication infrastructure, the supported process techniques or rules) [Dennis et al., 1988, Nunamaker Jr. et al., 1991]. Different theories exist that describe and predict the influence of these factors on group behaviour and performance in relation to group communication, group participation and group cohesiveness.

The thesis focuses on collaboration theories as a theoretical foundation for analysing given approaches for collaboration processes design. The theories used result from a functional research perspective, a normative approach for describing and predicting group behaviour and performance of small groups. This functional perspective is based on the following assumptions: (1) groups are goal-oriented; (2) group behaviour and performance varies and can be evaluated; (3) interaction processes have utility and can be regulated; (4) internal and external factors influence group behaviour and performance via interaction [Poole and Hollingshead, 2005, pg. 22]. Well-known studies included in this perspective focus on collaboration as an ideation process [Diehl and Stroebe, 1991, Nijstad et al., 2002, Nijstad and Stroebe, 2003, Milliken et al., 2003], decision making process [Poole and Hollingshead, 2005, Gouran and Hirokawa, 2003] and group think process [Irving, 1983, Henningsen et al., 2006]. The next paragraphs provides some of these theories which can be found in the literature of small group research.

Theories on group communication

The functional theory of Group Decision Making indicates a direct relationship between group communication and the effectiveness of collaboration [Poole and Hollingshead, 2005]. The theory defines five critical task functions that group communication needs to perform: (a) to develop a thorough and accurate understanding of the problem; (b) to achieve an appropriate understanding of the criteria for an acceptable decision; (c) to generate as many of the possible and realistic contributions as it can from which a good decision can be made; (d) to assess thoroughly and accurately the positive aspects of each alternative; and (e) to discuss the negative aspects of each alternative [Gouran and Hirokawa, 2003].

The thesis adopts the functional theory of group decision making for processes like knowledge creation and knowledge sharing and proposes that a collaboration process for ideation needs (a) to create a behavioural state where participants understand the goal, the task, the process steps of the collaboration process; and (b) to generate as many contributions as possible in relation to the intended goal of the process.

Theories on group participation

Production Blocking is a negative effect of group communication on the effectiveness of collaboration [Diehl and Stroebe, 1991, Nijstad and Stroebe, 2003]. The effect results from the implicit rule that in face-to-face groups only one person speaks at a time. The consequence is that group participants can be prevented from sharing knowledge. In order to not forget their own contributions and to listen to others contributions, participants have to use mental resources until it is their turn to speak. These resources cannot be used to produce new contributions (literature refers to these effects as Attention Blocking or Concentration Blocking). The participants can forget or suppress contributions because they later seem less original, relevant or important. Virtual groups can avoid these types of production blocking by using technological support that enables the participants to contribute at any given time during collaboration [Diehl and Stroebe, 1991]. However, this mode of communication can lead to a new digital form of production blocking that results from the time that is needed to type in a contribution (Communication Speed [Dennis and Williams, 2003]) as well as by the navigation and refresh time of the system.

The Evaluation Apprehension theory predicts that in group work the fear of negative evaluation can influence the performance of the process [Diehl and Stroebe, 1987]. The fear to be criticised for a contribution may cause participants to withhold their contributions during the collaboration process. A virtual group can use technological support to contribute under anonymous conditions, which has a positive effect on fear of criticism [Postmes and Lea, 2000].

The Social Loafing theory describes the tendency of participants to expend less effort when they believe their contributions to be dispensable and not needed for group success [Latane et al., 1979]. The effect increases with increasing group size and can be reduced when participants believe they are being evaluated as individuals rather than collectively as a group [Karau and Williams, 1993]. The opposite effect of social loafing is the Synergy Effect which appears whenever collaboration leads to a result of a group that exceeds the sum of the individual contributions. In a knowledge creation process, synergy can be created when participants use the ideas of other group participants as stimuli for knowledge creation [Hender et al., 2002].

Theories on group cohesiveness

The Social Identity theory predicts that group participants tend to classify themselves and others into various social categories which represent attitudinal, emotional and behavioural similarities between the self and in-group members [Tajfel, 1974]. High group identification can improve the performance of collaboration by creating Psychological Safety [Edmondson, 1999], a positive work climate in which the participants offer contrasting or alternative viewpoints.

The Groupthink effect refers to a behavioural state in which participants withhold their private concerns about the contributions of others due to politeness or feared reprisals

[Irving, 1983]. This group behaviour can have a direct influence on the effectiveness of collaboration; see functional theory of Group Decision Making [Poole and Hollingshead, 2005]. Groupthink can occur when group cohesiveness and a provocative situational context work together and structural defects are presented (such as insulation, lack of leader impartiality, lack of procedural norms and member homogeneity).

Conclusion

The presented theories describe factors that influence the quality of the collaboration process. With regard to the interdependencies of these theories (such as Evaluation Apprehension and Social Loafing), the thesis proposes that shared rules, norms and structures are necessary for global virtual groups to handle negative group behaviours and support group performance in a collaboration process. Support is needed during the design, the adaption and the execution of a collaboration process.

2.3 Technological support for collaboration

Collaboration support is given by tools, processes and services that support groups during the design and execution of collaboration. Besides professional facilitators, knowledge about collaboration is provided in different ways such as handbooks for group facilitation or databases for facilitation methods. The thesis focuses on the design-oriented research field of Computer Supported Cooperative Work (CSCW) [Grudin, 1994] to analyse given technological support for collaboration in global virtual groups. This research field combines engineering approaches such as Software Engineering [Jacobson et al., 1992, Gamma et al., 1995] and Business Process Engineering [Scheer, 1998] with design approaches like the pattern design approach [Alexander et al., 1977, van der Aalst et al., 2003, Schümmer and Lukosch, 2007]. Resulting groupware technologies like Group Decision Support Systems (GDSS) [DeSanctis and Gallupe, 1987], Electronic Meeting Systems (EMS) [Dennis et al., 1988, Grohowski et al., 1990] and Group Support Systems (GSS) [Davison and Briggs, 2000, Dennis et al., 1996] offer a variety of local and web-based applications to assist groups in structuring activities, generating and sharing data, and improving group communication.

Groupware technologies can be classified according to different approaches like the Taxonomy of GDSS by DeSanctis and Gallupe [DeSanctis and Gallupe, 1987], who use factors like group size, member proximity and task type in combination with the degree of information-exchange support by the technology. Another approach is given by the Classification Array for CSCW Systems [Penichet et al., 2007], which combines the Johansen-Time-Space-Matrix [Johansen, 1988] with groupware characteristics like information sharing, communication and coordination. A basic classification and comparison scheme for groupware is given by the Taxonomy of Groupware Technologies by Mittleman et al. [Mittlemann et al., 2008], which focuses on the core functionality, the supported actions or awareness indicators of a technology. The thesis uses this taxonomy to analyse and compare given groupware technologies with regard to their probability of supporting collaboration for global virtual groups with different tasks and group characteristics.

The influence of groupware technologies on collaboration has been analysed in different studies. According to group behaviours, technological support can provide means to improve collaboration by reducing certain negative phenomena such as Social Loafing [Shepherd et al., 1995] or Production Blocking [Diehl and Stroebe, 1987, 1991]. Other researcher [Fjermestad and Hiltz, 1998] found no significant differences between unsupported face-to-face processes and the use of groupware, but concluded that global virtual groups could use distributed technologies to expend time and money needed to travel to a meeting. Similar to Dennis et al. [Dennis et al., 2001], the thesis assumes a dependency between the effectiveness of groupware technology and its appropriate use by the group.

The thesis uses the Technology Transition Model [Briggs et al., 1999, 2001b] as a quality construct to analyse technological support for collaboration by focusing on the amount of mental effort a user must expend to use a technology for collaboration. This amount of mental effort is called Cognitive Load which combines the three dimensions Perceptual Load, Conceptual Load and Access Load. The user friendliness of a technology is represented by the Perceptual Load, which focuses on the amount of mental effort that is required to find and control the features of a groupware technology for collaboration. Conceptual Load specifies the amount of effort that is needed to understand what the technology is supposed to do during the collaboration process. The dimension Access Load describes how much effort is required to gain access to resources, support, and information that are needed by the user during collaboration. With regard to this model, the use of technological support for collaboration can lead to a high cognitive load if the user misunderstands the intended use of a groupware technology for collaboration. In this context, a discussion about existing challenges and principles for effective collaboration in virtual groups by Nunamaker et al. [Nunamaker Jr. et al., 2009, pg. 114, fig. 1] indicates the need for a far more detailed and explicit process description to reduce cognitive load and the dependency on outside expertise.

The quality of a collaboration process and its outcomes can be defined by factors like Efficiency, Effectiveness, Reusability, Predictability and Transferability of a collaboration process [Pinsonneault and Kraemer, 1990, Fjermestad and Hiltz, 1998, den Hengst et al., 2006]. The factors Efficiency and Effectiveness can be measured by quality and quantity of the process results as well as the satisfaction of the participants involved. Reusability defines the portability of a collaboration process; the number of technologies that support this process, as well as the adaptability of a process; the possibility to adapt a process to different group and content constellations. The consistency of a result over repeated uses of a process is defined by the Predictability of a collaboration process and can be measured by differences in input and output of a repeated process. Finally, the Transferability of a collaboration process can be measured by the time and effort needed to use a collaboration process with different technologies.

During the use of technological support for collaboration, organisations can use experts like facilitators to reduce the cognitive load of a global virtual group and to improve the quality of the collaboration process. The influence of facilitation on collaboration has been studied in different ways. Wong and Aiken [Wong and Aiken, 2003] analysed the effect of different facilitation modes on the effectiveness and efficiency of electronic meetings with simple idea generating and ranking tasks. They found significant evidence for the positive influence of human or automated facilitation on the process satisfaction, meeting effectiveness, group cohesiveness and usability of the groupware technology.

Ackermann [Ackermann, 1996] indicates that besides the meeting itself, the facilitator should influence the pre-workshop and post-workshop stages of a collaboration process. Different studies have focused on the roles and tasks of a facilitator [Clawson et al., 1993, Niederman et al., 1993, den Hengst et al., 2007]. For example, Clawson et al. [Clawson et al., 1993] divide the functions of a facilitator into a technical dimension (such as to appropriately select and prepares technology or to create comfort with and promote understanding of the technology) and a process dimension (such as to keep group focused on outcome or to develop the right questions). Groupware technologies can support the role and tasks of a facilitator by using simple interfaces to keep the user learning curve short [Nunamaker et al., 1996, Kolfschoten and Lee, 2010].

Conclusion

Groupware technologies can support collaboration in global virtual groups. However, the use of technological support can lead to a high cognitive load if the user misunderstands the intended use of a technology for a defined collaboration process. To reduce the cognitive load of a global virtual group, organisations can use experts like facilitators to guide a group in using technological support. Unfortunately, economic and internal organisational factors can prevent organisations to make use of facilitation support during the design and execution of a collaboration process. To compensate the missing knowledge, approaches are needed to support the design and execution of collaboration processes for global virtual groups.

2.4 Collaboration engineering

Considering the possible complexity of a collaboration process and the influence of facilitation on the outcome and the process itself, the successful configuration and use of groupware functionalities is fundamental to design predictable and efficient collaboration. Briggs et al. [Briggs et al., 2003] assume that the expertise needed for design and execution of collaboration can be reduced by packing and transferring knowledge about collaboration. They introduced Collaboration Engineering as a facilitation, design and training approach for recurring high-value tasks that provides the benefit of professional facilitation to groups without access to professional facilitators [Briggs et al., 2003].

2.4.1 A collaboration pattern approach

Based on the concept of pattern by Alexander et al. [Alexander et al., 1977], Collaboration Engineering classifies the collaboration process into six patterns of collaboration (state of 2006 [Briggs et al., 2006]):

Generate — *To move from having fewer to having more concepts in the pool of concepts shared by the group. The pattern includes collaboration activities for knowledge creation and knowledge sharing such as the collection of known concepts from the group; the creation of new concepts that were not previously known to all group members; or the improvement of already shared concepts by adding new details.*

Reduce — *To move from having many concepts to a focus on fewer concepts that the group seems worthy of further attention. The pattern includes collaboration activities for selecting a subset of shared knowledge by deriving more-general concepts from specific instances in the existing set or by capturing the essence of the shared concepts without eliminating unique concepts.*

Clarify — *To move from having less to having more shared understanding of concepts and of the words and phrases used to express them. The pattern includes collaboration activities for improving understanding of shared knowledge by proposing alternative explanations and formulations of existing concepts.*

Organize — *To move from less to more understanding of the relationships among concepts the group is considering. The pattern includes collaboration activities for improving understanding of shared knowledge by arranging existing concepts into labeled clusters or by structuring existing concepts according to their conceptual relationships.*

Evaluate — *To move from less to more understanding of the relative value of the concepts under consideration. The pattern includes collaboration activities for knowledge creation by collecting the group opinion with respect to the shared concepts or by identifying an order of preference among the shared concepts.*

Build Consensus	*To move from having fewer to having more group members who are willing to commit to a proposal. The pattern includes collaboration activities for identifying and overcoming the underlying causes of a lack of consensus.*

Briggs et al. used this classification to form a pattern language for collaboration by introducing a design pattern for best facilitation practice called thinkLet [Briggs et al., 2003]. They define thinkLets as named, scripted, reusable, and transferable collaborative activities for creating specific known variations of the six patterns of collaboration among people working together toward a goal [Briggs et al., 2006]. The initial conceptualisation of the design pattern thinkLet involved the three components Tool, Configuration and Script [Briggs et al., 2001a] which provide information for the technical and process functions of a facilitator [Clawson et al., 1993]. The components Tool and Configuration support the technical dimension of facilitation by defining a specific technology used and its appropriate preparation and use to create a pattern of collaboration. A process dimension is given by the component Script which concerns everything a facilitator would have to do or say to handle negative group behaviours and support group performance in a collaboration process using the specified technology.

Research shows that the provided facilitation knowledge of a thinkLet can help groups to predictably and repeatably create the pattern of collaboration the thinkLet is intended for, even without any facilitation expertise [de Vreede and Briggs, 2005]. However, the initial conceptualisation of a thinkLet ties a thinkLet closely to a specific technology in a specific configuration [Kolfschoten et al., 2006]. The use of other technologies requires changes in the three components by an expert, because small changes to a thinkLet script can create significant differences in group interactions [Shepherd et al., 1995].

Kolfschoten et al. [Kolfschoten et al., 2006] introduce with the thinkLet Class Diagram a formal specification of a thinkLet as a technology-independent logical design element. This specification uses the Unified Modelling Language notation to illustrate and define the key concepts and relations of a thinkLet script. An essential component is the concept Rule, whose instances define the Script of a thinkLet. Rules define the actions a participant must take individually in a given role, the constraints under which the actions must be executed and the capabilities that will be required to engender a pattern of collaboration [Briggs et al., 2006]. Intended actions of a participant can be classified into categories like Add, Edit, Relate, Read, Discuss and Judge [Kolfschoten et al., 2004, 2006]. In conclusion, the formal specification of a thinkLet reduce the complexity of given collected thinkLets to fundamental concepts, which allow researchers to understand the effects of facilitation interventions and collaboration process design.

2.4.2 An approach for collaboration process design

Collaboration Engineering uses thinkLets to form a pattern language for the design of collaboration processes. The design approach of Collaboration Engineering distinguishes between the roles of a Collaboration Engineer, a Practitioner and a Participant [Kolfschoten et al., 2011, Briggs et al., 2006]. The role of a Collaboration Engineer is defined as a specialist in collaboration process design, who has expertise in the design and documentation of collaborative work practices using thinkLets. A Practitioner is a task specialist in a specific domain, who has no professional expertise with collaboration process design or facilitation but can learn specific skills for guiding a collaboration process using thinkLets. A Participant is a member of a group, that executes a collaboration process by creating a sequence of different patterns of collaboration. To reach a pattern of collaboration, each participant follows the instructions defined by the thinkLet script.

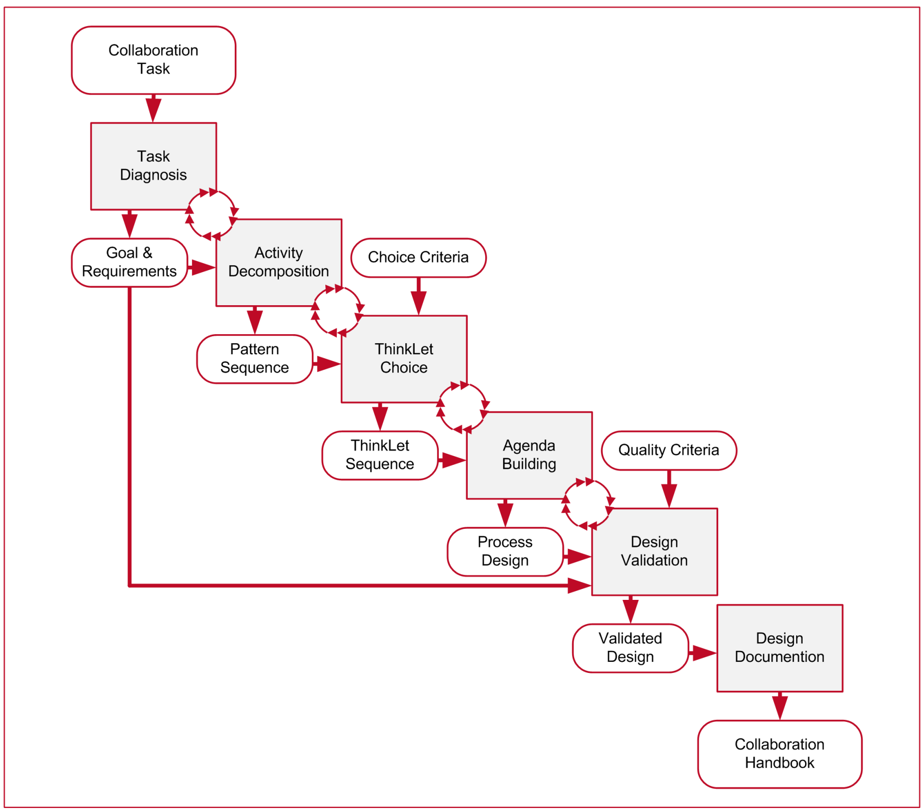

Figure 2.1: Process Design Approach for Collaboration Engineering adapted from [Kolfschoten and de Vreede, 2009]

According to the design approach of a collaboration process [Kolfschoten and de Vreede, 2009] (shown in Figure 2.1), the Collaboration Engineer analyses the collaborative task and the group characteristics to define requirements for the design of a collaboration process. In a second step the collaborative task will be decomposed into patterns of collaboration, which are used to select collaboration techniques (e.g. thinkLets or idea generation techniques) for a logical process model; a template of a collaboration process that contains a general description of collaborative activities for a collaborative task. The logical process model will be validated against the defined requirements in an iterative process and will be documented as a paper-based handbook.

A Practitioner configures the logical process model given by the paper-based handbook to a physical process design; a specific collaborative process that contains detailed descriptions of collaborative activities for a specific group and content constellation. A transition approach is used to transfer tacit knowledge and skills that are needed for this adaptation to practitioners with less expertise [Kolfschoten et al., 2011]. This approach combines lectures about the key concepts of Collaboration Engineering and challenges of a collaboration process with trainings to offer practice and feedback on the adaptation and use of a logical process design.

In conclusion, the given design approach represents and interesting an suitable approach for designing collaboration processes that can make use of technological support in a face-to-face environment. However, the thesis sees an unused benefit of this design approach for collaborative ideation processes that uses technological support in a virtual environment.

2.5 Research gaps in collaboration process design

The thesis focuses on the pre-development phase of the innovation process, which ranges from the generation of ideas to either their approval for development or its termination. The involved collaborative ideation process can be guided by idea generation techniques, which present formalised protocols that provide step-by-step sequences of actions or instructions to guide both the cognitive and social process of a group. Current collections of idea generation techniques provide a large number of techniques but no clear guidelines for the selection or use of a technique with regard to an innovation goal or given group characteristic.

Similar to idea generation techniques, the design pattern of the thinkLet Generate provide a way to guide the collaborative process of a group during ideation. However, from the literature, it remains unclear if the given set of four Generate thinkLets provide all possible approaches represented by existing idea generation techniques. The thesis regards this as a research gap in the research field of collaboration engineering. As a result:

Research is needed to understand existing approaches for ideation support and their application to improve the design approach of collaboration engineering for a collaborative ideation process.

The thesis assumes that resulting knowledge of this research can be used to support the design and execution of collaborative ideation in the pre-development phase of an innovation process. In this context, the thesis focuses on collaboration that uses technological support in a virtual environment. Nowadays, collaboration between geographically distributed groups comprise an important structural component of many multinational organisations. As a result, the research focus on collaboration support has changed from tools, processes and services that support collaboration in a face-to-face environment to technological support for collaboration in a distributed environment. Today, organisations can make use of technological support like groupware technologies that offer a variety of web-based applications to assist global virtual groups in structuring activities, generating and sharing data, and improving group communication across the globe.

Collaboration Engineering supports the appropriately use of groupware technologies by providing tacit knowledge and skills in a paper-based handbook, which can be used to train a global virtual group on how to use the functionalities of a technology in an optimal way. This approach works well for recurring collaborative tasks, where a predefined global virtual group uses a specific groupware technology over a certain period of time. However, the pre-development phase of the innovation process is characterised by changing collaboration tasks and dynamic groups, who constantly needs to be adjusted with regard to the knowledge and expertise required. As a result, a training of each participant is not guaranteed. To compensate the resulting missing knowledge about the groupware technology, a new design approach is needed to support the appropriately use of a technology.

Like other researchers, the thesis sees an interesting approach in using a design pattern approach for the development of new technological support for collaboration. For example, Kolfschoten et al. [Kolfschoten et al., 2007, 2010] adopt the concept of a Computer Aided Software Engineering tool from Software Engineering to Collaboration Engineering. The resulting conceptual design of a Computer Aided Collaboration Engineering (CACE) tool supports the design process of a collaboration process model by a library of different design patterns and guidelines for their selection and combination. The resulting model of a collaboration process can be used in different ways to support collaboration. With regard to a face-to-face workshop, the model provides information to generate printouts like process agendas, process manuals and cue cards for the facilitation of a collaboration process. Collaboration in a virtual environment can be supported by the design of a process model closely to a specific groupware technology. Here, the process manual provides similar to the initial conceptualisation of a thinkLet detailed information on how to configure and use a groupware technology. However, this generation of a specific process model reduces the reusability of the collaboration process model for other groupware technologies. As a result, the adaptation of the model for another groupware technology could lead to a high cognitive load for a practitioner with less expertise in using a groupware technologies.

Another approach for the use of design patterns is given by Briggs et al. [Briggs et al., 2010] who develop a process support system for rapid development of collaboration applications. Their approach uses a collaboration process model to develop a groupware technology that provides only tools and functionalities that fit to the process needs and does not have to be configured by the practitioner. The resulting groupware technology reduces by its pre-configuration the cognitive load for a user, but supports only the underlying collaboration process. As a result, a new groupware technology needs to be developed if the process model needs to be adapted in case of a changing situation.

Besides the given approaches, the thesis sees an unused benefit of a design pattern approach for the development of an adaptable groupware technology. Here, a machine-readable process description can be used to support the appropriately use of a technology by using the workflow of a collaboration process to configure the tools and functionalities of the technology automatically. A workflow can be defined as '*a collection of cooperating, coordinated activities designed to carry out a well-defined complex process*' [Davulcu et al., 1998] or as '*a network of tasks with rules that determine the (partial) order in which the tasks should be performed*' [van der Aalst and Hee, 2002]. The thesis adopts these definitions and defines a collaboration workflow as '*a network of collaborative tasks with rules that coordinate the involved collaboration activities of a group and provide information for the configuration of a groupware technology*'. However, the design of a machine-readable process description for a collaboration workflow is still a research gap. As a result:

> *Research is needed to analyse the feasibility of a new modelling approach that formalises the workflow of a collaboration process into a machine-readable process description.*

The thesis assumes that resulting knowledge of this research can be used to develop an adaptable groupware technology that provides similar functionalities as a Workflow Management System, which represents a system that defines, creates and manages the execution of workflows through the use of software applications [Leymann and Altenhuber, 1994, Hollingshead, 1995, Georgakopoulos et al., 1995]. Similar to the intended CACE tool [Kolfschoten et al., 2007, 2010] a Workflow Management System provides build-time functions for the definition and the modelling of the workflow process and its constituent activities. Further the system provides run-time control functions for the management of the workflow process and the resulting interaction activities between the user and an application in an operational environment.

The thesis assumes that an adaptable groupware technology can make use of the underlying process logic of the collaboration workflow to monitor and guide a global virtual group automatically through a collaborative ideation process. Here, the groupware technology can provide and adapt different user interfaces, which provide all needed information to execute a collaboration process. Furthermore, the groupware technology can provide functionalities to handle negative group behaviours and support group performance in an ideation process. However, the design of a groupware technology that can make use of a machine-readable process description to support collaboration is still a research gap. As a result:

> *Research is needed to analyse the feasibility to design an adaptable groupware technology that uses a machine-readable process description to improve collaborative ideation processes in global virtual groups.*

The thesis assumes that resulting knowledge of this research can be used to develop a conceptual design for a groupware technology, which can be used to analyse and design new artifacts to support the design, configuration and execution of collaboration in distributed environments.

2.6 Conclusion

This chapter presents the knowledge base of collaboration research by concepts, theories and approaches on collaboration in global virtual groups. An overview of existing theories are presented which describe and predict factors that influence the collaboration process. The thesis proposes that shared rules, norms and structures are necessary to support collaboration in global virtual groups. Groupware technologies are discussed as a technological support for collaboration.

According to the possible complexity of a collaboration process, the thesis sees a dependency between the effectiveness of groupware technology and its appropriate use by a global virtual group. As a result the faithful appropriation of a groupware technology is seen as fundamental for the design of predictable and efficient collaboration in distributed environments.

Collaboration Engineering is discussed as a facilitation, design and training approach for collaboration. The thesis indicates unused potential of the used pattern design approach for the design of a machine-readable process description that can be used to develop adaptable groupware technologies as technological support for collaborative ideation processes in global virtual groups.


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research
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Chapter 3

Improving collaboration process design for ideation

3.1 Overview

This chapter analyses the use of a design pattern approach to reduce uncertainties in the pre-development phase of the innovation process. A creative cognition approach is used to analyse the underlying mental principles of given idea generation techniques; best work practices to support the cognitive process of an individual for knowledge creation. The research results show that given idea generation techniques can be formalised and categorised into the three mental principles: Jumping, Dumping and Pumping. The chapter combines the mental principles with given design patterns for collaboration to improve the design approach of Collaboration Engineering for collaborative ideation processes.

3.2 Collaboration and the innovation process

The Innovation Process describes a complex multi-stage, multi-person process that includes the organisation and direction of human and capital resources to generate and implement ideas for new and enhanced products, manufacturing processes and services [Roberts, 2007]. A weak link in this iterative process is the pre-development phase, often called the Front End of Innovation, which ranges from the generation of an idea to either its approval for development or its termination [Cooper, 1988]. Because organisations may have different strategic goals, such as entering new markets or achieving a particular growth rate, different types of innovations need to be generated by the innovation process. In order to increase the probability of obtaining ideas that are suitable for the given innovation goal, the pre-development phase needs to be capable of generating different types of ideas. One approach to achieve such a pool of ideas is to conduct an ideation workshop with a group of participants who share their knowledge for the creation of new ideas in a collaboration process.

An ideation workshop can make use of idea generation techniques to support the generation of different types of ideas. These techniques provide a variety of best work practices to support and guide the collaboration process of the group during ideation [Santanen et al., 2004]. The collaboration process involved can be divided into a cognitive process within individual group members and a social process as group members interact [Dennis et al., 1999]. Here, the cognitive process describes the mental activities of an individual during ideation, which are used to retrieve existing information from knowledge or to generate new ideas by the exploration and transformation of conceptual spaces [Hender et al., 2002]. The social process is defined by the interaction process between the group members, which may influence the performance of an ideation process by resulting group behaviours such as Production Blocking [Diehl and Stroebe, 1991], Evaluation Apprehension [Diehl and Stroebe, 1987] or Social Loafing [Latane et al., 1979].

3.2.1 Idea generation techniques and the ideation process

Today, more than one hundred idea generation techniques can be found in literature on creativity [VanGundy, 1988, Higgins, 1994, VanGundy, 2005]. Most of these techniques provide a step-by-step sequence of actions or instructions to guide the cognitive and social process of a group in an ideation workshop. Several studies have characterised and classified these techniques along different dimensions [VanGundy, 1988, Smith, 1998, Herring et al., 2009]. For example, VanGundy [VanGundy, 1988] subdivided techniques for a creative problem solving process into group and individual techniques and used the dimensions: whether the technique indicates '*verbal*' or '*silent*' generation of ideas; whether ideas are produced by '*forced relationships*' or '*free association*'; and whether the technique uses stimuli that are '*related*' or '*unrelated*' to the given task. However, given classification approaches present idea generation techniques in a non-problem-specific form; providing no guidelines for the selection or use of a technique in relation to an innovation goal. As a result, a group has to rely on its experience with idea generation workshops in order to select an appropriate technique for a given innovation goal.

3.2.2 Groupware technologies and the ideation process

Groupware technologies have changed the innovation process by enabling collaboration in virtual groups across geographical distances. Technologies like ThinkTank™ [GroupSystems, 2010], TeamSupport™ [TeamSupport, 2010] and StreamWork™ [SAP, 2010] implement the ideation process as a divergent thinking process called Electronic Brainstorming; adapted from the face-to-face technique Brainstorming [Osborn, 1963]. In this process, a virtual group uses given groupware functionalities to contribute ideas individually while also reading ideas of others as stimuli for the generation of new ideas. Electronic Brainstorming has been studied with a focus on different factors such as the impact of stimuli type [Hender et al., 2001, 2002] or group size [Gallupe et al., 1992, Valacich et al., 1994]. Research results indicate that under certain circumstances, virtual groups using Electronic Brainstorming can produce more ideas, and more good ideas than groups using the face-to-face counterpart Brainstorming.

Besides Brainstorming, virtual groups could benefit from other idea generation techniques, which provide further approaches to support the creation of new ideas. However, most idea generation techniques were designed to support ideation in a face-to-face workshop; recommending the use of physical tools or materials (e.g. balloons, newspapers or whiteboards) to support the creative process. In literature on creativity, it often remains unclear how these tools and materials influence the cognitive process and social process of a group, as well as how they might be implemented analogously using groupware technologies. As a result, the faithful appropriation of an idea generation technique for ideation in global virtual groups using technological support is still a challenge in collaboration research.

3.2.3 Collaboration process design for the ideation process

In the field of Collaboration Engineering, the concept of a thinkLet has been developed as a design pattern for reusable and transferable collaborative activities which create specific variations of known patterns of collaboration [Briggs et al., 2006]. Similar to an idea generation technique, thinkLets of the pattern Generate define a collaborative process of a group for knowledge creation and knowledge sharing. Kolfschoten and Santanen [Kolfschoten and Santanen, 2007] define a specific set of basic Generate thinkLets and use the concept of a Modifier to influence both the cognitive and the social process of a group. These Generate thinkLets, called OnePage, LeafHopper, FreeBrainstorm and BranchBuilder describe different ways how groups can interact during the ideation process.

Generate thinkLets can make use of Modifiers to support the cognitive process of the individuals and handle negative group behaviours. A Modifier is defined as '*a repeatable variation to create a predictable change in the pattern of collaboration or the result that a thinkLets produces*' [Briggs et al., 2006, pg. 126]. Given Modifiers for thinkLets are Direction, Anonymity, Identification, Commenting, Qualitative Evaluation, Comparative, Carousel, Nominal, Dealing, Limited Input, Osborn and Analogy [Kolfschoten and Santanen, 2007, pgs. 6-8]. Each of these Modifiers alters the described collaboration process of a thinkLet to affect the cognitive or social process of a group in a specific way. For example, the Modifier Anonymity can be used to reduce Evaluation Apprehension by generating ideas in an anonymous collaborative process. Furthermore, the Modifier Direction uses a set of stimuli to guide the cognitive process of the participants.

Given Generate thinkLets are presented in a technology-independent logical design that supports the application of a thinkLet with different groupware technologies. However, from the literature, it remains unclear if the specific set of Generate thinkLets and Modifiers covers the range of possible approaches for ideation support, which are given by published idea generation techniques. Furthermore, the thesis is aware of few studies that analyse the use of thinkLets to support the innovation process [Elfvengren et al., 2009, Fähling et al., 2011]. In conclusion, clear guidelines for the selection of an appropriate Generate thinkLet and Modifier for the collaborative ideation process of an innovation process are missing.

3.3 Requirements for an engineering approach for the ideation process design

The thesis analyses the use of a design pattern approach to reduce uncertainties in the pre-development phase of an innovation process. Given idea generation techniques are analysed to understand existing approaches for ideation support. Resulting knowledge is used to improve the design approach of Collaboration Engineering for collaborative ideation processes. In this context, the thesis formulates the following requirements for an design approach for ideation:

R-1 *The design approach needs to provide best work practices to support the cognitive process of an individual during an ideation process.*

R-2 *The design approach needs to provide best work practices for the design of a specific environment that reduces negative group behaviours during an ideation process.*

R-3 *The design approach needs to provide guidelines for the design of an appropriate innovation process for a given innovation goal.*

Design patterns like the concept of thinkLets focus on the design of a collaboration process from an engineering perspective. The term Engineering can be defined as '*the creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes*' [Britannica, 2011]. The thesis views the idea generation process as a manufacturing process and adopts the Idea Engineering approach by Horton who indicates the need '*for a theoretical understanding and practically applicable idea generation methods*' to develop '*tailor-made idea production techniques for each new ideation task*' [Horton, 2006, pg. 2]. According to this approach, resulting design approaches for ideation should further fulfill the following criteria of traditional engineering disciplines [Knoll and Horton, 2011a]:

Adaptable *They should design an ideation process that can be tailored to meet a given innovation goal.*

Reliable *They should design an ideation process that always performs in the same way.*

Predictable *They should design an ideation process that generates a given result with predefined characteristics using specified resources.*

Efficient *They should design an ideation process that generates a quantity of output with the resources available.*

Measurable *They should design an ideation process with quantifiable performance.*

Transparent *They should be comprehensible and learnable for anyone.*

Well-Founded *They should be based on scientific principles and theories of creativity.*

The next paragraph presents and discusses different theories of creativity that could build the foundation of an engineering approach to design an ideation process.

3.4 A creative cognition approach for ideation

Over several decades, a variety of theories of creativity have been developed. These theories can be discriminated by the perspective they take on creativity which are called the 'four P's of creativity' [Bostrom and Nagasundaram, 1998]:

Person *related theories aim to identify the personality traits of an individual that may be an indicator for creative potential. For example the Function Model of Creativity Personality [Feist, 2010] indicates that genetic differences influence brain characteristics which can lead to different personality traits. Here, traits like Introversion, Emotional Sensitivity, Openness to Experience, and Impulsivity can lower the thresholds for creative thought or behaviour of an individual [Feist, 1999].*

Product related approaches focus on creativity as a property of a process outcome: works of art, publications or industrial products. For example the Creative Product Analysis Matrix (CPAM) [Besemer and Treffinger, 1981, Besemer, 1998] defines the three dimensions Novelty, Resolution, and Style as a metric for the analysis of a creative product.

Press related research focuses on the interactions between persons and environment. Theories in this area aim to provide frameworks to analyse organisational creativity in relation to factors like Culture, Structures, Climate or Leadership of an organisation [Puccio and Cabra, 2010].

Process related theories aim to understand the mental mechanisms of a person during a creative activity. For example, Wallas [Wallas, 1926] divides the creative process of an individual into four stages: Preparation (a stage that involves cognitive processes for analysing the existing situation which calls for a creative process), Incubation (a stage during which new perspectives on the situation will be created), Illumination (a stage that describes the appearance of a new idea) and Verification (a stage during which the validity of the idea is tested).

Bostrom and Nagasundaram [Bostrom and Nagasundaram, 1998] indicate that given theories of creativity mutually influence each other and are hence intimately related. As a result, each theory can provide a foundation to support the design of a collaborative ideation process. For example, given knowledge about personality traits can be used to define guidelines for the composition of a group by selecting employees of an organisation who may provide a high creative potential. Press-related theories can be used to create a collaboration environment that supports employees creativity. The ideation process itself can be supported by process related theories, which can be used to develop or analyse support methods for ideation like idea generation techniques [Smith, 1998]. Furthermore, product related approaches like the Creative Product Analysis Matrix can be used as a metric to support the selection of ideas by predefined characteristics [O'Quin and Besemer, 2006].

This research analyses given support methods like idea generation techniques in order to improve the design of the pre-development phase of an innovation process. Lubart [Lubart, 2001] argues that in terms of a comprehensive understanding of the ideation process, researchers need to specify their fundamental subprocesses. As a result, the thesis uses process-related theories of creativity to analyse the influence of idea generation techniques on the ideation process. These theories provide different creative cognition approaches to specify and study the underlying cognitive processes of an individual and their application to existing knowledge structures for the generation of ideas [Nijstad and Stroebe, 2006, Santanen et al., 2004, Welling, 2007]. For example, the Geneplore Model [Finke et al., 1992] characterises the creative process through a collection of basic cognitive processes and how they operate on given knowledge structures to generate ideas. The resulting creative process involves generative and explorative processes. Generative processes include the retrieval of knowledge and its modification by the reorganisation of knowledge by association, transformation and analogical transfer to construct loosely formulated ideas. These ideas will be elaborated and examined in an explorative process by cognitive processes that process the idea, test hypotheses and search for limitations.

3.4.1 SIAM: a cognitive model for ideation

The thesis uses a cognitive model called Search for Ideas in Associative Memory (SIAM) [Nijstad et al., 2002, Nijstad and Stroebe, 2006] to analyse the influence of an idea generation technique on the creative cognition processes of an individual. SIAM assumes that the creative cognition process can be characterised by the retrieval and modification of knowledge. As a result, the model extends the Search of Associative Memory (SAM) model [Raaijmakers and Shiffrin, 1980, 1981]; a theory of memory retrieval that combines elements of associative network models and random search models; for the generation of ideas.

Similar to other cognitive models, SIAM assumes that the human memory system can be broken down into two sub-systems, the Long-Term Memory (LTM) and the Working Memory (WM). The WM system is assumed to be a temporary storage system with limited capacity that is used by the individual to execute conscious operations, such as rehearsal, recognition and decision making. The LTM system is assumed to be an essential permanent storage area that provides unlimited capacity for the previously acquired knowledge of an individual. Knowledge in the LTM is stored in a richly interconnected network with numerous levels, categories and associations. This network can be partitioned into images: knowledge structures which consist of sets of strongly interconnected and semantically related concepts. The strength of a link between two concepts may be assumed to be related to the frequency of its traversal, or the relatedness among the concepts that are connected. A concept within an image can have links of different strength to other images that contain related concepts. As a result, images are assumed to have fuzzy boundaries which may overlap to a considerable degree.

A schematic depiction of this knowledge structure in the LTM system is given in Figure 3.1. Here, an image is represented by a central concept (search cue) which is linked to a number of concepts which represent features of the central concept or related associations. For example, the concepts *service*, *product*, *employee*, *warehouse*, *lab* and *department* are related associations of the central concept *organisation* and may be grouped together into an image. The boundary of this image shows an overlapping with the boundaries of the images *university*, *science* and *pharmacy* which are also semantical related to the concept *lab*.

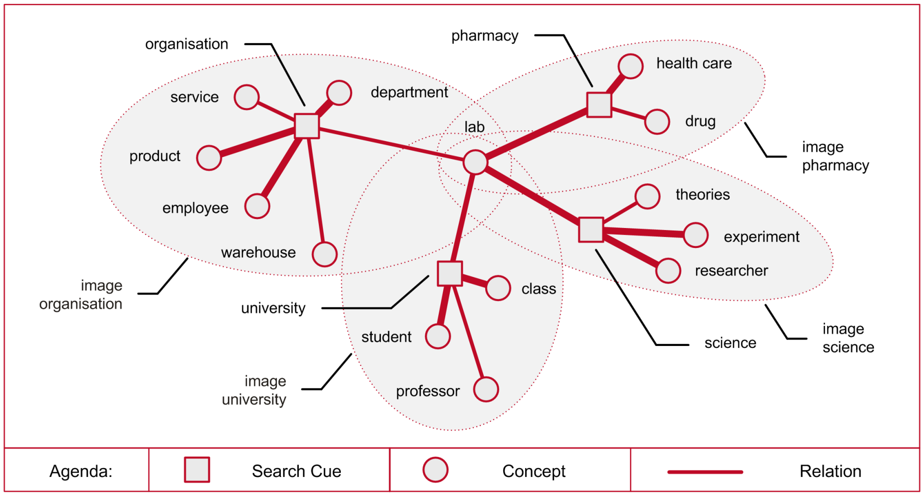


Figure 3.1: Schematic depiction of the knowledge network

3.4.2 The cognitive ideation process

Based on the SIAM model, the creative cognition process of an individual can be described as a two-stage process (see Figure 3.2) in which a knowledge activation stage is followed by an idea production stage [Nijstad et al., 2002, Nijstad and Stroebe, 2006].

During the knowledge activation stage, a search cue is used by the individual to activate previously acquired knowledge from the LTM system. The individual assembles this search cue in the WM system from external stimuli, such as task related words or pictures, which are received through the five senses of the individual. Which image in the LTM system will be activated by a given search cue is probabilistic and depends on the strength of the association between the search cue and the concepts of the image. An activated image will be temporarily stored in the WM system, after which the concepts of the image will be accessible for the individual.

In the idea production stage, active knowledge is used in the WM system to generate new ideas by combining knowledge, forming new associations, or applying knowledge to a new domain [Mednick, 1962]. Here, the individual uses the conscious operations of the WM system to combine the concepts of the image with one another or with elements of the search cue. Over a period of time, the individual will generate more ideas that have already been mentioned. Smith [Smith, 2003] explains this effect with the assumption that a generated idea is strongly associated with the problem, the search cue, and the active image from which it is generated. This association will increase the probability that a particular idea is generated again. In this case, the individual can add previously generated ideas or external stimuli to the given search cue to activate a new image. This recursive process will be terminated, if the individual gets the impression that only few additional ideas can be generated.

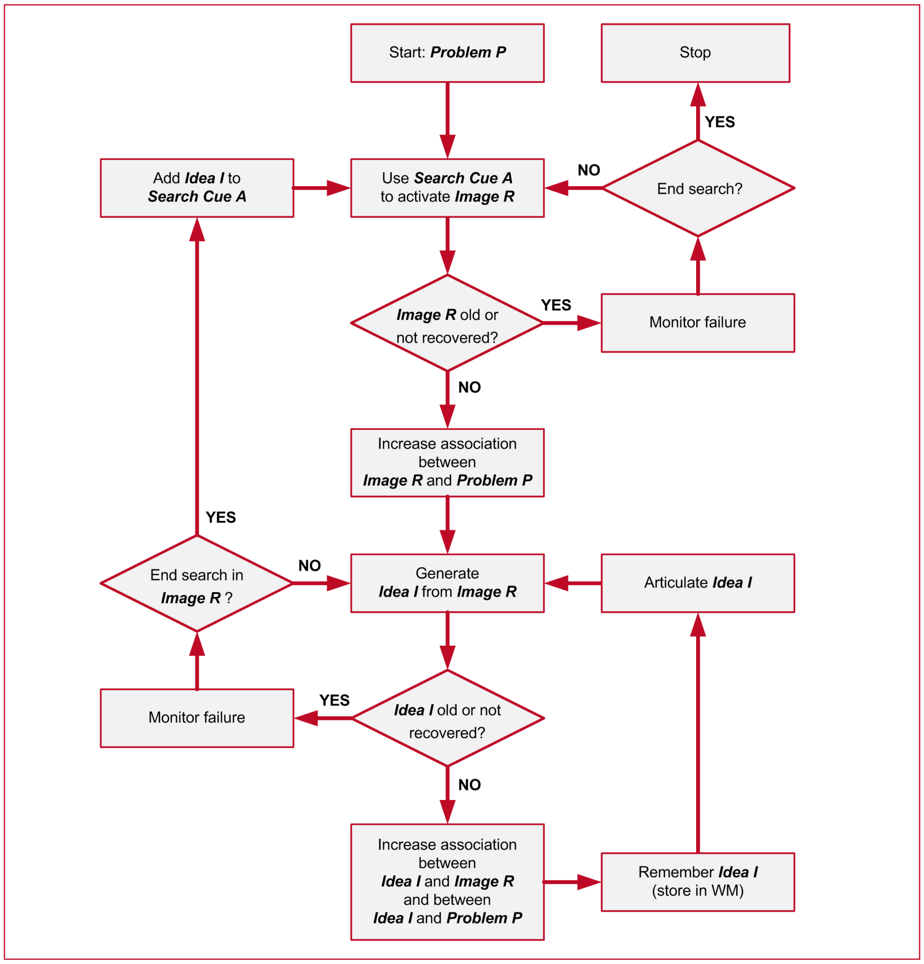


Figure 3.2: Flowchart of ideation adapted from [Nijstad and Stroebe, 2006]

3.4.3 The change of perspective

Nijstad and Stroebe [Nijstad and Stroebe, 2006] assume that without any external stimuli, the individual will only modify the search cue by adding previously generated ideas which leads to an activation of semantically related images. As a result, the individual will think primarily within bounded areas of the knowledge network. The likelihood of forming new associations between previously unrelated images decreases and only a small area of the solution space will be considered [Gettys et al., 1987, Mednick, 1962].

By leading the individual to different areas of their knowledge network, an individual can be supported to leave well-trodden thought paths and to overcome occupational blindness (see Figure 3.3). As a result, the thesis sees the use of external stimuli as a basic requirement to support the creative process and calls the resulting cognitive

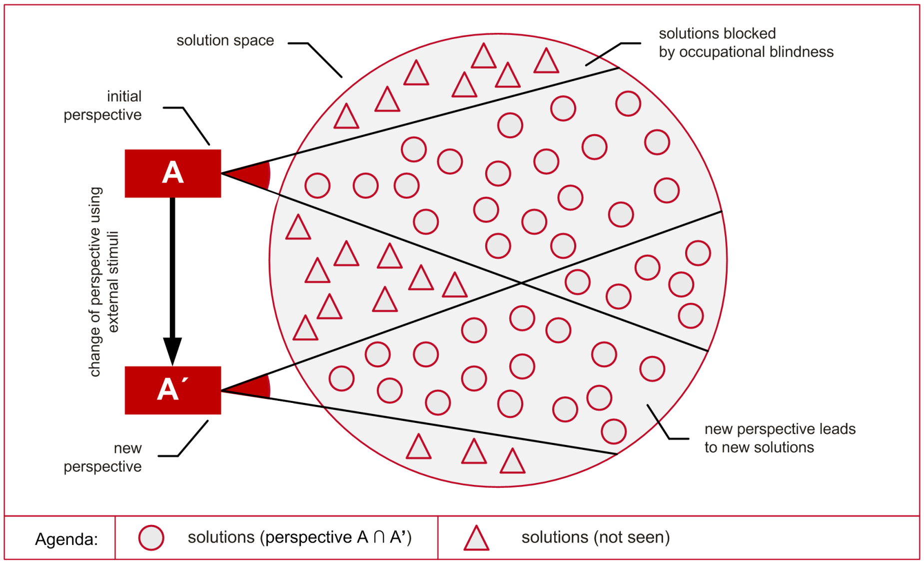


Figure 3.3: Change of perspective

process of an individual a Change of Perspective: '*a mental principle that uses external stimuli to activate larger areas of the knowledge network of an individual that would not be activated by an associative process*' [Knoll and Horton, 2011c]. Idea generation techniques use external stimuli in the form of checklists or questions as an intervention to support the ideation process. However, the influence of these stimuli on the creative cognition processes of an individual is not well understood.

3.4.4 The ingredients of an idea generation technique

To gain a theoretical understanding of the different ways how stimuli enhance the creative cognition process of an individual, the thesis applies the cognitive model SIAM to analyse given idea generation techniques. Given idea generation techniques present formalised protocols which provide step-by-step sequences of actions or instructions to guides both the cognitive and social process of a group. To apply the SIAM model for the analysis of the creative cognition process, the thesis needs to identify the ingredients of a technique that influence the cognitive process of an individual. Smith [Smith, 1998] regards an idea generation technique as a combination of actions or instructions to guide the cognitive process of the individual (Strategy), suggestions for the material or tools that can be used to support the cognitive process (Tactic) and a set of requirements for the creative press (Enabler). The thesis adopts these three ingredients of an idea generation technique in relation to the Collaboration Engineering approach by the terms Algorithm, Format and Setting [Knoll and Horton, 2011c]:

Algorithm *defines a sequence of formal steps that guides the cognitive activities of an individual. These activities can lead to ideas by the exploration and transformation of conceptual spaces [Mednick, 1962]. The Algorithm can guide these cognitive processes by providing stimuli, that supports the retrieval of associated areas of knowledge [Hender et al., 2002].*

Format *refers to the implementation of the Algorithm when carried out. Similar to the design pattern of a thinkLet, the Format defines how group members interact during the ideation process. This description can further includes information about tools or materials, that can be used to support the cognitive activities of an individual.*

Setting *refers to the implementation of the Algorithm by using the Format for a given group situation. Similar to the concept of a modifier for a thinkLet, Setting defines how possible social phenomena can be affected by changing the Format to create an environment that supports the ideation process.*

The ingredient approach is used to analyse the relationship between the creative task, the instructions provided, the material used and the outcome of an idea generation technique.

3.5 Analysing the mental principles of idea generation techniques

The research objective is to get a theoretical understanding how idea generation techniques influence the cognitive and social process of a group. As a result, the thesis analyses the intended cognitive and physical activities for the provided instructions of common idea generation techniques. Different collections of idea generation techniques are used to improve the significance of this research [VanGundy, 1988, Higgins, 1994, VanGundy, 2005]. These collections contain all of the well-known techniques which can be seen as representative of common techniques in ideation practice.

The research methodology is similar to that used by Smith [Smith, 1998] and categorises an idea generation technique by its ingredients. The cognitive model SIAM is used to describe possible creative cognition processes that result from the ingredient of an idea generation technique. Here, the thesis formalises the provided instructions of a technique into a sequence of activity steps. Each sequence of steps is subsequently normalised: recurring steps are deleted, similar steps are consolidated, and complex steps are divided into basic cognitive and physical activities of an individual such as knowledge activation, selection, and association forming.

To illustrate the research methodology, consider the following analysis of the idea generation technique Combo Chatter [VanGundy, 2005, pgs. 127-129]; originally known as Semantic Intuition. This technique can be described by the three steps:

Step 1 *Instruct participants to generate two lists of five words related to their problem and write them on a flip chart. Tell them to do this as a group.*

Step 2 *Have each group member take turns selecting one word from each list and have the group use the combination to stimulate ideas.*

Step 3 *Direct them to write down any ideas on sticky notes and place them on a flip chart paper for evaluation.*

The analysis of the instructions reveals a number of different cognitive and physical activities of an individual. The first step of the technique instructs each participant of a group '*to generate two lists of five words related to their problem*'. The intended cognitive activity for each individual can be described as a cognitive process of using the problem statement as a search cue to activate knowledge in the LTM system. The activated knowledge in the WM system will be analysed for problem related words. The individual can be supported during this process by external stimuli which define the content of each list. Associated words will be collected by the physical activity '*to write the words on a flip chart*'.

In the second step, the individual is requested '*to select one word from each list*' and '*to use the combination as a stimulus to generate ideas*'. The words used result from the image '*problem statement*' and therefore represent task-related stimuli for the mental activity '*to combine the words to a stimulus*'. Here, the individual will combine two words in the WM system to a new search cue for knowledge activation. Depending on the resulting stimuli, the activated knowledge can represent a challenge for the existing relationships of the image '*problem statement*' and semantically related concepts. In this case, the individual will use the stimulus to activate knowledge areas about consequences of the resulting situation. The activated images are used in the WM to generate ideas by forming new associations or by applying knowledge to the problem domain.

The last step represents the physical activities '*to write down any ideas on sticky notes*' and '*to place them on a flip chart paper*'. The individual is requested to reuse the second step to generate another idea or to combine a new stimulus.

3.6 The mental principles of idea generation techniques

The research methodology is used in different studies to analyse the mental principles of common idea generation techniques [Knoll and Horton, 2010, 2011a,c]. A first study indicated the existence of three mental principles which create a Change of Perspective by activating larger areas of the knowledge network of an individual, which would not be activated by an associative process. These principles are called Analogy, Provocation and Random [Knoll and Horton, 2010]:

Analogy — *the mental principle of setting a focus on a semantically-related area in the knowledge network. Idea generation techniques that use this mental principle provide external stimuli related to the creative task to support the individual in searching for similar situations. The individual uses the knowledge about these situations to generate ideas for the creative task.*

Provocation — *the mental principle of modifying the given associations of the creative task in the knowledge network. Idea generation techniques that use this mental principle provide external stimuli to challenge the assumptions of the creative task. The individual analyses the resulting situation for consequences or processes, which are used as stimuli to generate ideas for the creative task.*

Random — *the mental principle of setting a focus on a random area in the knowledge network. Idea generation techniques that use this mental principle provide external stimuli unrelated to the creative task to support the individual in activating unrelated knowledge. The individual uses the knowledge about these unrelated situations to generate ideas for the creative task.*

Further studies on the mental activities show that the mental principles Analogy and Random initiate similar cognitive processes. Both principles interrupt the association chain by external stimuli to activate distant knowledge areas. The principle Analogy uses concepts of the creative task as stimuli for knowledge retrieval, which increases the probability that the activated image shares concepts with the image of the creative task. The principle Random uses random elements as stimuli to retrieve knowledge, which will be weakly associated to the image of the creative task. As a result, the thesis introduces a new categorisation approach that combines the underlying cognitive process of Analogy and Random into one mental principle but distinguishes between the characteristic of stimuli used. In this context, the thesis proposes that cognitive processes can be mapped onto three mental principles: Jumping, Dumping, and Pumping [Knoll and Horton, 2011c]. The next chapter will present each of these principles in more detail.

3.6.1 The mental principle Jumping

The mental principle Jumping refers to a cognitive mechanism called analogical thinking, in which the individual retrieves knowledge from different situations or problems to generate ideas [Finke et al., 1992, Gentner et al., 1997, Gavetti and W., 2005, Welling, 2007]. Research describes analogical thinking as a multistage process, where an individual searches in memory to access useful information that have an analogical connection to a given creative task [Dahl and Moreau, 2002]. An analogical connection is given, if some basic concepts of the creative task and the analogous situation are similar. The individual maps corresponding parts of the analogy and the creative task onto each other, and finally applies the transferred knowledge to generate ideas.

Idea generation techniques can support the individual in analogical thinking by providing step-by-step sequences of actions or instructions to guide the activation and use of analogous situations. The thesis formalises this approach and defines the underlying mental principle of an idea generation technique as a guided cognitive process to activate distant knowledge areas. In a colloquial term, the individual does '*a mental jump*' to a distant location in the associative network. This principle can also be found in the earlier introduced mental principles Analogy and Random. Here, dependent on the stimulus characteristic, the individual activates knowledge that has no or only a weak association to the image of the creative task. The mental principle Jumping combines these principles and distinguishes between the knowledge areas activated.

The mental principle jumping using task-related stimuli

Knowledge about an analogous situation can be activated by using task-related stimuli; concepts that are related to the images of the creative task. Idea generation techniques combine these characteristic concepts with external stimuli like facilitator instructions that request the individual to search for an analogous situation (e.g. Copy Cat [VanGundy, 1988, pg. 47]).

The following list presents the mental principle Jumping as a formal sequence of steps using task-related stimuli (compare to Figure 3.4) and its application for the creative task '*to provide a new service for the customers of a supermarket*':

Step 1 *Select a characteristic attribute of the creative task.*
A supermarket displays a large number of items.

Step 2 *Find an analogous situation with the same attribute.*
Another place which displays a large number of items is a museum.

Step 3 *Imagine how the task might be solved in this analogous situation.*
A museum uses audio guides to provides the visitors background information on the exhibits being viewed.

Step 4 *Generate ideas by applying the solution to the creative task.*
A supermarket uses audio guides to provide the customers background information on the products.

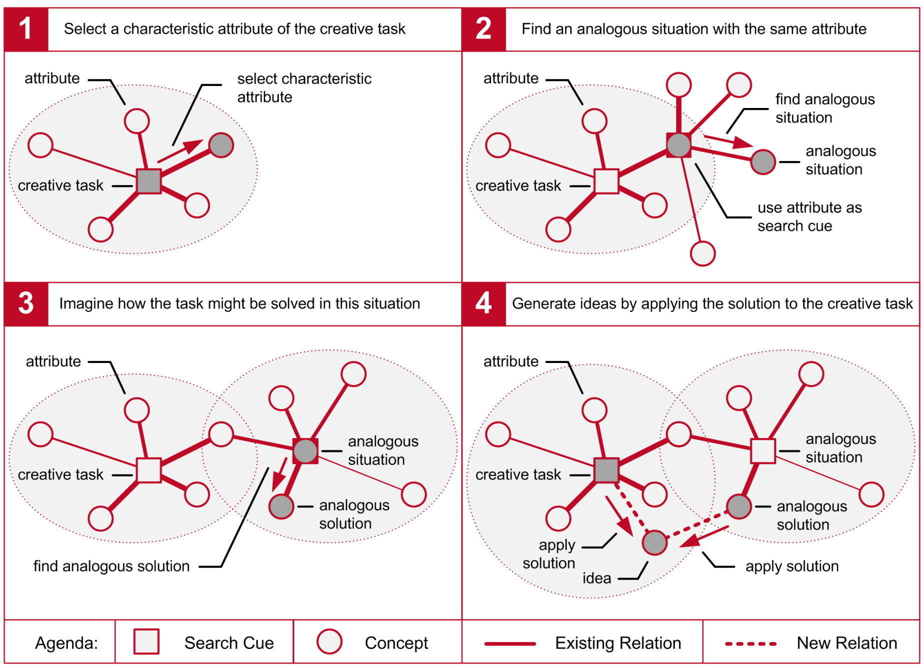


Figure 3.4: Mental principle jumping using task-related stimuli

The mental principle jumping using task-unrelated stimuli

Knowledge about a random situation can be activated by using task-unrelated stimuli; random elements that have no relations to the given creative task. Idea generation techniques provide these random elements as words (e.g. the techniques Picled Brains [VanGundy, 2005, pg. 92] or Say What? [VanGundy, 2005, pg. 105]) or physical elements such as sculptures or inkblots (e.g. the techniques Sculptures [VanGundy, 1988, pg. 163] or Rorschach Revisionist [VanGundy, 1988, pg. 101]) and instruct the individual to use them as stimuli for the generation of new ideas.

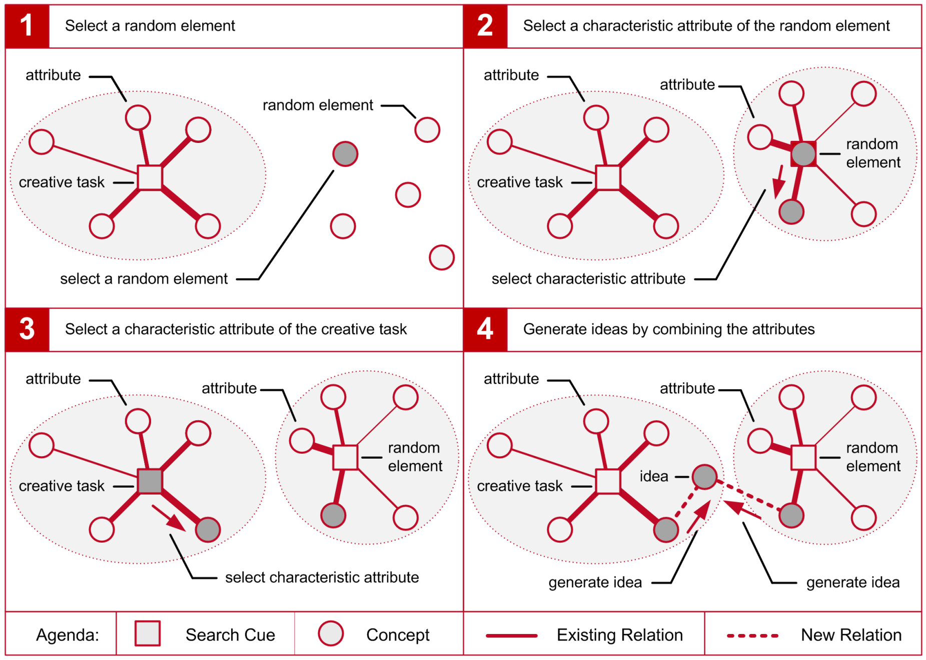


Figure 3.5: Mental principle jumping using task-unrelated stimuli

The following list presents the mental principle Jumping as a formal sequence of steps using task-unrelated stimuli (compare to Figure 3.5) and its application for the creative task '*to provide a new service for a lecture at an university*':

Step 1 *Select a random element.*
A parrot.

Step 2 *Select a characteristic attribute of the random element.*
A parrot repeats phrases and imitates the human voice.

Step 3 *Select a characteristic attribute of the creative task.*
A student uses notes from the lecture to learn for a subject.

Step 4 *Generate ideas by combining these attributes.*
A professor offers audio notes for a lecture with extended information.

Table 3.1 shows an overview of idea generation techniques from different collections that use the mental principle Jumping. In conclusion, the analysed collections provide more idea generation techniques which use unrelated stimuli (26/101 in [VanGundy, 2005], 18/59 in [VanGundy, 1988] and 08/64 in [Higgins, 1994]) than techniques which support analogical thinking by using related stimuli (10/101 in [VanGundy, 2005], 05/59 in [VanGundy, 1988] and 06/64 in [Higgins, 1994]).

Mental principle jumping using related stimuli		
[VanGundy, 2005]	[VanGundy, 1988]	[Higgins, 1994]
Battle Of The Sexes	Analogies	Analogies and Metaphors
Bionic Ideas	Attribute Analogy Chains	Direct Analogies
Chain Alike	Bionic	Personal Analogies
Copy Cat	Gordon/Little	Relatedness
I Like It Like That	Two Words	Synectics
It's Not My Job		TRIZ
Imaginary Mentor		
Stereotype		
Switcheroo		
What's The Problem?		

Mental principle jumping using unrelated stimuli		
[VanGundy, 2005]	[VanGundy, 1988]	[Higgins, 1994]
666	Battelle-Bildmappen-Brainwritting	Establish Idea Sources
A Likely Story	Catalog	Excursion
Ballloon, Balloon, Balloon	Checklists	Googlestorming
Best Of	Cliches, Proverbs, and Maxims	Organized Random Search
Bouncing Ball	Focused-Object	Picture Stimulation
Doodling' Around The Block	Games	Product Improvement Checklist
Excerpt Excitation	Greeting Cards	Relational Words
Fairy Tale Time	Metaphors	The Napoleon Technique
Grab Bag Forced Association	Modifier-Noun Associations	
Greeting Cards	Nonlogical Stimuli	
Idea Shopping	Product Improvement CheckList ™	
Mad Scientist	Relational Algorithms	
Picled Brains	Rolestorming	
Picture Tickler	Sculptures	
Post It, Partner	Stimulus Analysis	
Preppy Thoughts	Super Heros	
Puzzle Pieces	Visual Synectics	
Rolestorming	Word Diamond	
Roll Call		
Rorschach Revisionist		
Say What?		
Sculptures		
Super Hero		
Text Tickler		
Tickler Things		
Word Diamond!		

Table 3.1: Idea generation techniques using the mental principle jumping

3.6.2 The mental principle Dumping

The mental principle Dumping refers to the cognitive mechanism of challenging characteristic attributes of the creative task to generate a new perspective. Confronted with the creative task, the individual reverses assumptions about the creative task to leave well-trodden thought paths and overcome occupational blindness. The individual analyses the resulting situations for useful information that can be used to generate ideas.

Idea generation techniques can support the individual in challenging assumptions by providing step-by-step sequences of actions to guide the activation and reversal of assumptions. The thesis formalises this approach and defines the underlying mental principle of an idea generation technique as a guided cognitive process to challenge given knowledge areas. In a colloquial term, the individual '*mentally dumps*' associations in the network. Idea generation techniques based on this principle use task-related stimuli to activate the image of the creative task. Concepts of the creative task will be modified by an external stimulus such as facilitator instructions which request to challenge the existing relationships between the image and concepts (i.e. by switching the concepts or combining random elements with the concept). Most idea generation techniques provide checklists as possible stimuli to challenge the creative task. A generalised checklist for this modification is given by Osborns checklist [Osborn, 1963, pg. 286], which includes the following verbs: put to other uses, adapt, modify, magnify, minify, substitute, rearrange, reverse, and combine.

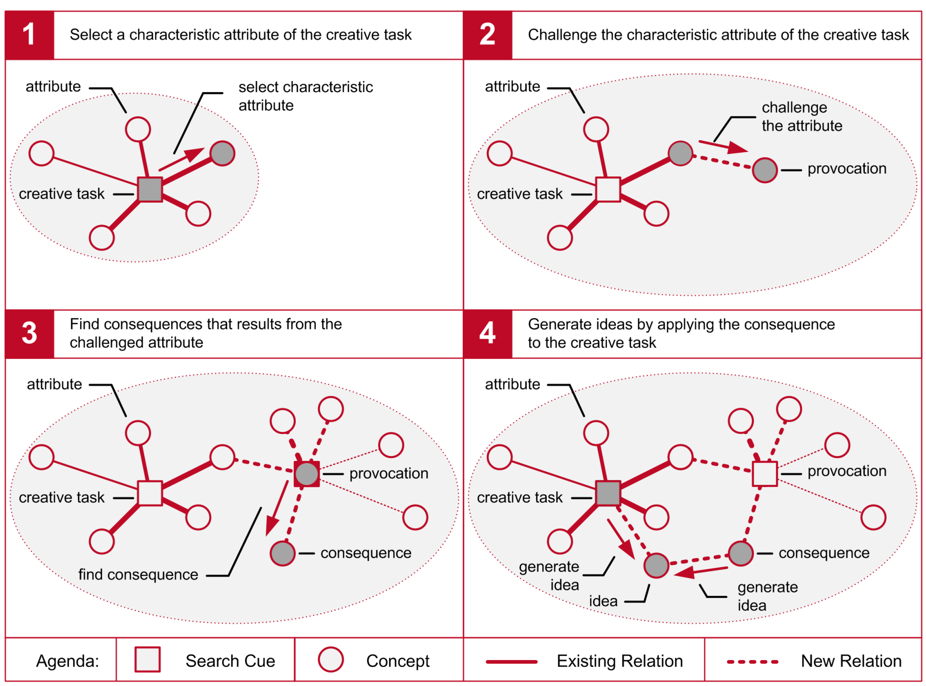


Figure 3.6: Mental principle dumping

The following list presents the mental principle Dumping as a formal sequence of steps (compare to Figure 3.6) and its application for the creative task '*to provide a new process for the selection of an employee for a management position in an organisation*':

Step 1 *Select a characteristic attribute of the creative task.*
Employees are evaluated by their superiors.

Step 2 *Challenge the characteristic attribute of the creative task.*
Employees are evaluated by their subordinates.

Step 3 *Find consequences that result from the challenged attribute.*
If the employees are evaluated by their subordinates, the superiors would get information about the social skills and personality characteristics of the employees to manage subordinates well.

Step 4 *Generate ideas by applying this consequence to the creative task.*
Include evaluations by subordinates as part of the promotion selection process.

The thesis found different idea generation techniques that use the mental principle Dumping. Table 3.2 shows an overview of these techniques from different collections of idea generation techniques (18/101 in [VanGundy, 2005], 10/59 in [VanGundy, 1988] and 03/64 in [Higgins, 1994]) According to the stimuli used, the thesis found no idea generation technique that uses the principle Dumping with task-unrelated stimuli.

Mental principle dumping		
[VanGundy, 2005]	[VanGundy, 1988]	[Higgins, 1994]
Altered States Handout	Assumption Reversal	Morphological Analysis
Be #1	Exaggerated Objectives	Reversal-Dereversal
Bend It, Shape It	Heuristic Ideation Technique	SCAMPER
Bi-Wordal	Hypothetical Situations	
Circle Of Opportunity	Listing	
Combo Chatter	Morphological Analysis	
Exaggerate That	Reversals	
Get Crazy	Semantic Intuition	
Ideas In A Box	Sequence-Attribute Modification Matrix	
Law Breaker	Wishful Thinking	
Noun Action		
Noun Hounds		
Parts Is Parts		
Problem Reversal		
SAMM I Am		
Tabloid Tales		
What If?		
Turn Around		

Table 3.2: Idea generation techniques using the mental principle dumping

3.6.3 The mental principle Pumping

The mental principle Pumping refers to a cognitive mechanism called application, the adaptive use of existing knowledge in its habitual context to generate new ideas [Welling, 2007]. Confronted with the creative task, the individual focuses on specific concepts within the image of the creative task and searches for knowledge that can be used to generate ideas.

Idea generation techniques can support the individual in adapting specific knowledge by providing step-by-step sequences of actions to guide the association process onto specific concepts within the image of the creative task. The thesis formalises this approach and defines the underlying mental principle of a technique as a guided cognitive process to change the focus on specific concepts of the creative task. In a colloquial term, the individual '*mentally pumps*' specific associations in the knowledge areas. Idea generation techniques based on this principle use external stimuli such as facilitator instructions to guide the cognitive process of the individuals to knowledge areas of the creative task. The resulting concepts of these knowledge areas provide different starting points to generate new ideas in an associative process.

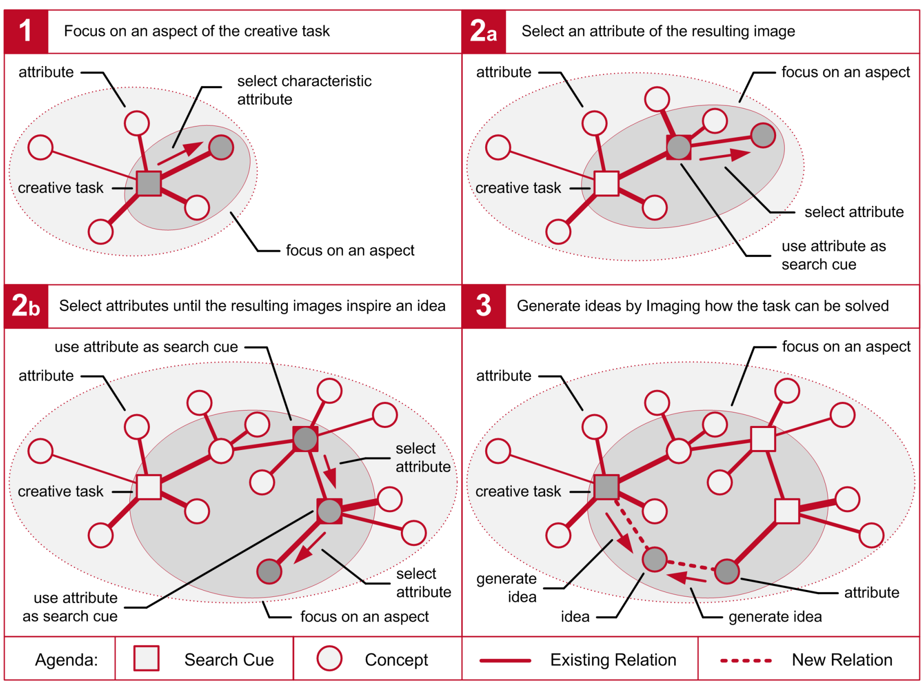


Figure 3.7: Mental principle pumping

The following list presents the mental principle Pumping as a formal sequence of steps (compare to Figure 3.7) and its application for the creative task '*to provide a new product idea for a wristwatch*':

Step 1 *Select an aspect of the creative task to focus on.*
A wristwatch has an alarm.

Step 2 *Repeatedly select a characteristic aspect of the previous step until it inspires an idea.*
The wristwatch makes sounds when the alarm goes off.
In some situations, the alarm sound could disturb other people.

Step 3 *Write down the idea for solving the creative task.*
A 'visual-alarm' wristwatch that gives visual alarms for situations when you do not want to disturb other people.

The thesis found different idea generation techniques that use the mental principle Pumping to guide the association process onto specific concepts within the image of the creative task. Table 3.3 shows an overview of these techniques from different collections of idea generation techniques (03/101 in [VanGundy, 2005], 05/59 in [VanGundy, 1988] and 09/64 in [Higgins, 1994]).

Mental principle pumping		
[VanGundy, 2005]	[VanGundy, 1988]	[Higgins, 1994]
Mental Breakdown	Attribute Association Chains	Attribute Association Chains
Modular Brainstorming	Attribute Listing	Attribute Listing
Parts Purge	Component Detailing	Back to the Customer
	Circumrelation	Back to the Sun
	Problem Inventory Analysis	Circle of Opportunity
		Crawford Slip Method
		Input-Output
		Name Possible Uses
		The Focused-Object Technique

Table 3.3: Idea generation techniques using the mental principle pumping

3.6.4 No mental principle: the influence of the ingredient Format

The thesis defines the ingredient Algorithm of an idea generation technique as a sequence of formal steps that guide the mental activities of an individual. Under this condition, the analysis shows that different idea generation techniques do not guide the mental activities at all.

No mental principle		
[VanGundy, 2005]	[VanGundy, 1988]	[Higgins, 1994]
As Easy As 6-3-5	Brainwriting Game	7X7 Technique
Blender	Brainwriting Pool	Association
Brain Borrow	Brainsketching	Brainstorming
Brain Mapping	Classical Brainstorming	Brainwriting
Brain Purge	Collective Notebook	Brainwriting 6-3-5
Brainsketching	Crawford Slip Writing	Brainwriting Pool
Brain Splitter	Creative Visualization	Creative Imaging
Dead Head Deadline	Free Association	Deadline
Doodles	Fresh Eye	Delphi
Drawing Room	Storywriting	Examine It With The Senses
Essence Of The Problem	Symbolic Representation	Fresh Eye
Force-Fit Game	Force-Fit Game	Gallery Method
Group Not	Gallery Method	Gordon/LittleTechnique
Get Real!!!	Method 6-3-5	Idea Bits And Racking
Idea Diary	Phillips 66	Idea Board
Idea Links	Pin-Cards	Idea Triggers
Idea Mixer	SIL Method	Innovation Commitee
Idea Pool	Story Boards	Intercompany Innovation Groups
Idea Showers	Super Group R	Lion's Den
Ideatoons	Trigger Method	Lotus Blossom Techniques
Lotus Blossom	Wildest Idea	Mind Mapping
Museum Madness		Mitsubishi Brainstorming Method
Music Mania		Music
Name Change		NHK Method
Organizational Brainstorms		NKJ Method
Out-Of-The-Blue Lightning Bold Cloudbuster		Norminal Group Technique
Pass The Buck		Phillips 66
Pass The Hat		Photo Excursion
Phillips 66		Pin Card Technique
Play By Play		Rolling In The Grass Of Ideas
Rice Storm		SIL Method
Say Cheese		Sleeping/Dreaming On It
Sense Making		Storyboarding
Skybridging		Take Five
Spin The Bottle		The FCB Grid
Story Boards		The Two-Words Technique
The Shirt Off Your Back		Visualization
That's The Ticket!		What If?
The Name Game		
Wake-Up Call		
We Have Met The Problem And It Is We		
What Is It		
You're A Card, Andy!		
Your Slip Is Showing		

Table 3.4: Idea generation techniques using no guiding principle

Table 3.4 shows an overview of these techniques from different collections of idea generation techniques (44/101 in [VanGundy, 2005], 21/59 in [VanGundy, 1988] and 38/64 in [Higgins, 1994]). Similar to the classical idea generation technique Brainstorming [Osborn, 1963], these techniques instruct a group of individuals to think about the creative task and simply use their knowledge about the creative task to generate ideas. Furthermore, most techniques suggest a group to share their resulting ideas as stimuli to inspire one another and activate knowledge unrelated to the creative task. Under this condition, an idea generation technique only changes the perspective at random. Depending on the characteristics of the shared stimuli, each individual will use a cognitive process similar to one of the presented mental principles: Jumping, Dumping, or Pumping. As a result, a facilitator has no significant influence on the cognitive process of the individuals which reduces the predictability of the process results.

An explanation for the large number of techniques that do not deliberately steer the Change of Perspective can be found by the ingredients of an idea generation technique. Many common techniques instruct the individuals to generate ideas for the creative task and only differ in their Format or Setting. For example, the Format of the idea generation techniques Idea Pool [VanGundy, 2005, pg. 340] and Brainwritting Pool [VanGundy, 1988, pg. 133], [Higgins, 1994, pg. 143] instruct a group of individuals to write down ideas on a sheet of paper, collect them in the center of a table, and use the ideas of others as stimuli to generate new ideas. In contrast, the techniques Museum Madness [VanGundy, 2005, pg. 342] and Gallery Method [VanGundy, 1988, pg. 151], [Higgins, 1994, pg. 153] define the Format to write ideas individually on sheets of flip-chart paper that are pinned to the walls of a room. By walking around and reading each others ideas, individuals can use documented ideas as stimuli to generate new ideas. In this manner, many idea generation techniques have been published that are algorithmically equivalent to an associative process and vary only in their Format and Setting.

3.6.5 Conclusion of the analysis

The analysis shows that many common idea generation techniques can be classified by the ingredient Algorithm and the identified mental principles: Jumping, Dumping and Pumping. By using external stimuli, these mental principles can lead to an activation of areas of the knowledge network that would not be activated by an associative process. The resulting new perspectives on a given task allow the individual to combine concepts of semantically unrelated images. Therefore, generated ideas can cover larger areas of the possible solution space.

The thesis further found a large number of idea generation techniques that do not guide the mental activities by a predefined sequence of formal steps and can lead to different mental principles at random. These techniques only ask for ideas and define how the group members interact during the ideation process.

3.7 A design approach for collaborative ideation processes

The thesis analyses existing approaches for ideation support and their application to improve the design approach of Collaboration Engineering for collaborative ideation processes. A new approach is introduced to describe, analyse and compare common idea generation techniques against the three ingredients: Algorithm, Format and Setting. The research results show that common idea generation techniques can be classified by the ingredient Algorithm and the identified mental principles: Jumping, Dumping and Pumping.

The given design approach of Collaboration Engineering uses the concepts of Generate thinkLets and Modifiers to define a collaborative process of a group for knowledge creation and knowledge sharing. According to the presented definition of the ingredients of an idea generation technique, Generate thinkLets present different ways for the group members to interact during the ideation process, similar to the ingredient Format. The concept of Modifiers is used to support the cognitive process of the individuals and handle negative group behaviours [Kolfschoten and Santanen, 2007]. Like the ingredient Setting of an idea generation technique, Modifiers alter the described collaboration process by adding rules to a thinkLet or by replacing existing thinkLet rules with different rules. This modification of a basic collaboration process allows the facilitator to affect possible social phenomena.

Besides affecting social phenomena of a group during collaboration, Modifiers can be used to influence the cognitive process of an individual during the ideation process, similar to the ingredient Algorithm. For example, the Modifier Direction alters the rules of a Generate thinkLet by providing a set of stimuli to guide the focus of the participants [Kolfschoten and Santanen, 2007, pg. 6]. Another Modifier is called Analogy and proposes to use an analogous situation to generate ideas [Kolfschoten and Santanen, 2007, pg. 6]. However, given Modifiers do not represent all mental principles that were found during this research. As a result, only common idea generation techniques can be represented as a combination of existing Generate thinkLets and Modifiers, which limits the possibility to support and guide the cognitive process of an individual during ideation.

The thesis indicates a redesign of the current approach for collaboration process design [Kolfschoten and de Vreede, 2009] by using the identified mental principles for ideation to support the design of collaborative ideation processes that allow the facilitator to guide the cognitive process of the involved individuals. In contrast to Kolfschoten and Santanen [Kolfschoten and Santanen, 2007], the thesis does not use the concept of Modifiers to influence the cognitive process of an individual during the ideation process. The thesis assumes that these cognitive processes represent a basic requirement of an ideation process and should not be represented as a variation of a collaboration process.

Instead of generating new Modifiers for the thinkLet design pattern, the thesis uses the concept Change of Perspective and combines it with Generate thinkLets and Modifiers to define a new design approach for collaborative ideation processes. The basic assumption of this design approach is that the ideation process of a group is both a cognitive process within individual group members and a social process as group members interact. Similar to an idea generation technique, the approach defines the ideation process as a combination of different ingredients that define and influence the cognitive and social activities of the group [Knoll and Horton, 2011a,c]:

Change of Perspective — *defines the mental principle as a sequence of formal steps that are used to guide the cognitive activities of the individuals.*

Generate thinkLet — *refers to the implementation of the Change of Perspective in a collaboration process. It defines how the group members share ideas that emerge during the cognitive process.*

Modifier — *refers to the implementation of the Change of Perspective by using Generate thinkLets for a given group situation. It defines variations of the Generate thinkLets in order to affect social phenomena.*

The thesis uses a pattern approach to capture the essence of Change of Perspective and Modifier in a compact form that can be easily communicated to those who need the knowledge. Alexander [Alexander et al., 1977] introduced a three-part rule to represent a design pattern by the relation between a certain context, a problem and a solution. The thesis adopts this approach but combines similar to the design pattern thinkLet the elements context and problem into one element. This results from the fact that Changes of Perspective similar to thinkLets do not provide a solution for a given problem but represent work tactics that can be used to guide a collaboration process to achieve an intended goal. As a result, the thesis defines the design patterns of a Change of Perspective, Generate thinkLet and Modifier by the following elements (The resulting design patterns of Change of Perspective, thinkLet and Modifier are presented in the Appendix A):

Name — *name of the design pattern.*

Sensitising Picture — *helps the reader to remember the design pattern by giving a visual idea of how the design pattern might work.*

Context *gives the reader information when to choose or not to choose the design pattern by describing the situation a design pattern is intended for.*

Solution *describes how to implement the design pattern.*

The introduction of the concept Change of Perspective as a mental principle reduces the need for some of the existing Modifiers like Analogy, Direction and Carousel, which impact the cognitive process of a group. Furthermore, the thesis refines given Modifiers and distinguishes between social and process modifiers. Social modifiers support the social process of a group by altering the described collaboration process to affect possible behaviours of a group like Evaluation Apprehension or Social Loafing. These modifiers are Anonymity, Identification, Osborn, Nominal and Dealing. Process modifiers influence the collaboration process by altering process characteristics like the intended time or the characteristic of the outcome. These modifiers are Limited Input, Comparative, Commenting and Qualitative Evaluation.

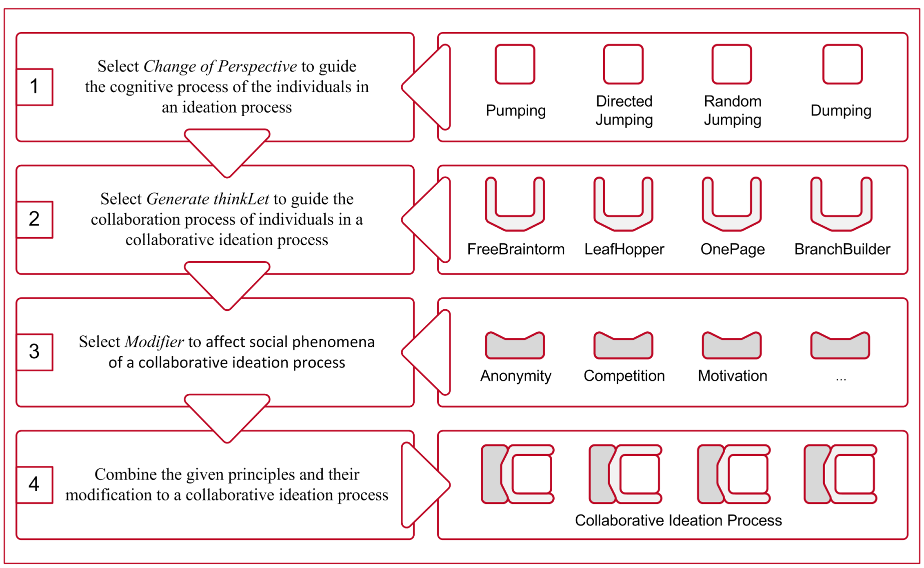


Figure 3.8: Design approach for an ideation process using the design pattern change of perspective, thinkLet and modifier

The resulting design approach for a collaborative ideation process is based on the presented approach for collaboration process design (shown in section 2.4.2, Figure 2.1). Here, the Collaboration Engineer analyses the collaborative task and the group characteristics to define requirements for the design of a collaboration process. In a second step the collaborative task will be decomposed into patterns of collaboration, which are used to select collaboration techniques (e.g. thinkLets or idea generation techniques) for a logical process model; a template of a collaboration process that contains a general description of collaborative activities for a collaborative task.

The new design approach for a collaborative ideation process [Knoll and Horton, 2011c] (shown in Figure 3.8) refines the decomposition step of a collaboration process for the pattern Generate and indicates to combine the design patterns of Change of Perspective, Generate thinkLet and Modifier into a new design approach. Here, the collaboration engineer analyses the creative task of the ideation process and the group characteristics to define requirements for a collaborative ideation process. The requirements will be used to select design patterns of a Change of Perspective, which define the mental principles that will be used to guide the cognitive activities of the individuals during the ideation phase. Generate thinkLets will be selected for the implementation of the Change of Perspective in a collaboration process. Here, the collaboration engineer defines how the group members share ideas that emerge during the process. In a last step, the collaboration engineer selects Modifiers with regard to the given group characteristics to handle possible social phenomena that influence the performance of the ideation process.

3.7.1 Application of the collaborative ideation design approach

In order to demonstrate the application of the design approach in more detail, this paragraph describes the design of a collaborative ideation process for a fictive scenario of a supermarket that wants to introduce a first-class category of customers. A collaboration engineer is hired to design and document an ideation process that combines customers and employees of the supermarket in an open innovation process to identify ideas for the creative task '*to provide a new service ideas for the first-class customers of a supermarket*'.

In a first step of the design process, the collaboration engineer analyses the creative task and the group characteristics to define requirements for collaborative ideation process. These requirements will be used in the following steps to select concepts like Change of Perspective, Generate thinkLet and Modifier that fit the given creative task and group constellation. In this scenario, the supermarket wants to generate ideas that can be implemented with medium effort by using knowledge from similar situations to generate ideas. By analysing the design patterns of Change of Perspective, the collaboration engineer identifies the change of perspective Jumping with task-related stimuli as an appropriate mental principle to guide the cognitive activities of a group during ideation. This mental principle represents an appropriate choice because there might be other organisations that have already successfully implemented first-class offers.

In a second step, the collaboration engineer selects and combines Generate thinkLets to define the implementation of a selected Change of Perspective in a collaboration process. For example, the thinkLet *OnePage* can be used to collect characteristic attributes about the creative task (Jumping / Step 1: '*Select a characteristic attribute of the creative task*'). Here, the group uses a single public storage space to collect in parallel attributes of a supermarket. These attributes might be *arrival*, *shopping*, *payment*, *service*, or *customer experience*. The collaboration engineer can select the thinkLet *LeafHopper* to collect analogous situations for the generated attributes (Jumping / Step 2: '*Find an analogous situation with the same attribute*'). Here, a private storage place for analogous situations is provided for each of the generated attributes. The participants of a group can choose and change the attribute to which they want to contribute analogous situations as interest and inspiration dictate. Analogous situations could be: *airlines*, *hotels*, *theaters*, or *railways*. The thinkLet *LeafHopper* can be used again to collect analogous solutions for the creative task (Jumping / Step 3: '*Imagine how the task might be solved in this analogous situation*'). For example, analogous solutions might be *a business gate at an airport*, *a box in a theater* or *a butler in a hotel*. The collaboration engineer can use again the thinkLet *OnePage* to apply the resulting list of analogous solutions to the creative task (Jumping / Step 4: '*Generate ideas by applying a solution to the creative task.*'). Here, a single public storage space is provided to collect in parallel the solutions for the creative task by using the analogous solutions as stimuli.

In the third step of the design process, the collaboration engineer uses theories on collaboration to analyse the given group constellation for possible social phenomena that could influence the performance of the ideation process. For example, the collaboration engineer could identify that the social structure between the participating employees of the supermarket could lead to Evaluation Apprehension. This social behaviour can be reduced by the modifier *Anonymity*, which suggest to design an ideation process where the participants make contributions in an anonymous form. As a result, the collaboration engineer decides to use technological support to allow the participants to contribute under anonymous condition. As a positive side effect the ideation process can be implemented as a virtual workshop, allowing the participation between employees and customers in distributed environments.

In the last step, the collaboration engineer combines the selected design patterns of Change of Perspective, Generate thinkLet and Modifier to a logical process model that will be validated against the defined requirements in an iterative process. The resulting ideation process will be documented in a paper-based handbook that can be used by a facilitator to prepare and guide the collaborative ideation process. For this scenario, the handbook provides tacit knowledge and skills for a facilitator on how to configure and use a groupware technology to implement the ideation process. For example, for a groupware technology that provides only a text-based tool to contribute and share contributions, the handbook could suggest to implement the ideation process as a question-and-answer process.

3.7.2 Discussion of the design approach

The introduced design approach is currently used in a one-semester undergraduate course which is given each semester by the Computer Science Department at the University of Magdeburg, Germany [Horton, 2006]. Goal of this course is to give students an introduction to innovation and ideation process design. During the course, students are organised into teams which need to design and execute a collaborative ideation process for a real-life ideation task from the local community. A student evaluation [Horton et al., 2011] of this course shows that students appreciate the use of the design approach to generate collaborative ideation processes, rather than to select and combine existing idea generation techniques.

However, the thesis assumes that the current design approach of a collaborative ideation process can be improved by understanding the influence of stimuli characteristic on the identified mental principles. Resulting knowledge can be used to define rules for the use of stimuli to guide the creative cognition process of an individual using a mental principle, which supports the collaboration engineer in selecting a Change of Perspective and defining stimuli that support the individual during ideation.

3.8 Analysing the influence of stimuli characteristic on the ideation process

According to the SIAM model, the productivity of an ideation process varies according to the stimuli used and the knowledge retrieved from the LTM system. Not every image provides a starting point for the generation of new ideas. Research indicates that the use of idea generation techniques supports individuals during the ideation process. However, most idea generation techniques that use stimuli are presented in a general form; providing predefined stimuli or formal descriptions to generate stimuli before or during their execution. It often remains unclear if the stimuli used are suitable to support the ideation process for a given creative task.

Different studies analysed the influence of external stimuli on the idea generation process. For example Hender et al. [Hender et al., 2002] focus on the relationship between stimuli, cognitive load, and quantity and creativity of ideas for different idea generation techniques, which use different mental principles. Their research results support the assumption that the underlying mental principle of a technique and the external stimuli can have a great impact on the creative outcomes. Santanen et al. [Santanen et al., 2003] compared two idea generation techniques with regard to the creative score of the solutions generated and the concentration of creative solutions. Both techniques use an associative process to generate ideas. One uses external stimuli to support the ideation process. According to the experiment description, the stimuli provide different ways to think about the given creative task, similar to the mental principle Pumping. The authors argue that the use of external stimuli can support the generation of solutions with higher average creativity rating, and higher concentration of creative solutions compared to using no stimuli.

The thesis analyses the influence of external stimuli for the mental principle Jumping to analyse the feasibility to define rules for the selection of stimuli with regard to a given mental principle [Knoll and Horton, 2011b]. In this context, the thesis formulates the following research question:

How does the characteristic of an external stimulus affect the outcome of an ideation process using the mental principle Jumping?

3.8.1 Assumptions for the mental principle Jumping

The mental principle Jumping refers to a cognitive mechanism called analogical thinking; a multistage process of retrieving and using semantically related knowledge in an associative process to generate ideas. External stimuli can be used to guide the cognitive processes of an individual for the retrieval of knowledge that is used to generate ideas for the creative task.

With regard to the general goal of an ideation workshop, resulting ideas should fulfill the conditions to be practicable and effective for a given creative task. An idea can be defined as practicable if the idea can be implemented with the resources available and as effective if the idea achieves its goal when implemented. The thesis assumes that concepts that have a significant effect on the creative task support the activation of analogous images that provide knowledge for the generation of effective ideas. Otherwise, by identifying concepts that represent the context of the creative task, an individual will activate analogous images that share the same or a close conceptual domain with the image of the creative task. This relationship could lead to the generation of more practicable ideas.

Concepts of a creative task can be formulated as statements by experts and can be used by an idea generation technique as external stimuli to guide an individual in activating specific analogous images. The thesis adopts this property of a concepts and characterises external stimuli as '*typical*' or '*relevant*' for a creative task:

Typical *characterises the relationship between an external stimulus and the context of the creative task. An external stimulus is 'typical for the context of the creative task' if it is a strongly associated concept of the image that describes the context of the creative task.*

For example, the context of the creative task '*a university wants to provide a new service for students*' is an '*university*'. Concepts which are strongly associated to the image '*university*' are '*employs a professor*', '*has a science lab*' or '*has a library*'. These concepts represent stimuli which are characteristic of the task situation, because they will activate the image '*university*' early on during a free association process. In contrast, concepts like '*has a building*', '*is part of a city*' or '*people work there*' are more common and will be shared by different images.

Relevant — *characterises the relationship between an external stimulus and the creative task. An external stimulus is relevant for the creative task if it has a significant effect on the creative task.*

For example, concepts that are relevant for the creative task '*a university wants to provide a new service for students*' are associated to the image '*students*' like '*live in an apartment-sharing community*' or '*have a low budget for the month*'. These concepts represent stimuli which could be relevant for a possible solution, because they provide problems, processes or purposes that can be used to generate ideas. In contrast, concepts like '*a professor has a high salary*','*people work at the university*' or '*the science lab is on the first floor*' are not necessarily relevant for the creative task.

To investigate the influence of the defined characteristics of stimuli on ideation processes using the mental principles Jumping, the following null hypothesis and hypotheses are defined:

H-0 — *There is no significant impact of stimuli characteristics on the outcome of an ideation process using the mental principle Jumping.*

H-1 — *Statements of the creative task can be characterised by the properties 'typical' and 'relevant'.*

H-2 — *An ideation process using external stimuli with the property 'typical' will tend to produce more practical ideas compared to an ideation process using external stimuli that are not typical for the creative task.*

H-3 — *An ideation process using external stimuli with the property 'relevant' will tend to produce more effective ideas, compared to an ideation process using external stimuli which have no significant effect on the creative task.*

In order to evaluate the hypotheses, the thesis designs an multi-stage experiment that implements an ideation process using the mental principle Jumping. This experiment uses the creative task:

How can a supermarket increase its popularity among its customers?

The task was used because the participants of the experiment were familiar with the context of the creative task.

3.8.2 Evaluation of the statement characteristics

The first stage of the experiment focuses on the hypothesis H-1. Input for this experiment was a set of eighty-one different statements that describe the creative task and its context. These statements were generated by two professional facilitators in an associative process using the stimuli '*supermarket*' and '*customers of a supermarket*'. Examples of the resulting statements are:

A supermarket is anonymous.
A supermarket is part of a nationwide company.
A supermarket distinguishes between regular stock and promotional goods.
A supermarket has a parking lot.

The generated statements were categorised by five experts, two women and three men. The experts were deemed to be appropriate subjects for this experiment, because they have experience with the design of ideation workshops and were familiar with the context of the creative task. Each expert received all statements as a randomly organised list and was instructed to score each statement individually with regard to the definition of the properties '*typical*' and '*relevant*'.

The property '*typical*' was scored on a scale of 1 (not typical: the statement is weakly related to the context of the creative task) to 4 (very typical: the statement is strongly related to the context of the creative task). The thesis defines a statement as typical for the context of the creative task, if the score was 3 or better.

The property '*relevant*' was scored on a scale of 1 (not relevant: the statement has a weak effect on the creative task) to 4 (very relevant: the statement has a significant effect on the creative task). A statement was defined as relevant for the goal of the creative task if the score is 3 or better.

The resulting scores of the experts are summed up to categorise the statements into the categories: '*typical - relevant*'; '*not typical - relevant*'; '*typical - not relevant*' and '*not typical - not relevant*'. Further, the experts were interviewed with regard to their experience with the properties defined during the categorisation of statements.

3.8.3 Results of the categorisation stage

The results of the categorisation of statements according to the criteria '*typical*' and '*relevant*' are shown in Table 3.5. Eighteen statements were similarly categorised by all experts (22.22% of all statements). The number of statements which were similarly categorised by four or more experts was 54 (66.67% of all statements). Only nine statements were rated consistently (no more than one score different for a criterion) on both criteria by all experts.

equally categorised by all of the five experts

relevant		typical: NO	typical: YES
	YES	0	2
	NO	14	2

equally categorised by four or more experts

relevant		typical: NO	typical: YES
	YES	7	5
	NO	32	10

equally categorised by three or more experts

relevant		typical: NO	typical: YES
	YES	15	7
	NO	39	20

Table 3.5: Results of the categorisation of statements against their characteristics

The results of the categorisation suggest some support for the Hypothesis H-1. However, the interviews with the experts show that personal experiences have an influence on the categorisation process. For example, the statement '*a supermarket receives a significant proportion of the private household budget*' (scores for typical: 2, 2, 3, 2, 4) was interpreted differently by the experts. According to the personal situation, the experts have several associations to a supermarket in relation to their household budget. Furthermore, they indicate that the property '*relevant*' is highly subjective because of missing criteria for the identification of a relevant statement for the creative task.

3.8.4 Evaluation of the stimulus characteristics

In a second stage of the experiment, the thesis focuses on the hypothesis that the characteristic of an external stimulus affects the cognitive mechanism of analogical thinking (see H-2 and H-3). An experiment is designed that implements an ideation process using the mental principle Jumping to solve the creative task: '*How can a supermarket increase its popularity among its customers?*'.

The experiment has two dependent variables: the number of ideas generated for a stimulus with a defined characteristic, and the characteristic of the generated ideas itself. The characteristic of generated ideas was analysed with regard to '*practicability: the effort that is needed to implement the idea*' and the '*effectiveness: the degree so which the idea solves the problem*'.

The thesis uses twenty of the most consistently categorised statements of the first stage of the experiment as external stimuli for the ideation process, five statements for each of the four categories (shown in Table 3.6)

Twenty-two students from a large university participated individually in an ideation workshop, five women and seventeen men. The student's age ranged from 21 to 31 years (M= 23.54; SD=2.87). Students were deemed to be appropriate subjects for this study, because they are familiar with supermarkets and represent potential customers. They were further motivated to participate because 1) they were interested in the topic of creativity or 2) they received course credit for their participation.

Upon arrival, a facilitator informed the participants verbally about the creative task of the experiment. The participants were told to write down different analogous situations for a set of different statements and to use their knowledge about these situations to generate ideas for the creative task. The process sequence used can be described as follows:

Repeat the following steps until all of the stimuli provided have been used:

Step 1 *The participant receives a statement as a stimulus for the creative task.*

Step 2 *The participant generates a list of analogous situations which he or she associates with this statement. (duration: 1 minute).*

Step 3 *The participant uses the list of analogous situations to generate solutions for the creative task, by thinking how this task has been or might be solved in this analogous situation. (duration: 4 minutes).*

The facilitator used an example to demonstrate the process in detail. During the experiment, no verbal communication was allowed between the participants. Further, the participants were requested not to judge any idea in mind and to write down every idea during the experiment. After the introduction, each participant received a set of twelve different statements as stimuli, three from each of the four categories. The stimuli from each category were randomly selected and organised in a way that each stimulus belonged to a different category than the one that preceded it (A-B-C-D-A-B-C-D). During the experiment, each of the twenty statements was used at least ten times as a stimulus. To assign an analogous situation and the resulting ideas to a provided

'typical - relevant' statements:
A supermarket has several parallel cash registers.
A supermarket has convenience goods.
A supermarket offers a great variety of goods for sale.
A supermarket provides products for many personal situations.
A supermarket provides similar goods with different prices.

'not typical - relevant' statements:
A supermarket treats everyone equally.
A supermarket has a parking lot.
A supermarket puts goods together according to the wishes of a customer.
People try to make your stay there as short as possible.
At a supermarket you have to stand in a queue.

'typical - not relevant' statements:
A supermarket presents goods on long shelves.
A supermarket has shopping carts.
A supermarket uses announcements to get the customer's attention.
People make a list of the products they are looking for there.
At a supermarket you buy more goods than you wanted.

'not typical - not relevant' statements:
A supermarket advertises in the local paper.
A supermarket wants to make a profit.
Supermarket staff wears an uniform.
Using a supermarket requires a car.
At a supermarket you meet many strangers.

Table 3.6: Characteristics of the external stimuli used to evaluate H-2 and H-3

stimulus, the participants received a set of forms that documented these relations by predefined identification numbers.

One thousand two hundred and twenty-two ideas were generated during the ideation process. All ideas were digitised including information on 1) the participant who generated the idea 2) the analogous situation used 3) the stimulus which was used to generate the analogous situation, and 4) the position of the stimulus used in the set of stimuli of the participant. Non-ideas, including statements which only described the analogous situation or comments, were excluded. The ideas were independently scored by three experts, who used two four-point scales to rate each idea with regard their practicability and effectiveness for the creative task (shown in Table 3.7). The overall score for each criterion of a generated idea was calculated by summing the scores of each expert and subtracting the number of the experts. Thus, a criterion ranges from 0 to 9.

3.8.5 Results of the ideation stage

The results of the evaluation of the ideas generated in relation to their own characteristics and the characteristics of the stimuli used are shown in Table 3.8. The analysis showed that the scores of the experts were in agreement (no more than one score different) in 90.6% for the criterion '*practicability*' and in 92.4% for the criterion '*effectiveness*'. According to the hypothesis H-2, external stimuli with the characteristic '*typical*' generate 10.3% more '*practicable*' and 1.8% less '*non practicable*' ideas than the mental principle Jumping using external stimuli which are '*not typical*'. For the hypothesis H-3, the analysis shows that external stimuli with the characteristic '*relevant*' generate 1.4% more '*effective*' and 7.7% less '*non effective*' ideas than the mental principle Jumping using external stimuli which are '*not relevant*'.

The research results show no statistically significant difference between the independent variables. However, they provide some indications to reject the null hypothesis. An analysis of the generated analogies supports this assumption, which shows an interesting relationship between the stimuli used, the analogies generated and the resulting ideas. Here, the analysis shows that analogies that results from different stimuli generate more top ideas and a smaller variance in idea quality. This property supports our assumption of a cognitive model for ideation and can be described by a possible higher intersection between the images of the analogy and the creative task. This intersection represents similarities between the images, which could be used as starting points by individuals to map corresponding parts of the images onto each other, and finally to apply the transferred knowledge to generate ideas. By adapting knowledge from an analogous situation with a high intersection with the creative task, the probability increases that resulting ideas are based on similar concepts which increases the practicability and effectiveness of an idea.

A number of limitations exist in this experiment. The experiment only used one creative task (the generation of service ideas). Therefore, the results cannot be generalised to other tasks until the experiment has been repeated with other kinds of tasks (e.g. the generation of product ideas). The experiment uses sentences and phrases as stimuli to

Scale of 'practicability':	
Score of 1	*impractical - the idea cannot be implemented by a supermarket without great effort.*
Score of 2	*less practical - the idea cannot be implemented by a supermarket without effort.*
Score of 3	*practical - the idea can be implemented by a supermarket with medium effort.*
Score of 4	*very practical - the idea can be implemented by a supermarket without effort.*
Scale of 'effectiveness':	
Score of 1	*ineffective - the idea will not increase the popularity of a supermarket for customers.*
Score of 2	*hardly effective - the idea will increase the popularity of a supermarket for a small number of customers.*
Score of 3	*effective - the idea will increase the popularity of the supermarket for most customers.*
Score of 4	*very effective: the idea will increase the popularity of the supermarket for all customers.*

Table 3.7: Four-point scales to rate ideas according to their practicability and effectiveness

generated ideas resulting from relevant / not typical stimuli

effectiveness \ practicability	NO	YES
YES	130	42
NO	81	46

generated ideas resulting from relevant / typical stimuli

effectiveness \ practicability	NO	YES
YES	149	49
NO	74	51

generated ideas resulting from not relevant / not typical stimuli

effectiveness \ practicability	NO	YES
YES	144	31
NO	86	46

generated ideas resulting from not relevant / typical stimuli

effectiveness \ practicability	NO	YES
YES	146	44
NO	64	38

Table 3.8: Results of the categorisation of ideas against the characteristics of their stimuli used

support the mental process of an individual. It would be necessary to analyse the characteristics of other types of stimuli, like pictures that provide more information than a sentence and allow the individual much more space for interpretation. Limitation is also given by the use of a small number of students in a laboratory experiment. A larger sample size should reduce the effect of possible outliers on the result.

3.8.6 Conclusion of the analysis

In conclusion, the presented hypotheses H-1 to H-3 could not be significantly proved. However, the results provide support to define rules for the use of stimuli to guide the creative cognition process of an individual using a mental principle. These rules represent a first step to improve the new design approach for collaborative ideation processes by supporting collaboration engineers in selecting a Change of Perspective and defining appropriate stimuli related to a given creative task. However, further research is needed to focus on the relationship between stimuli, mental principles and resulting ideas to validate and redefine rules for its selection and use.

3.9 Discussion of the research results

This chapter presents a creative cognition approach to analyse the underlying mental principles of given idea generation techniques. A new approach is introduced to describe, analyse and compare common idea generation techniques against the three ingredients: Algorithm, Format and Setting. Common idea generation techniques were analysed to gain a theoretical understanding of the different ways the ingredient Algorithm stimulates the ideation process. The analysis shows that there are three mental principles called Jumping, Dumping and Pumping that support the cognitive process of an individual for knowledge creation. The mental principles were formalised by the concept Change of Perspective, which defines the mental principle as a sequence of formal steps that will be used to guide the creative cognition process.

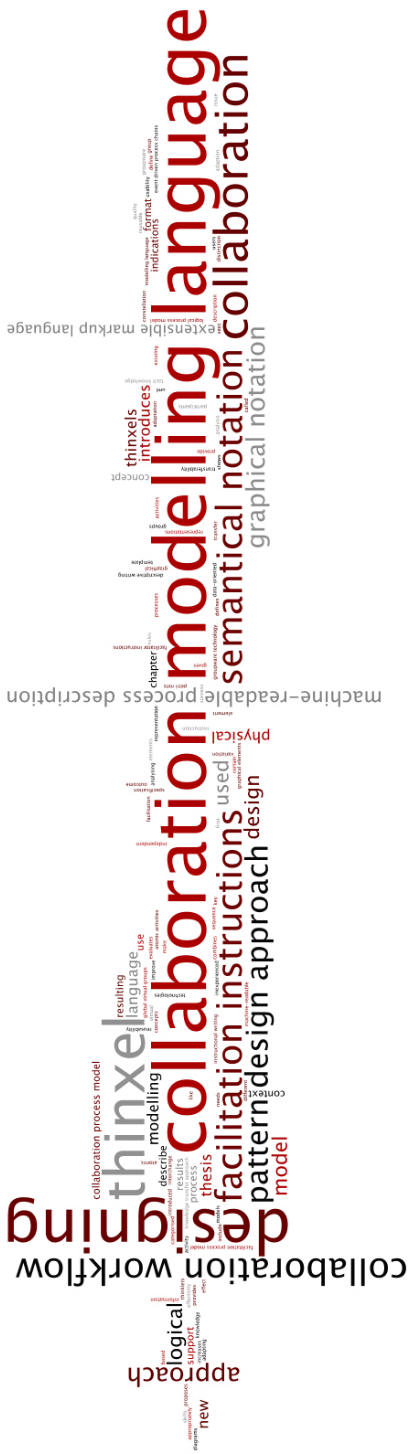
The chapter introduces a new design approach for collaborative ideation processes based on a given approach for collaboration process design. The new design approach combines a limited number of formal cognitive and social principles by enhancing the given concepts of Generate thinkLets and Modifiers by the concept Change of Perspective.

The chapter analyses the Change of Perspective to improve the design approach of a collaborative ideation process. Here, the thesis analyses in a first study the influence of external stimuli characteristics on the outcome of an ideation process using the mental principle Jumping. The research results provide support to define rules for the design and use of stimuli for a Change of Perspective in relation to given creative task. However, further research is needed to better understand the relationship between stimuli and resulting ideas to validate and redefine rules for a design approach for collaborative ideation processes.

The resulting design approach fulfills the formulated requirements for an design approach for ideation. The concept Change of Perspective provides knowledge to guide to mental activities of well-known ideation methods that represent idea generation techniques in current ideation practice (supports R-1). The redesign of the concept of Modifier distinguishes between interventions that affect social phenomena and variations of a thinkLet which provide best work practices for the design of a specific environment that reduce negative group behaviours during an ideation process (supports R-2). Furthermore, provides the used pattern approach itself first guideline for the selection of a Change of Perspective, a thinkLet and a Modifier with regard to a given innovation goal or context (supports R-3).

The design approach further fulfills the characteristics of traditional engineering methods. The used concepts are based on scientific results and provide a simple approach to explain and teach the design of a collaborative ideation process. The design approach supports the design of an appropriate ideation processes for a given creative task and group constellation using given resources available. Furthermore, the approach can be used to analyse and understand the influence of each concept on the cognitive and social process of a group during ideation. Research results can be used to better predict the output of the ideation process and to provide better guidelines for the design of a predictable collaborative ideation process.

Currently, the resulting model of a collaborative ideation process is documented in a paper-based handbook, which provides tacit knowledge and skills to prepare and implement the ideation process. To support collaboration in global virtual groups, the handbook needs to provide tacit knowledge and skills how to configure and use technological support to implement the ideation process. These specification of a handbook, still ties an ideation process to a specific groupware technology. The thesis assumes that a machine-readable process description can be used to develop an adaptable groupware technology, which supports the appropriately use of a technology by using the workflow of a collaboration process to configure the tools and functionalities of the technology automatically. However, the design of a machine-readable process description for a collaboration workflow is still a research gap. As a result, the next chapter will analyse the feasibility of a new modelling approach that formalises the workflow of a collaboration process into a machine-readable process description.



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collaboration workflow
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process description
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Chapter 4

Designing a modelling language for collaboration

4.1 Overview

This chapter analyses the feasibility of a modelling approach that formalises a collaboration process into a machine-readable process description. Based on an analysis of given approaches for process modelling, a new modelling approach for collaboration processes is introduced called Collaboration Modelling Language (CML). This approach uses the concept of a thinXel as a formal instruction element that produces low cognitive load on the participants and holds their attention to the collaboration process. A graphical and semantical notation of the CML is presented which make use of a design pattern approach to describe the workflow of a collaboration process. Furthermore, a knowledge transfer approach is introduced to transfer necessary knowledge for the adaption and execution of a collaboration process for global virtual groups.

4.2 Need for a collaboration modelling language

The previous chapter introduces a new design approach for collaborative ideation processes. This design approach adopts given concepts of Collaboration Engineering and combines them with a new concept Change of Perspective to guide the creative cognition process of a group. The resulting model of a collaborative ideation process is documented in a paper-based handbook, which provides a general workflow description of the intended cognitive and collaborative activities of a group. Furthermore, the handbook provides information to guide a group in using a specific groupware technology for collaboration.

Resulting to the fact that virtual teams comprise an important structural component of many multinational organisations, the thesis sees a need for technological support to assist global virtual groups in structuring activities, generating and sharing data, and improving group communication across the globe. During a face-to-face workshop, a facilitator can identify a misuse of the technology or the intended collaboration process. In a virtual environment, technological functionalities are needed to compensate the missing physical presence of a facilitator. Here, a far more detailed and explicit collaboration process model can take over some functions of a facilitator by providing information how to appropriately use the provided functionalities of groupware technology for a given collaborative task.

The thesis assumes that the underlying process logic of the collaboration workflow can be used to develop adaptable groupware technologies that provides functionalities to monitor and guide a virtual group automatically through a collaborative ideation process. Here, a machine-readable process description can be used to describe the collaboration workflow in a format that can be processed by different groupware technologies. A modelling language can make use of a pattern design approach to divide the collaboration process into patterns of collaboration, which characterise the ways in which a group can move toward its goals. Furthermore, design patterns can be used to transfer tacit knowledge and skills that are needed for the appropriately use of a groupware technology for collaboration.

The thesis formulates different requirements for a process model for collaboration in distributed environments:

R-1 *The model needs to describe a collaboration process in a machine-readable format.*

R-2 *The model needs to describe a collaboration process in a logical as well as a physical design.*

R-3 *The model needs to transfer tacit knowledge and skills for the execution of a collaboration process.*

Different modelling approaches like the Business Process Modelling Notation (BPMN) [White, 2004], the XML Process Definition Language (XPDL) [WMC, 2008] or the Facilitation Process Model (FPM) [de Vreede and Briggs, 2005] provide concepts to describe the workflow of a collaboration process. For example, the Workflow Management Coalition [Hollingshead, 1995] develops a meta-model that defines a basic set of object types for simple process definitions. Their approach of a machine-readable language is called XML Process Definition Language (XPDL) [WMC, 2008] and defines a common interchange format, which supports the transfer of process definitions between different products. The primary focus of XPDL is the core business processes of an organisation that can be managed by a Workflow Enactment Service. However, a facilitated process is not taken into account.

Similar to given modelling approaches, the thesis intends to use the following process information to define the workflow of a collaboration process:

Process Activity — *describes the order and type of the activities of a participant with a defined role in a collaborative process.*

Process Data — *describes the type and the value of the data elements that will be used or developed by a defined collaborative activity.*

Process Event — *describes the influence of events on the activities of the collaborative process.*

Besides this process information, the quality of facilitation is a key issue for collaboration success [Niederman et al., 1993, Shepherd et al., 1995, Wong and Aiken, 2003]. For example, Shepherd et al. [Shepherd et al., 1995] shows that slight variations in facilitator instructions have no impact on collaboration activity, but influenced the motivation and as a result produce significant differences in group productivity. By taking this factor into account, the thesis assumes that a process model should further include a specification of the facilitation instructions, which define the collaboration workflow of the participants by a sequence of atomic activities. With the limitation to one activity per instruction, a facilitation instruction represents a reusable pattern element that enables the design of a collaboration process model by describing the single steps all participants have to go through.

4.3 Concept of thinXels - atomic instruction elements

The thesis introduces the concept of a thinXel as a new design approach for a reusable instruction element. A thinXel is defined as '*an atomic facilitator instruction leading to a response that has a well-defined function in the context of the group's goal*' [Knoll et al., 2007]. The name '*thinXel*' (thinking element) is formed analogously to the well-known '*pixel*' (picture element) in Computer Graphics.

The concept of a thinXel is based on the Shannon-Weaver Model of a communication process [Shannon, 1948] which describes the transmission of a message between a sender and a receiver. In this model, the sender encodes a given intention in a message, which will be transmitted to the receiver via a channel. The receiver needs to decode the message to understand the intention and be able respond to it. Noise can degrade the quality of the transmission, so that the interpretation of the message might not match the intention of the sender. In a collaboration process, a facilitator instruction or user interface represents a coded intention of the facilitator for the participants of a collaboration process. This message can lead to unintended activities of the participants by providing to much information (e.g. an instruction or interface that provides information for more than one process step) or only abstract information about the collaboration process (e.g. an interface or instruction that leaves open how to execute an intended activity). As a result, a thinXel is introduced as an instruction element that represents one atomic instruction or interface which leads to only one basic activity of the participants.

The design of a thinXel is influenced by the research on the Cognitive Network Model, which shows that the working memory of a participant is limited. People can only pay attention to about seven concepts at the same time [Miller, 1956]. Without a refresh by conscious rehearsal or by external stimuli, the content of the working memory would fade within seconds [Brown, 1958]. As a result, the thesis intends that an instruction element may contain only those pieces of information that must be conveyed to the participant to perform the activity intended by the collaboration workflow. An example is the instruction '*Please write down on a sheet of paper a comment, which you associate with the issue*' for the collaborative activity '*to create a comment for the issue*'. The concept of thinXel uses this property and defines that an instruction element should lead to one basic activity like '*add*', '*select*' and '*move*'. This makes a thinXel an atomic instruction element.

These properties define the difference between the concept of a thinkLet and a thinXel. A thinkLet is a reusable logical design element that describes a sequence of abstract rules which lead to a collaboration pattern. However some abstract rules of a thinkLet can leave open the question, which instruction or interface should be used to achieve an intended action [Knoll et al., 2007]. Therefore it depends on the experience of the practitioner or software engineer which instruction or interface is used. In contrast, a thinXel represents a reusable physical design element which defines one atomic instruction or interface that leads to only one atomic activity of the participants.

The concept of thinXel can be categorised into context and data-oriented thinXels [Knoll et al., 2008]:

A context-oriented thinXel — *represents an instruction element with the intention to create a working environment for the collaboration process.*

Resulting instructions or interfaces explain the constraints, goals and the intended working process, which can support the participant's acceptance of the collaboration process. Furthermore, these instruction elements can be used to modify the working environment by requesting the participants to select a working element (e.g. a pen and some sheets of paper) or to decide which activity should be done next. Examples of the indented actions of the participants can be: *to know* (to know the process goal), *to read* (to read the process information), *to select* (to select a concept from the dataset) or *to take* (to take something from somewhere).

A data-oriented thinXel	*represents an instruction element with the intention to change the existing dataset of the group process.*

Resulting instructions or interfaces can be divided into three kinds of activities: *to create* (to create a concept to the groups work space), *to grow* (to enhance an existing concept from the groups work space with new concepts) or *to relate* (to establish the relationships between two concepts). Other data activity like the defined actions of a thinkLet (Add, Delete, Edit, Relate, Judge) [Kolfschoten et al., 2004] can be represented by a combination of these three activities. For example, the activity Delete can be represented by the activity *to relate*, which leads to a relation between a given contribution and a contribution named Wastebasket.

4.3.1 A class diagram of a collaboration process

Similar to the concept of Rules in Collaboration Engineering [Briggs et al., 2006] a sequence of thinXels can be used to describe actions that participants must execute using the capabilities provided to them under some set of constraints. However, the concept of thinXels provide a more detailed description of an action by taking the factor facilitation into the account. As a result, the thesis intends to combine the concepts of thinkLet and thinXel to define the collaboration workflow in more detail.

Figure 4.1 illustrates a class diagram for a collaboration process combining the concepts of thinkLet and thinXel. This model refines the given thinkLet class diagram [Kolfschoten et al., 2006] by replacing the concept of Rule by the new concept of thinXel. The central component of this model is the *collaborationprocess* that defines a collaborative process for a group of participants. A *participant* is a person that executes the activities that are related to the *collaborationprocess*. A *role* abstractly denotes a set of behaviors, rights and obligations a *participant* needs to execute the intended activities of the process.

The collaboration process itself is composed of a sequence of *thinkLets* that represents a named, scripted, reusable, and transferable collaborative activity for creating specific known variations of the six patterns of collaboration among people working together toward a goal [Briggs et al., 2006]. Under the old model, rules describe actions that participants must execute using the capabilities provided to them under some set of constraints. To include the facilitation factor, *thinXels* were used to define the relationship between a *participant* in a defined *role*, an *instruction* for an intended *action* and its result on *context* and *dataset*. Table 4.1 provides some examples of these data and context-oriented thinXels. Here, an *instruction* provides information for the *participant* how to use the provided *capabilities* and certain pieces of information given by *parameter* to achieve an intended *action*. According to the given group constellation this *instruction* can vary in *style* from formal to informal. Similar to Collaboration Engineering, *modifier* defines repeatable variations of a *thinkLet* in order to create a predictable change in the pattern of collaboration or the result that a thinkLet produces.

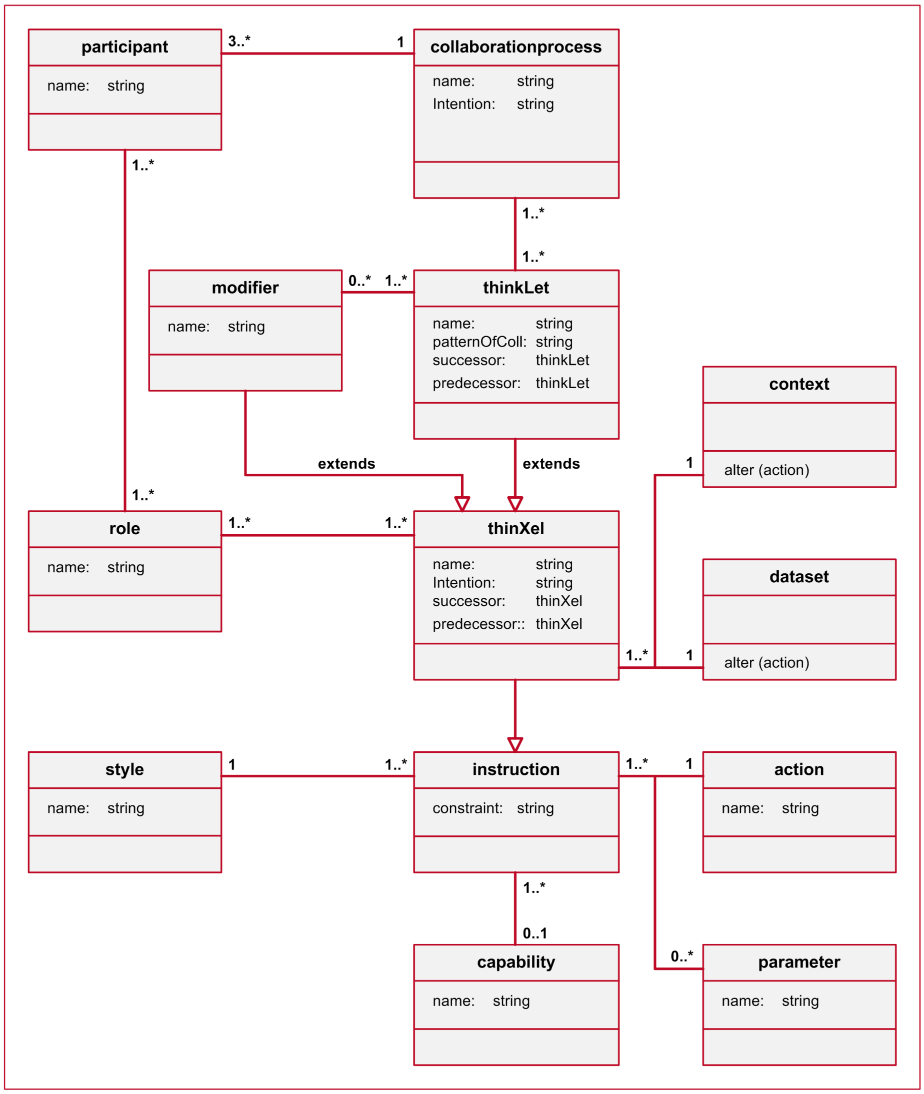

Figure 4.1: Class diagram of a collaboration process using thinkLet and thinXel adapted from [Kolfschoten et al., 2006]

Type	Action	Capability	Parameter	Style	Instruction
Context	Read	sheet of paper with process information		formal	Please read the following information about the process
Context	Select	application that supports selection		formal	Please select one contribution from the given list of contributions by <using the application in a specific way>
Context	Decide	different work stations		informal	We have distributed different work stations across the room. Now go around and decide at which station you want to work in the next phase
Context	Organise			informal	Now all of you should build groups of three participants
Data	Create	application that supports generation	task	formal	Please create a contribution for the <task> by <using the application in a specific way>
Data	Grow	application that supports generation	criterion	informal	Change the contribution if you think that it does not fulfill the <criterion> by <using the application in a specific way>
Data	Relate	set of cards with the contributions; paper clips		informal	Combine contributions with a similar content by using a paper clip

Table 4.1: Examples of data and context-related thinXels

4.4 Evaluation of the concept of thinXels

This section evaluates the concept of a thinXel as an atomic instruction element that reduces misunderstanding of facilitation instructions during collaboration using technological support [Knoll et al., 2007]. To investigate the influence of varying facilitator instructions, a groupware technology is used that allows the design and execution of different ideation processes which use the mental principle Jumping and vary in the complexity of their used facilitation instructions. In this context, the thesis formulates the following research question:

> *How does the variation of facilitator instructions affects the outcome of a collaboration process for ideation in global virtual groups?*

Furthermore, the following null hypothesis and hypotheses are defined:

H-0 *There is no significant impact of facilitation instruction characteristics on the outcome of a collaboration process using the mental principle Jumping.*

H-1 *A thinXel-based collaboration process will keep the participants more focused on the process outcome compared to a collaboration process with complex facilitation instructions.*

H-2 *A thinXel-based collaboration process will more efficiently execute the intended collaboration process compared to a collaboration process with complex facilitation instructions.*

4.4.1 Experiment design for hypotheses evaluation

In order to evaluate the hypotheses, the thesis uses a controlled experiment that implements three collaboration processes for ideation using the mental principle Jumping. The experiment uses the creative task:

What kind of new services can a citizens advice bureau provide to the citizens?

The experiment uses the mental principle Jumping (introduced in section 3.6.1) that refers to a cognitive process of retrieving and using semantically related knowledge in an associative process to generate ideas. External related stimuli are used to guide the cognitive processes of an individual for the retrieval of knowledge that can be used to generate ideas for the creative task. The experiment uses possible related problems, persons and processes of a citizens advice bureau as focal points to guide an individual in analysing the creative task for analogous situations which can be used to generate new service ideas for the creative task.

The mental principle Jumping was used by three ideation processes that vary in the complexity of their facilitation instructions. All collaboration processes were executed by a virtual group using a groupware technology that provides functionalities for the implementation of the ideation process as a sequence of questions that build on each other. Each variation of the three ideation processes was executed three times by different groups for the duration of 36 minutes.

Twenty-seven students from a large university participated in groups of three persons in an virtual ideation workshop, thirteen women and fourteen men. The students age ranged from 21 to 28 years (M: 24.67, SD: 2.17). Students were deemed to be appropriate subjects for this study, because they were familiar with the citizens advice bureau and represent potential customers. They were further motivated to participate because they were interested in the topic of creativity.

Upon arrival, a group of three participants were informed verbally about the creative task of the experiment. They received an introduction to the functionality of the groupware technology and each participants was seated in front of one computer. The facilitator informed the participants verbally to generate service ideas by only following the facilitator instructions provided by the groupware technology. No verbal communication was allowed between the participants during the experiment, but they were allowed to use the chat application of the groupware technology to communicate with each other. During the experiment, the participants could see each others contributions, which were recorded with timestamps by the groupware technology in relation to the presented facilitation instruction. Furthermore, the groupware technology recorded private communication between the group participants.

The experiment has two dependent variables: the attention of the participants to the collaboration process and the efficiency of the collaboration process itself. The attention of the participants to the collaboration process was determined by the time interval between two contributions a participant generated as a result of the provided facilitation instructions. This interval should be short during a high attention period to the process. Furthermore, private communication between the group participants should decrease.

The efficient execution of the intended ideation process was measured by analysing the ideas generated for the creative task. Each process used three foci to guide the cognitive process of an individual during ideation. An efficient ideation process should create a set of ideas that are distributed equally across the foci used. Therefore, the number of non-redundant ideas was counted in relation to the focal points used. Furthermore, a questionnaire was used to document the impressions of the participants about the ideation process. The questionnaires used a scale from 1 to 6, where the value 1 represent the best value.

In the next paragraphs, the thesis presents each of the used experiments in more detailed to show the differences between the complexity of the used facilitation instructions.

Experiment E-1: a collaboration process using atomic instruction elements to maximise the influence of a facilitator

The experiment E-1 represents a thinXel-based variation of a collaboration process for ideation using the mental principle Jumping. Here, the ideation process is divided into three sub-processes. Each sub-process uses a different focus to guide the cognitive process of the individual. During the ideation process, the groupware technology presents a facilitation instruction for the duration of three minutes and allows the participants to generate a list of possible contributions related to the instruction. The facilitation script of this experiment is defined as follows:

Phase 1: Mental principle jumping using the focus problem

Step 01	*Please write down a problem that you associate with a citizens advice bureau.*	*03 Minutes*
Step 02	*Please write down an institution that also has this problem.*	*03 Minutes*
Step 03	*Please write down a service that this institution offers its clients.*	*03 Minutes*
Step 04	*Please write down a new service idea by adapting this service to the citizens advice bureau.*	*03 Minutes*

Phase 2: Mental principle jumping using the focus person

Step 05	*Please write down a person that you associate with a citizens advice bureau.*	*03 Minutes*
Step 06	*Please write down an institution where this person can be met.*	*03 Minutes*
Step 07	*Please write down a service that this institution offers its clients.*	*03 Minutes*
Step 08	*Please write down a new service idea by adapting this service to the citizens advice bureau.*	*03 Minutes*

Phase 3: Mental principle jumping using the focus process

Step 09	*Please write down a process that you associate with a citizens advice bureau.*	*03 Minutes*
Step 10	*Please write down an institution where this process also exists.*	*03 Minutes*
Step 11	*Please write down a service that this institution offers its clients.*	*03 Minutes*
Step 12	*Please write down a new service idea by adapting this service to the citizens advice bureau.*	*03 Minutes*

The thesis assumes that this facilitation script will keep the participants focused on the process outcome and support an efficiently execution of the intended collaboration process.

Experiment E-2: a collaboration process using abstract instruction elements to reduce the influence of a facilitator

The experiment E-2 reduces the influence of a facilitator and intends to verify the assumption that a facilitator instruction should lead to one activity to generate more benefit from a collaboration process. Here, the ideation process combines the three sub-processes of experiment E-1 into one collaboration process; integrating the foci problems, persons and processes into one facilitator instruction. The resulting ideation process uses four process steps which use more abstract instructions than in experiment E-1. During the ideation process, the groupware technology presents a facilitation instruction for the duration of nine minutes and allows the participants to generate a list of possible contributions related to the instruction. The facilitation script of this experiment is defined as follows:

Step 01	*Which attributes (problem, people, and process) do you associate with a citizens advice bureau?*	*09 Minutes*
Step 02	*Which institution has the same attribute?*	*09 Minutes*
Step 03	*Which service idea is offered by this institution?*	*09 Minutes*
Step 04	*Which new service idea can be adapted to the citizens advice bureau?*	*09 Minutes*

The thesis assumes that this facilitation script will keep the participants less focused on the process outcome as a facilitation script of a thinXel-based collaboration process. This could have a negative effect on the efficiently execution of the intended collaboration process.

Experiment E-3: a collaboration process using complex instruction elements to minimise the influence of a facilitator

The experiment E-3 intends to verify the assumption that a complex facilitator instruction can lead to a loss of attention by the participants for the intended collaboration process. The ideation process uses the facilitation script of experiment E-2, but reduces the influence of the facilitator. The resulting ideation process is divided into two process phases. In the first phase, the facilitation script of experiment E-2 is used as a training to introduce and explain the mental principle Jumping to the participants. Here, the groupware technology presents a facilitation instruction for the duration of two minutes. In the second phase of the experiment, the participants are instructed to use the presented principle independently for twenty-eight minutes to create new ideas without any further instructions from the facilitator. During this phase, the groupware technology provides the possibility to jump freely between the presented process steps of the mental principle Jumping. The facilitation script of this experiment is defined as follows:

	Phase 1: Exercise the mental principle jumping	
Step 01	*Which attributes (problem, people, and process) do you associate with a citizens advice bureau?*	*02 Minutes*
Step 02	*Which institution has the same attribute?*	*02 Minutes*
Step 03	*Which service idea is offered by this institution?*	*02 Minutes*
Step 04	*Which new service idea can be adapted to the citizens advice bureau?*	*02 Minutes*
	Phase 2: Apply the mental principle jumping	
Step 05	*Use this creativity technique in the presented way, to create new service ideas for a citizens advice bureau.*	*28 Minutes*

The thesis assumes that this complex facilitation script can lead to a loss of attention by the participants for the intended collaboration process. This could have a negative effect on the efficiently execution of the intended collaboration process.

4.4.2 Experiment results

Each of the experiments used the mental principle Jumping to support the group in generating ideas. In this context, three foci were used to guide the individuals in analysing the creative task for analogous situations, which can be used to generate new service ideas for the creative task. Table 4.2 shows the number of generated contributions that describe the current situation of the citizens advice bureau categorised according to these foci. The number of resulting service ideas are shown in Table 4.3. Furthermore, the experiment analyses the time interval between two contributions a participant generated as a result of the facilitation instructions provided (shown in Table 4.4).

Experiment E-1: contributions resulting from the process steps 01, 05 and 09

	Group G-1			Group G-2			Group G-3				
Participant	P-01	P-02	P-03	P-04	P-05	P-06	P-07	P-08	P-09	M	SD
focus process	08	06	17	04	05	05	04	04	10	7,00	4,27
focus problem	12	03	10	04	04	04	04	05	08	6,00	3,20
focus person	13	05	16	04	11	02	03	04	17	8,33	5,92

Experiment E-2: contributions resulting from the process step 01

	Group G-4			Group G-5			Group G-6				
Participant	P-10	P-11	P-12	P-12	P-14	P-15	P-16	P-17	P-18	M	SD
focus process	08	04	07	07	20	23	00	01	05	8,33	7,97
focus problem	03	03	10	04	07	03	09	07	06	5,78	2,68
focus person	02	01	01	02	08	01	02	02	02	2,33	2,18

Experiment E-3: contributions resulting from the process step 01

	Group G-7			Group G-8			Group G-9				
Participant	P-19	P-20	P-21	P-22	P-23	P-24	P-25	P-26	P-27	M	SD
focus process	02	01	02	03	07	05	06	04	01	3,44	2,19
focus problem	04	03	03	02	06	02	04	03	03	3,00	1,73
focus person	00	02	00	02	01	02	02	02	00	1,22	0,97

Table 4.2: Experiment E-1, E-2 and E-3: contributions generated for the three foci process, problem and person

Experiment E-1: service ideas resulting from the process steps 04, 08 and 12

	Group G-1			Group G-2			Group G-3				
Participant	P-01	P-02	P-03	P-04	P-05	P-06	P-07	P-08	P-09	M	SD
focus process	06	03	05	04	04	04	01	01	08	4,00	2,24
focus problem	06	06	05	06	07	09	01	02	09	5,67	2,74
focus person	07	04	03	03	02	04	05	02	08	4,22	2,11

Experiment E-2: service ideas resulting from the process step 04

	Group G-4			Group G-5			Group G-6				
Participant	P-10	P-11	P-12	P-12	P-14	P-15	P-16	P-17	P-18	M	SD
focus process	05	01	07	04	06	08	02	00	02	3,89	2,80
focus problem	12	04	04	00	02	01	05	04	07	4,33	3,57
focus person	01	00	00	06	09	10	00	02	00	3,11	4,11

Experiment E-3: service ideas resulting from the process step 04

	Group G-7			Group G-8			Group G-9				
Participant	P-19	P-20	P-21	P-22	P-23	P-24	P-25	P-26	P-27	M	SD
focus process	11	24	25	19	26	37	07	03	06	17,56	11,45
focus problem	00	02	02	00	01	02	17	03	05	3,56	5,27
focus person	02	05	03	02	01	06	10	07	00	4,00	3,24

Table 4.3: Experiment E-1, E-2 and E-3: service ideas generated for the three foci process, problem and person

Experiment E-1: time interval between two contributions

	Group G-1			Group G-2			Group G-3				
Participant	P-01	P-02	P-03	P-04	P-05	P-06	P-07	P-08	P-09	M	SD
mean (M)	00:19	00:26	00:17	00:44	00:29	00:36	00:44	00:44	00:18	00:31	00:12
standard deviation (SD)	00:16	00:35	00:19	00:38	00:30	00:35	00:40	00:38	00:12		

Experiment E-2: time interval between two contributions

	Group G-4			Group G-5			Group G-6				
Participant	P-10	P-11	P-12	P-12	P-14	P-15	P-16	P-17	P-18	M	SD
mean (M)	00:30	00:45	00:32	00:29	00:12	00:26	00:36	00:40	00:36	00:32	00:09
standard deviation (SD)	00:23	00:47	00:21	00:27	00:11	00:21	00:32	00:36	00:28		

Experiment E-3: time interval between two contributions

	Group G-7			Group G-8			Group G-9				
Participant	P-19	P-20	P-21	P-22	P-23	P-24	P-25	P-26	P-27	M	SD
mean (M)	00:34	00:26	00:51	00:50	00:26	00:26	00:25	00:32	00:52	00:36	00:12
standard deviation (SD)	00:59	00:24	00:36	01:06	00:28	00:21	00:21	00:20	00:44		

Table 4.4: Experiment E-1, E-2 and E-3: resulting time interval between two concepts

No communication between the group participants was detected during the experiment E-1. The evaluation of the questionnaire shows that the participants understood the facilitator instruction (M: 1.33 SD: 0.5), and always knew what they were supposed to do (M: 1.44, SD: 0.72). In summary, 192 contributions were generated, which describe problems, persons and processes of the citizens advice bureau. The participants used analogies from each of the three foci to create 125 new service ideas for the citizens advice bureau (Group G-1: 45 ideas, Group G-2: 43 ideas and Group G-3: 37 ideas). The mean for the time interval between two concepts was 31 seconds for all participants.

During experiment E-2, a process oriented communication between the participants was detected in one of the three groups. Similar to experiment E-1, the participants indicated that they understood the facilitator instruction (M: 1.67 SD: 1.0) and always knew what they were supposed to do (M: 1.78 SD: 0.83). They generated 148 contributions that describe problems, persons and processes of the citizens advice bureau. An analysis of the generated contributions shows a preference of the participants for the foci process and problem. As a result, only three participants used analogies from all of the three foci to generate new service ideas. In summary, the groups generated 102 new service ideas for the citizens advice bureau (Group G-4: 34 ideas, Group G-5: 46 ideas and Group G-6: 22 ideas). The mean for the time interval between two contributions was 32 seconds for all participants.

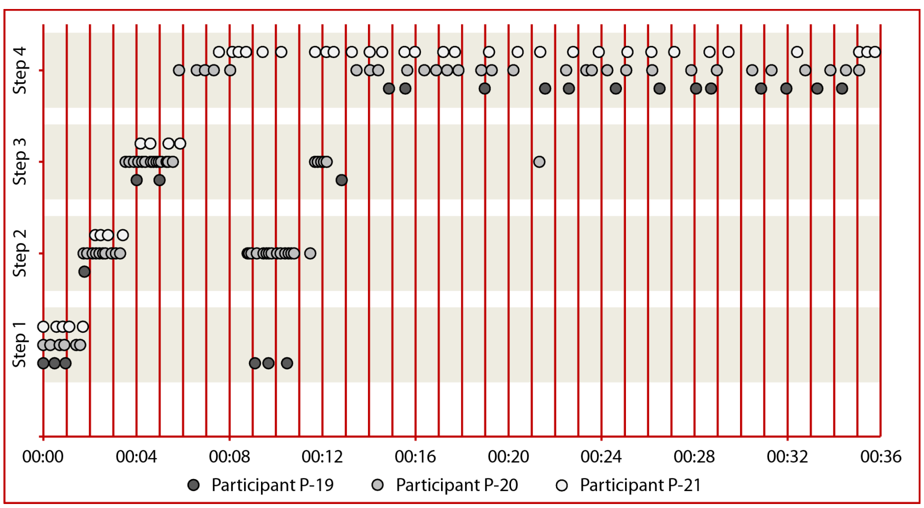

Figure 4.2: Experiment E-3: The activities of the participants in group G-7 (x = time, y = process steps)

During the Experiment E-3, private communication between the participants was detected in two of the three groups. The evaluation of the questionnaire shows that the participants understood the facilitator instruction (M: 1.33 SD: 0.5), and always knew what they should do (M: 1.56 SD: 0.53). However, after the training some participants did not followed the indented collaboration process. Figure 4.2 illustrates this effect for the activities of the participants in group G-7. With the beginning of the second part of the experiment (time stamp 00:08), participant P-21 only used the process step 4 to create new service ideas instead of using the intented mental principle Jumping. A detail analysis shows that the participant used the generated service ideas in step 4 as stimuli for the generation of new ideas, similar to the classical idea generation technique Brainstorming [Osborn, 1963]. During the whole experiment, 72 concepts were generated that describe problems, persons and processes of the citizens advice bureau. However, some participants who followed the intended collaboration process did not create concepts for all of the three foci and showed a preference for the focus process. As a results, 226 service ideas were created (group G-7: 74 ideas, group G-8: 94 ideas and group G-9: 58 ideas). The mean for the time interval between two concepts was for all participants 36 seconds.

The results of the experiments E-1, E-2 and E-3 provide indications to reject the null hypothesis. According to the hypothesis H-1, the thesis assumes that the time interval between two concepts will be short during a high attention period to the process. The analysis shows that no significant difference exists between experiment E-1 and E-2 (E-1: M: 31 seconds, SD: 12 seconds; E-2: M: 32 seconds, SD: 09 seconds), which use atomic or abstract instruction elements to guide the collaboration process. During experiment E-3 the time gap increases with the decrease of the facilitators influence (E-3: M: 36 seconds, SD: 12 seconds). Some participants misunderstood the intended collaboration process and used a more generic process like the idea generation technique Brainstorming to generate new service ideas. However, they stated that they understood the facilitator instruction and did always knew what they should do. Furthermore, experiment E-3 was the only experiment were private communication between the participants was detected. In conclusion, the research results show no statistically significant to prove the hypothesis H-1, but provide some indications that atomic instruction elements keep the participants more focused on the intended collaboration process.

The result of the created concepts shows that experiment E-1 (192 concepts) generated much more concepts for the development of new service ideas than experiment E-2 (148 concepts) and E-3 (72 concepts). On the other hand, experiment E-3 (226 service ideas) created more service ideas than the experiments E-1 (125 service ideas) and E-2 (102 service ideas). However, a closer analysis of the service ideas shows that most of the ideas of experiment E-3 are extended versions of other ideas, which were created by the participant themselves. Only experiment E-1 created a well balanced distribution of concepts and service ideas for the provided foci. This result provides some support for the hypothesis H-2 which assumes that a thinXel-based collaboration process is more efficient in executing the intended collaboration process.

4.4.3 Conclusion of the analysis

In conclusion, the presented hypotheses could not be significantly proved. However, the results support the assumption that a process model for collaboration should use atomic instruction elements to reduces misunderstanding of facilitation instructions during collaboration. This property of a thinXel could support the appropriately use of a groupware technology for collaboration in global virtual groups. Currently, the virtual presence of the participants made it difficult for a facilitator to identify a misuse of the technology or the intended collaboration process. As a result, the thesis proposes that a modelling language should combine the concepts of thinkLet (a design pattern to transfer tacit knowledge and skills for the appropriately use of a groupware technology) with the concept of thinXel (an atomic instruction element to guide the participants through an intended collaboration process).

4.5 Collaboration modelling language

This section introduces a modelling language for collaboration processes that makes use of the pattern design approach given by the concepts of thinkLets and thinXels. The thesis uses a graphical as well as semantical notation to describe the workflow of a collaboration process by different pieces of process information like the process activities of the participants, the data elements used and the influence of events on the process activities.

4.6 Graphical notation of the collaboration modelling language

A graphical notation is used as a language independent approach to increases the usability of a collaboration process model. Different approaches to model processes like the Event Driven Process Chains (EPCs) [van der Aalst, 1999], Business Process Modelling Notation (BPMN) [White, 2004], Petri Nets [van der Aalst, 1998], UML activity diagrams [Ambler, 2005] and the Facilitation Process Model (FPM) [de Vreede and Briggs, 2005] are analysed with regard to their modelling constructs and syntactical rules for their composition.

Process models like the EPCs or the PBMN provide proven solutions to model and analyse business processes from an abstract process perspective but did not formalise the single activities of a group participant. Mathematical models like Petri Nets allows the description and analysis of different processes but reduce the usability of the model by a small number of modelling constructs (places, transitions, arcs and token), which require some degree of abstraction by the user to use them as different collaboration process elements. For example, process elements like the process states of participants, data used and events will be described by the same modelling construct of a token in a place. To improve process understanding, the FPM uses the pattern design approach of a thinkLet as a process container that provides abstract information to support an intuitive understanding of the model.

In conclusion, none of the existing graphical models provides an intuitive approach to describe the concurrent process activities, the data used and the influence of internal and external events on a collaboration process. As a result, the thesis combines well proven modelling constructs with new abstract representations for the concepts of thinkLets and thinXels to improve an intuitive understanding of a collaboration process model.

The resulting design of these elements follows graphical representations of existing elements from process models like EPCs, Petri Nets, UML activity diagrams and FPM. The graphical notation includes the following elements [Knoll et al., 2008]:

Graphical elements: participant flow and group flow

The modelling language uses the concepts of thinkLets and thinXels to describe the workflow of a collaboration process. These concepts define the activities of the participants which create a collaboration process. The resulting process flow describes the path of the participants through the collaboration process and can be represented by a simple arrow symbol. The graphical element of an arrow can be used to illustrate concurrent processes but does not distinguish between an individual participant and a group of participants moving synchronously through the process. To show a clear visual distinction between these process flows, the graphical element uses two different kinds of lines (show in Figure 4.3). Here, a single line represents an element for an individual participant and a double line stands for a group of participants.

Figure 4.3: Graphical elements: participant flow and group flow

Graphical elements: data path and signal path

The modelling language uses the elements *data path* and *signal path* to represent the connections between data and event elements of the collaboration process and the activities of the participants. Simple arrow symbols are used as a graphical representation for these elements (shown in Figure 4.4).

Figure 4.4: Graphical elements: data path and signal path

Graphical element: decision

The modelling language uses the element *decision* to direct the process flow by reacting to different internal and external stimuli. The graphical representation of this element is similar to the decision element of a UML activity diagram but distinguishes between participant and group flow (shown in Figure 4.5).

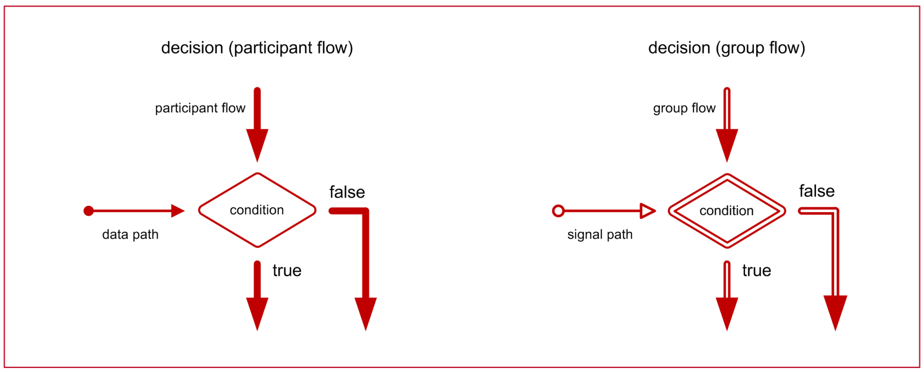

Figure 4.5: Graphical element: decision

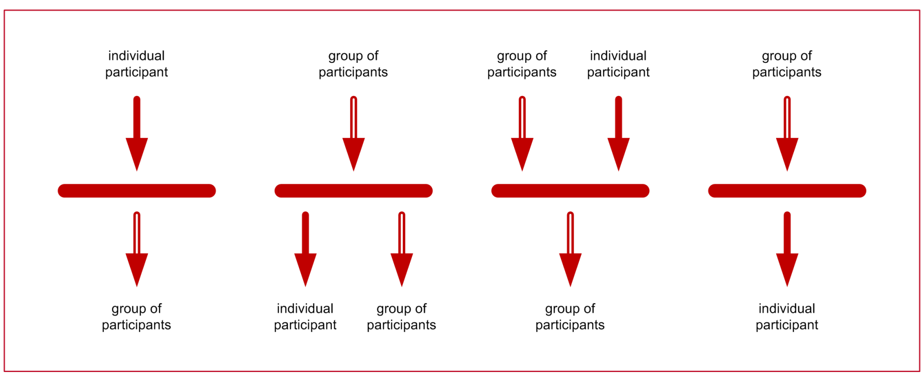

Figure 4.6: Graphical element: transition

Graphical element: transition

The modelling language uses the element *transition* for the representation of concurrent processes including parallelization and synchronization. This element represents the places in the model where individual participants can be added to a group or a group process can be divided into different processes. This property is new for the concept of transitions and allows the description of collaboration processes with concurrent activities of the participants in a simple form. The graphical representation for the element *transition* (shown in Figure 4.6) follows the transition element in a UML activity diagram.

Graphical elements: sender, receiver and response

During the collaboration process, internal and external events can influence the activities of the participants. For describing these kinds of interaction, the modelling language uses the elements *sender*, *receiver* and *response*. The element *sender* represents the places in the model where a signal is generated and transfered to the element *receiver*, which can be used to exchange signals between different process templates and thinkLets. The graphical representations of the elements *sender* and *receiver* (shown in Figure 4.7) are similar to those in a UML activity diagram and are connected by the element *signal path*.

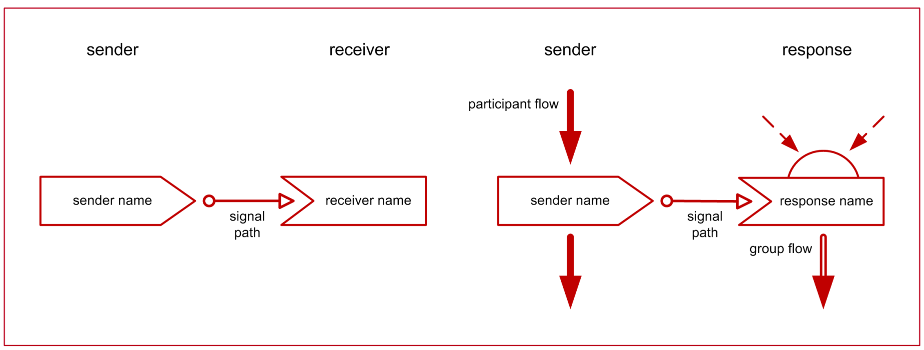

Figure 4.7: Graphical elements: sender, receiver and response

The element *response* represents the influence of a signal on the activities of the participants. It interrupts the participants in their current activities and changes their process flow. The graphical symbol of this element is a half-circle representing a collecting point for participants. An example for this situation is shown in Figure 4.7. With the arrival of a participant the *sender* sends a signal via the *signal path* to the *receiver* which interrupts the current activities of the participants (represented by dashed arrows) and guides them to a new group flow.

Graphical element: storage place

During the collaboration process, participants can produce various types of data such as contributions like ideas, comments or ratings. Therefore, the modelling language uses the element *storage place* (shown in shown in Figure 4.8) to represent a data element that is able to store particular types of data. By using this element, the data flow of a collaboration process can be described by the connection between the element *storage* *place* and process elements that require or generate data.

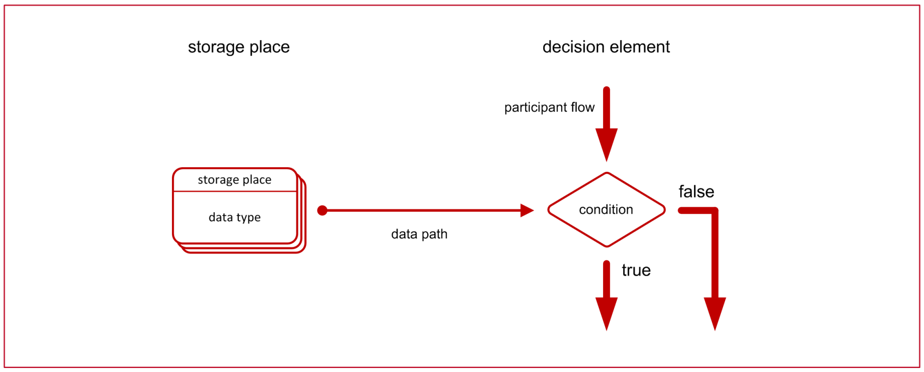

Figure 4.8: Graphical element: storage place

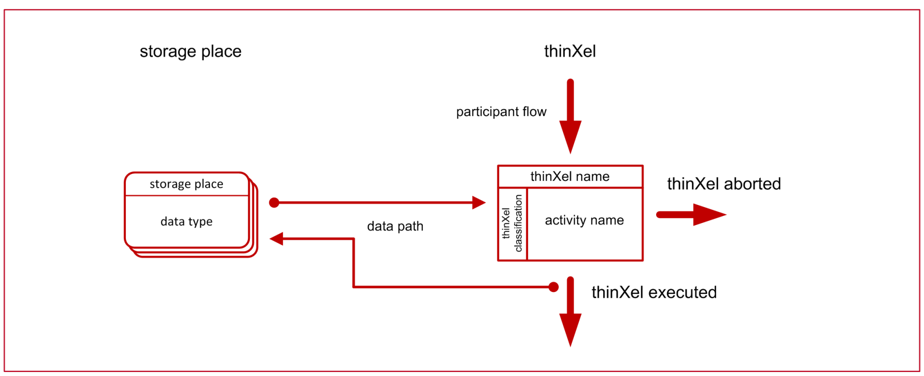

Figure 4.9: Graphical element: thinXel

Graphical element: thinXel

During the collaboration process, the workflow of the participants can be described by a sequence of atomic activities. However, it is up to the participants to execute or abort an intended workflow. For example, in some situations the participants did not have the skills to execute an intended activity. As a result, the modelling language represents the concept of a thinXel as a binary logical design element that represents an atomic reusable activity of a participant that can be executed or aborted by the participant. The graphical representation of the element thinXel (shown in Figure 4.9) follows the element thinkLet in the Facilitation Process Model.

Graphical elements: process template and process template construction plan

The modelling language uses the element *process template* to reduce the complexity of a collaboration process model by reducing an individual process of a participant to an abstract element. Here, a *process template* refers to the element *process template construction plan*, which describes a detailed representation of an individual process of a participant. The graphical representation of the element *process template* (shown in Figure 4.10) follows the element thinkLet in the Facilitation Process Model.

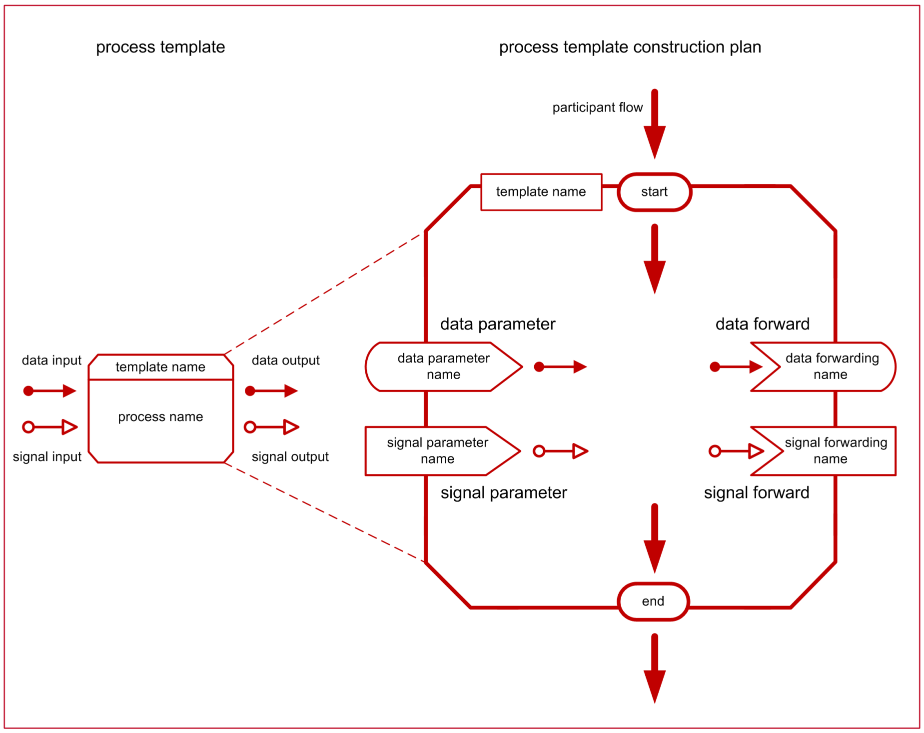

Figure 4.10: Graphical elements: process template and process template construction plan

The referred construction plan includes interface elements to connect the element *process template* with the process, data and signal flows of other elements. Here, the interface elements *start* and *end* represent the connection of the participant flow between the *process template* and the collaboration process. Data and signals can be received by the interface elements *data parameter* and *signal parameter* and can further be forwarded by the elements *data forwarding* and *signal forwarding*.

Graphical elements: thinkLet and thinkLet construction plan

The presented elements of the modelling language can be used to describe the workflow of a collaboration process. However, the representation of each participant activity increases the complexity of the process model and decreases its usability. The modelling language uses the concept of a thinkLet to remedy this situation and defines the element *thinkLet* as a reusable collaboration process pattern for a group that can be integrated into different collaboration processes. The graphical representation of the element *thinkLet* (shown in Figure 4.11) results from the Facilitation Process Model.

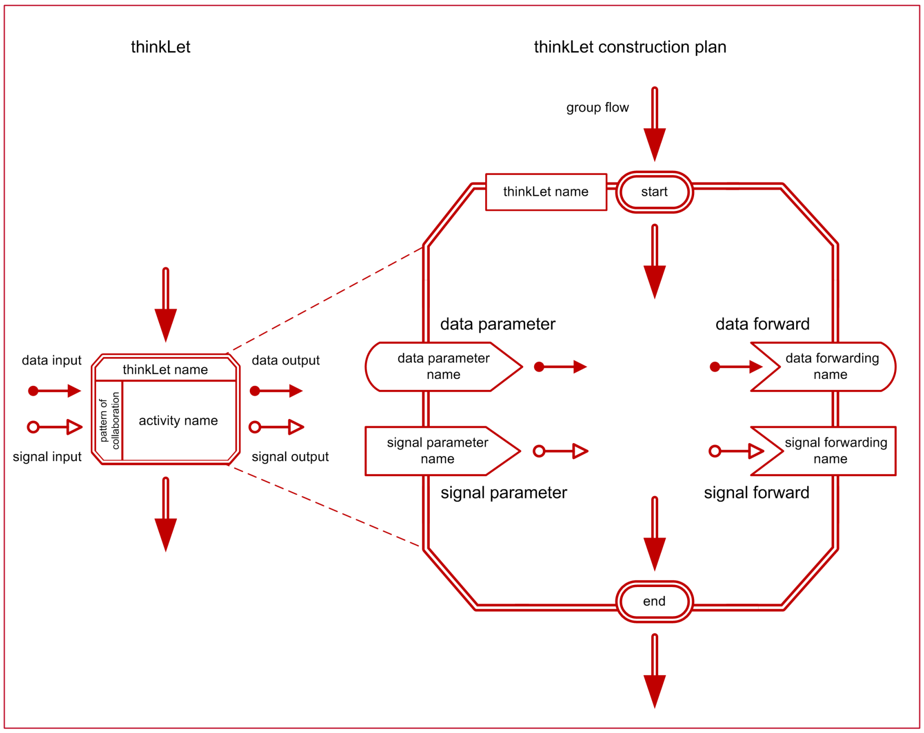

Figure 4.11: Graphical elements: thinkLet and thinkLet construction plan

The detailed process model is represented by the element *thinkLet construction plan* that includes special interface elements to connect the element *thinkLet* with the process flow of the collaboration process. Similar to the element *process template construction plan*, this construction plan uses the elements *start* and *end* to connect a group flow to the construction element. Data and signals can be received by the interface elements *data parameter* and *signal parameter* and can be forwarded by the elements *data forwarding* and *signal forwarding*.

Graphical element: signal data generator

The element *signal data generator* describes an abstract element, which can be embedded into the collaboration process to produce specific kinds of data or signals. An example of this is a timer which sends a signal after a certain period of time or a random number generator which offers random numbers. The graphical representation of the element *signal data generator* (shown in Figure 4.12) combines a basic form with a specific name that represents the function of the element.

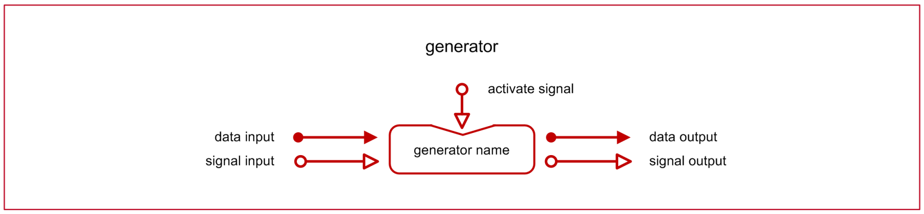

Figure 4.12: Graphical element: signal data generator

4.6.1 Rules for composition

The thesis analyses given workflow patterns [van der Aalst et al., 2003] to define rules for the composition of the modelling constructs. These rules improve the usability of the modelling language by providing a process designer a set of elementary concepts that can be used to design a collaboration process model. In conclusion, the following elementary compositions rules are defined (a detailed representation of the composition rules is shown in the Appendix B):

Activity sequence	*an activity in a workflow process is enabled after the completion of another activity in the same process.*
Collaboration pattern sequence	*a collaboration pattern in a workflow is enabled after the completion of another collaboration pattern in the same process.*
Parallel split	*a point in the workflow process where a group process splits into multiple processes which can be executed in parallel by a group or an individual.*

Synchronization	*a point in the workflow process where multiple parallel groups or individuals converge into one group.*
Exclusive choice	*a point in the workflow process where a group process splits into multiple processes which can be executed in parallel by a group or an individual.*
Simple merge	*a point in the workflow process where two or more alternative workflow paths come together without synchronization.*
Activity loop	*a point in the workflow process where one or more activities of the workflow process can be executed repeatedly.*
Collaboration pattern loop	*a point in the workflow process where one or more collaboration patterns can be executed repeatedly.*
Cancel activity sequence	*a point in the workflow process where, based on a decision or workflow control signal, an enabled activity sequence is aborted.*
Cancel collaboration pattern sequence	*a point in the workflow process where, based on a decision or workflow control signal, an enabled collaboration pattern sequence is aborted.*
Working with data	*data in the workflow process can be defined as global or local.*

4.7 Application of the graphical notation of the collaboration modelling language

This section represents a possible application of the graphical notation of the modelling language to describe a collaboration process. In this application, the graphical notation is used to describe the thinkLet construction plan of the thinkLet FreeBrainstorm [Briggs and de Vreede, 2003], a logical design of a collaboration process with the goal to generate a set of contributions and share them by randomly swapping private storage places. The collaboration process itself is subdivided into a preparation and a brainstorming phase.

During the preparation phase, a group of participants receives information about the collaboration process and generates in parallel a set of contributions for a given topic. In the brainstorming phase, these contributions are used in an associative process to generate new contributions. Furthermore, the participants can add comments to enhance given contributions with more detailed information.

The thinkLet construction plan of the thinkLet *FreeBrainstorm* (shown in Figure 4.13) provides different data and signal parameters to adapt the collaboration process model to a specific group and content constellation:

process information	*a data parameter that represents general information about the collaboration process.*
brainstorming task	*a data parameter that represents a brainstorming task that is used during the collaboration process.*
stop preparation	*a signal parameter that represents an event to stop the preparation phase of the collaboration process.*
time for brainstorming	*a data parameter to define the time that is planned for the brainstorming phase of the collaboration process.*
generated contributions	*a data forward element that is used to provide the generated contributions to other collaboration processes.*

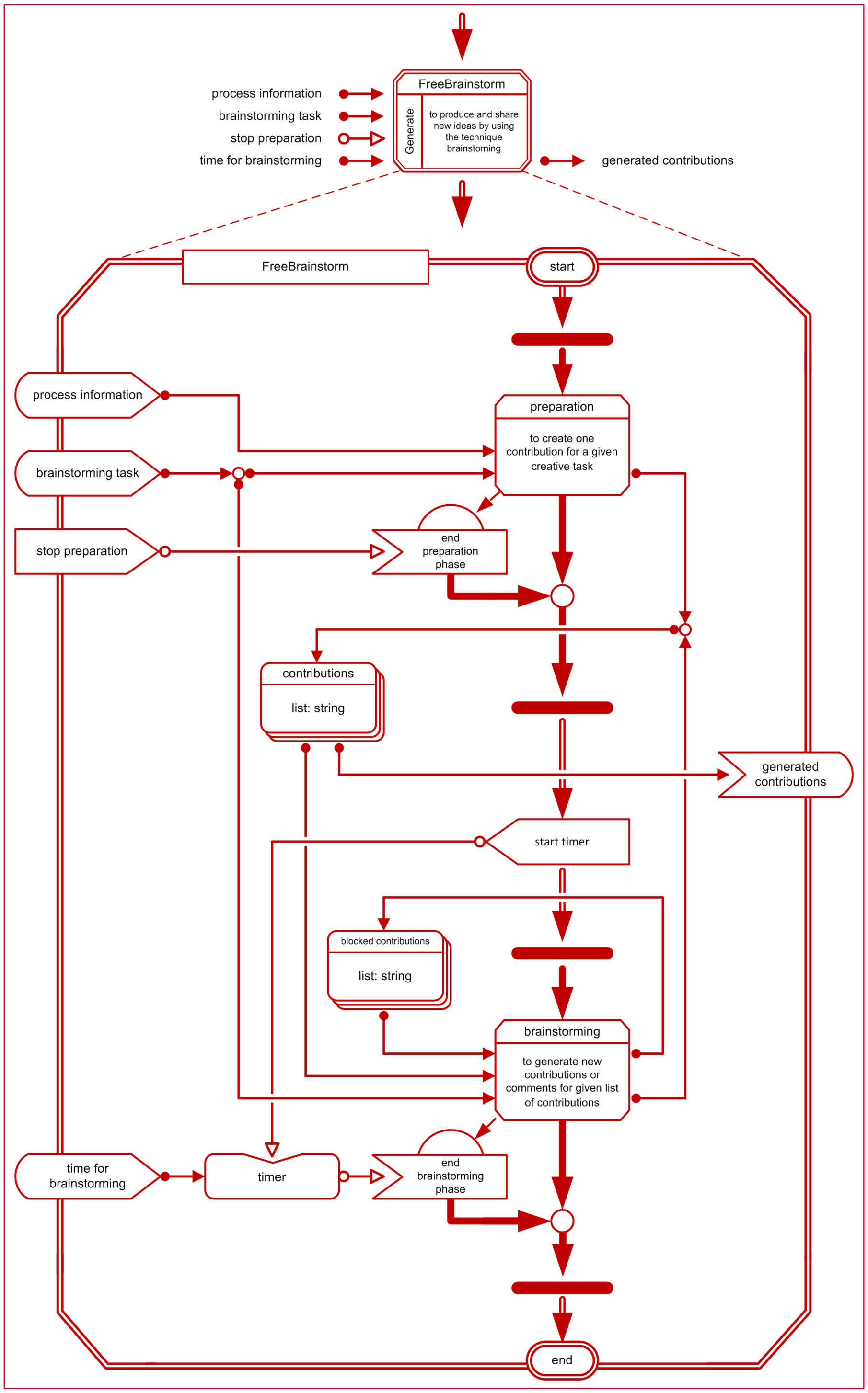

Figure 4.13: ThinkLet construction plan: FreeBrainstorm

The construction plan of the thinkLet *FreeBrainstorm* starts with a transition element that divides the group flow into concurrent participant flows. Each participant is guided to the process template *preparation*, which is used to provide information about the collaboration process and generate a set of contributions as a basis for the brainstorming phase.

Figure 4.14 represents the construction plan of the process template *preparation*. This construction plan is connected to the construction plan of the thinkLet *FreeBrainstorm* by the following data and signal parameters:

process information	*a data parameter that represents general information about the collaboration process.*
process task	*a data parameter that represents a task that is used by a participant in an associative process to generate a contribution.*
process result	*a data forward element that is used to provide the generated contribution of a participant to other collaboration processes.*

According to the process template *preparation*, a participant is guided to the context-oriented thinXel *read information*. This thinXel shows the participant information about the collaboration process, which are defined by the data parameter *process information* and provided via the data path that connects the data parameter to the thinXel element. In a second step, the participant flow guides the participant to the data-oriented thinXel *create contribution* that represents the intention to generate a contribution for a given task. The thinXel is connected with the data parameter *process task* to provide a predefined task as a stimulus for an associative process. The generated contribution will be sent to the data forward element *process result*, which is connected to the public storage element *contributions*. The participant leaves the process template *preparation* after the generation of a contribution and is guided by a participant flow to a transition element that synchronises the participant flows of the participants.

During the preparation phase, a facilitator can stop the phase by sending a signal via the signal parameter *stop preparation* to the response element *end preparation phase*. The response element interrupts all participants that use the process template *preparation* in their current activities and guides them to a transition element to synchronize the concurrent processes of the participants.

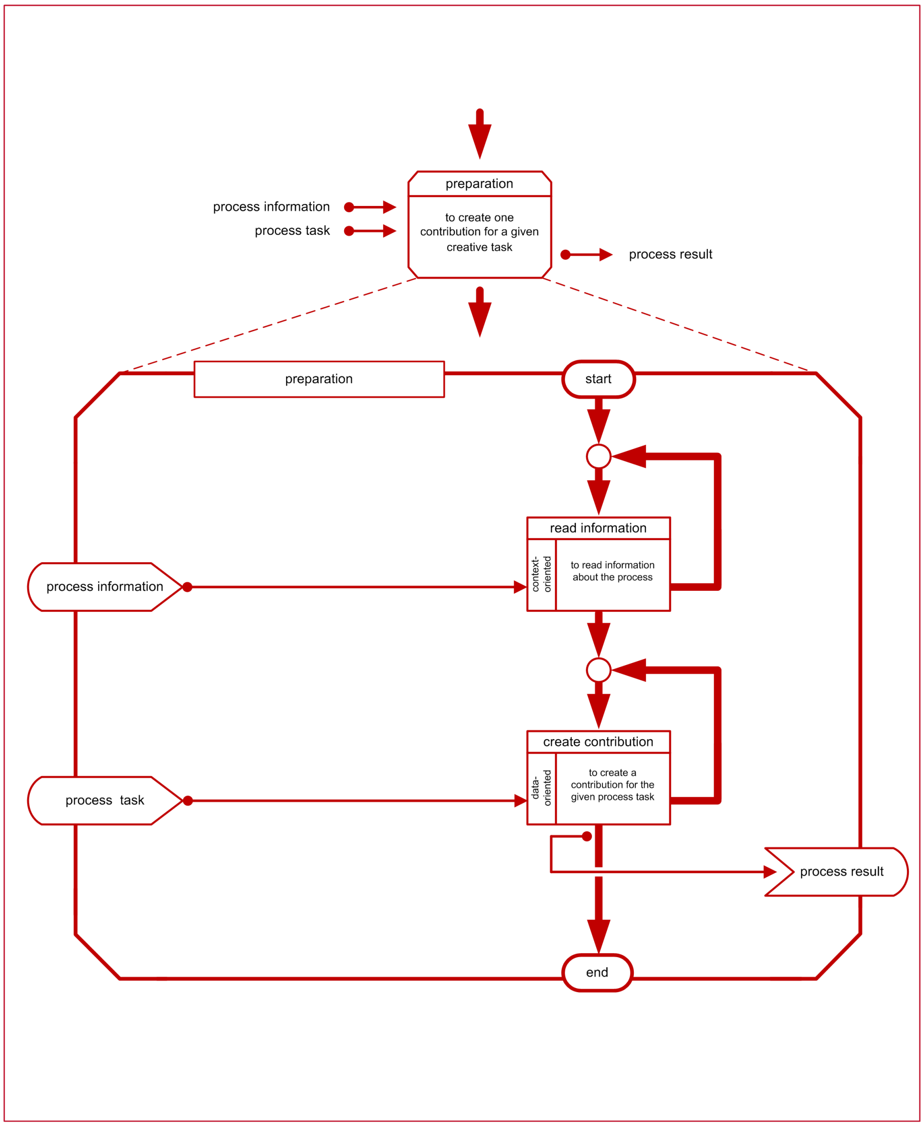

Figure 4.14: Process template construction plan: preparation

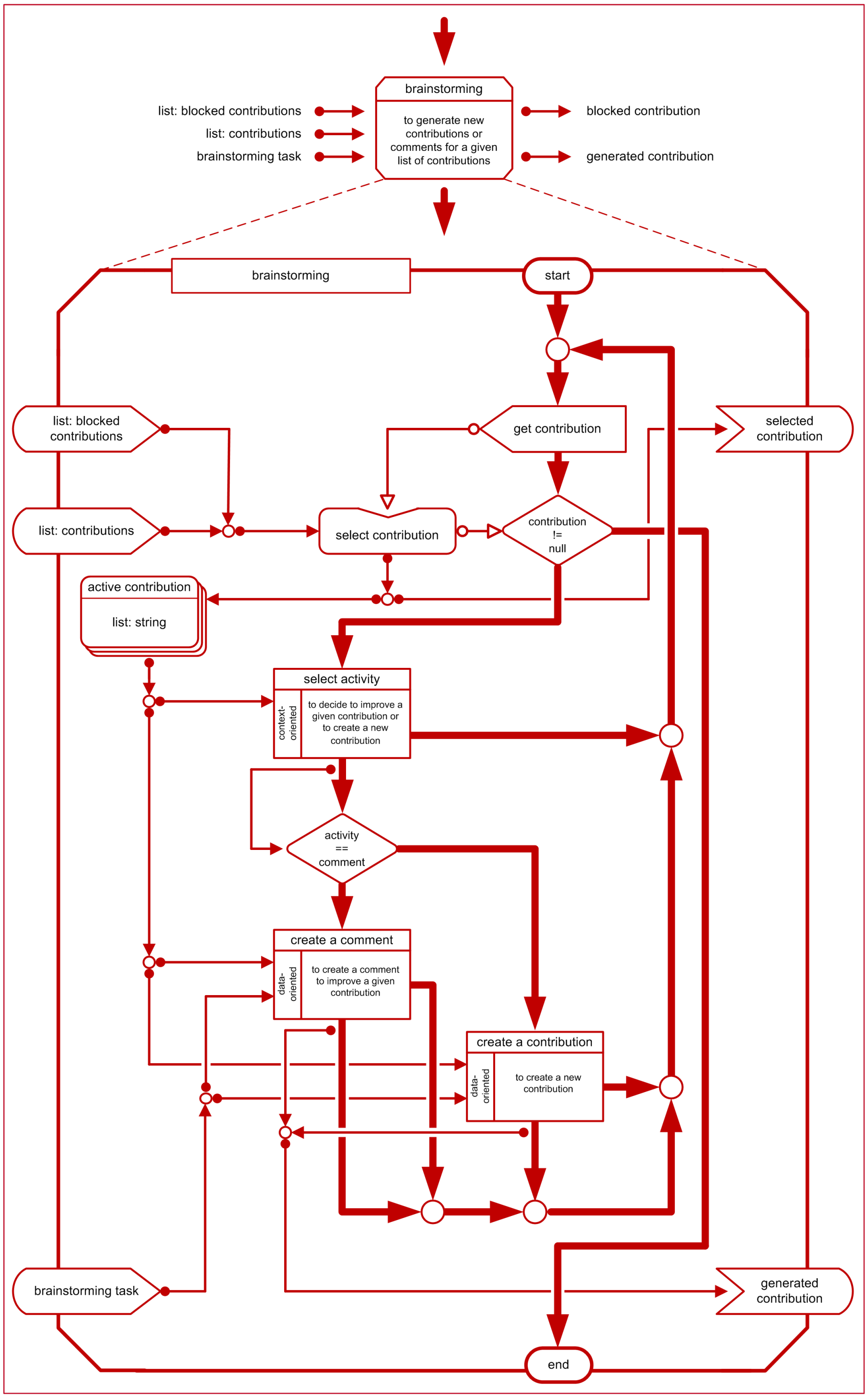

Figure 4.15: Process template construction plan: brainstorming

The transition element sends the participants as a group to the brainstorming phase of the collaboration process. The resulting groupflow activates the sender element *start timer* that sends a start signal to the signal generator *timer*, which is used to limit the time of the process phase brainstorming. The timer is set to a value that is predefined by the data parameter *time for brainstorming*. A transition element again divides the group flow into concurrent participants flows and guides each participant to the process template *brainstorming*, which is used to generate new contributions and to comment existing contributions in an associative process. Figure 4.15 represents the construction plan of the process template *brainstorming*. This construction plan is connected to the construction plan of the thinkLet *FreeBrainstorm* by the following data and signal parameters:

brainstorming task	*a data parameter that represents a brainstorming task that is used during the collaboration process.*
list: contributions	*a data parameter to provide a list of contributions which are used to generate new contributions or to comment existing contributions*
list: blocked contributions	*a data parameter that provides a list of contributions currently used by other participants.*
selected contribution	*a data forward element that is used to mark the selected contribution of a participant as blocked for other participants.*
generated contribution	*a data forward element that is used to provide the generated contribution of a participant to other collaboration processes.*

The construction plan starts with a sender element *get contribution* that automatically sends a signal to the data generator *select contribution*. This generator uses the data parameter *list: contributions* and *list: blocked contributions* to select a contribution that is currently not used by another participant. A selected contribution and related comments for this contribution are stored via a data path in the private storage place element *active contribution*. Furthermore, the data forward element *selected contribution* provides the selected contribution to the thinkLet construction plan *FreeBrainstorm*, which stores the selected contribution in the public storage place element *blocked con-*

tributions, which in turn provides input data for the data parameter *list:blocked contributions*. The decision element *contribution != null* checks if a contribution exists and - if a contribution exists - guides the participant to the context-oriented thinXel *select activity*. Otherwise, a participant is guided to the element *end* of the construction plan and finishes the brainstorming phase.

The thinXel *select activity* provides the selected contribution and possible existing comments and instructs the participant to decide between the following activities: '*to improve the contribution by creating a comment*' or '*to use the contribution as a stimulus to generate a new contribution*'.

If the participant decides to improve the given contribution by adding a new comment, the decision element *activity == comment* guides the participant to the data-oriented thinXel *create a comment*. The thinXel provides the given contribution and the brainstorming task as stimuli and instructs the participant to create a comment that improves the given contribution. A created comment is stored via the forward data element *generated contribution* in the global storage place element *contributions* of the thinkLet construction plan *FreeBrainstorm* and will be available to each participant. The participant is guided back to the sender *get contribution* to get a new contribution.

Another participant flow is described for the situation that the participant wants to use the presented contribution as a stimulus to generate a new contribution. In this case the participant is guided by the decision element *activity == comment* to the data-oriented thinXel *create a contribution*. Here, the thinXel provides the given contribution and the brainstorming task as stimuli and instructs the participant to create a new contribution, which is stored via the forward data element *generated contribution* in the global storage place element *contributions* and can be seen by other participants. The participant is guided back to the sender *get contribution* to get a new contribution.

If the participant does not want to improve the given contribution or to generate a new contribution and aborts the context-oriented thinXel *select activity*, the participant flow guides the participant back to the sender *get contribution* to get a new contribution. The same happens, if the participant aborts the data-oriented thinXels *create a comment* and *create a contribution*.

The brainstorming phase stops, if the activated signal generator *timer* of the thinkLet construction plan *FreeBrainstorm* sends a signal after a certain period of time to the response element *end brainstorming phase*. This element interrupts all participants in their current activities and guides them to a transition element, where the participants will be guided as a group to the exit of the thinkLet element.

4.8 Evaluation of the graphical notation of the collaboration modelling language

The application of the graphical notation for collaboration process design was analysed in an one-semester undergraduate student project [Magdeburg, 2012]. The primary purpose of this project is to promote soft skills such as teamwork and to give students the opportunity to participate in a university research project. During the project, a team of students was requested to develop a groupware technology to support collaboration work.

At the beginning of the project, students were given an introduction to the collaboration engineering approach for the design of collaboration processes. Furthermore, they were trained in using the graphical notation of the collaboration modelling language to describe the workflow of a collaboration process. With this knowledge, they were requested to use the modelling language to develop collaboration process models that can be used as scenarios for the design and evaluation of a groupware technology. During the process design, the students used a two-stage process involving the design of graphical process models for given thinkLets like LeafHopper, PinTheTailOnTheDonkey and PopcornSort [Briggs and de Vreede, 2003], which were used in a second stage to design process models for different collaboration processes like a collaborative ideation process or a group meeting.

During the project different interviews were conducted to analyse the use of the graphical modelling language for collaboration process design. The students indicated that it takes some time to understand how to model a collaboration process. However, they appreciated the level of detail of the collaboration process model, which helped them to understand and explain a collaboration process in different phases of the project. For example, during the system design phase, they used the graphical process model to identify and discuss requirements of the groupware technology. Furthermore, the graphical notation was used during the evaluation phase to design a collaboration process that was used to evaluate the developed groupware technology. An analysis of the resulting collaboration process models shows that the team could use the graphical notation to describe different thinkLets as a thinkLet construction plan. Furthermore, the students adopted the pattern approach and defined process templates for recurring process elements, which they reused in different process models.

In conclusion, the presented elements of the graphical notation form a modelling language to describes the workflow of a collaboration process by combining well proven modelling constructs with new abstract representations for the design patterns of thinkLets and thinXels. In contrast to other modelling approaches, the graphical notation introduces a clear visual distinction between a process flow of an individual participant and a group of participants moving synchronously through the process. This property is new for modelling languages and allows the description of collaboration processes with concurrent activities of the participants in a simple form, which provides a more detailed level for the discussion of a collaboration process design.

4.9 Semantical notation of the collaboration modelling language

This section introduces a semantical notation as a possible machine-readable expression of the collaboration modelling language. The thesis assumes that a design pattern approach can be used to pack and transfer tacit knowledge and skills which are needed for the appropriately use of a groupware technology for collaboration in global virtual groups. In this connection, the thesis distinguishes between a logical and physical process model.

A logical process model represents a template of a collaboration process that contains a general description of group activities for a collaborative task. The semantical model describes the workflow of a collaboration process by using abstract design elements, which define the process, data and signal flow of a collaboration process. Furthermore, parameters are provided to adapt the collaboration process model to a specific group and content constellation, which improves the reusability of a logical process model.

A physical process model represents a specific collaborative process that contains detailed descriptions of collaborative activities for a specific task and group constellation. Here, the semantical model describes the workflow of a collaboration process by using a detailed specification of the abstract design elements, which are used by the logical process model. For example, a physical design element of a collaboration activity provides instructions and information for the participant on how to execute this activity to reach an intended goal, while in contrast, the logical design element provides information for a practitioner on how to develop these instructions for different group and content constellation.

The thesis uses Extensible Markup Language (XML) [Bray et al., 1998] as a means of modelling a collaboration process in a machine-readable process description. As a W3C standard, XML becomes a standard for data interchange on the Web, which can provide a common base for researchers on collaboration to define collaboration process models independently of the choice of a groupware technology. Here, XML defines similar to the XML Process Definition Language (XPDL) [WMC, 2008] a set of rules for describing the graphical elements of the collaboration modelling language in a machine-readable format. Resulting from the detailed representation of the process, the semantical representation of a collaboration process model can be a complex document. Therefore, a Document Type Definition (DTD) is used to define grammatical rules for the use of the XML elements, which allows a process designer to check a collaboration process model for validity.

```xml

<?xml version="1.0" encoding="utf-8"?>
<!DOCTYPE cml SYSTEM "cml.dtd">

<!--process template construction plan: brainstorming-->
<processtemplate id="processtemplate-brainstorming" name="brainstorming process template construction plan">

 <!--connection elements to connect the participant flow to other construction elements-->
 <start id="start" name="element-start" group="false"/>
 <end id="end" name="element-end" group="false"/>


 <!--the data-in parameters of the process template construction plan: brainstorming-->
 <data-in-parameter id="data-in-process-task" name="process task" datatype="string"/>
 <data-in-parameter id="data-in-list-contributions" name="list of contributions" datatype="string-list" />
 <data-in-parameter id="data-in-list-blocked-contributions" name="list of currently used contributed" datatype="string-list" />


 <!--the data-forward parameters of the process template construction plan: brainstorming-->
 <data-forward-parameter id="data-forward-selected-contribution" name="selected contribution" datatype="string" />
 <data-forward-parameter id="data-forward-generated-contribution" name="generated contribution" datatype="string" />


 <!--the storage places of the process template construction plan: brainstorming-->
 <storage-place id="storage-active-contribution" name="storage place of a selected contributions" datatype="string" />


 <!--the senders of the process template construction plan: brainstorming-->
 <sender id="sender-get-contribution" name="get contribution" group="false" />


 <!--the generators of the process template construction plan: brainstorming-->
 <generator id="generator-select-contribution" name="select contribution" type="select-from-list">
  <data-in-parameter id="contributions" name="list of contributions" datatype="string-list"/>
  <data-in-parameter id="blocked-contributions" name="list of blocked contributions" datatype="string-list"/>
  <data-forward-parameter id="selected-contribution" name="selected contribution" datatype="string" />
  <signal-in-parameter id="start" name="start signal"/>
  <signal-forward-parameter id="result" name="output signal"/>
 </generator>


 <!--the decision elements of the process template construction plan: brainstorming-->
 <decision id="decision-contribution-selected" name="check selected contribution">
  <signal-in-parameter id="signal-contribution" name="signal"/>
  <condition id="contribution-selected-condition" qualifier="signal-contribution != NULL"/>
 </decision>

 <decision id="decision-activity-selected" name="check selected activity">
  <data-in-parameter id="selected-activity" name="activity type"/>
  <condition id="activity-selected-condition" qualifier="selected-activity == comment"/>
 </decision>


 <!--the thinxels of the process template construction plan: brainstorming-->
 <activity id="activity-select" name="select next step" type="select">
```

```xml
  <data-in-parameter id="active-contribution" name="active contribution" datatype="string"/>
  <data-forward-parameter id="selected-activity" name="selected activity" datatype="string" />

  <description>... participants select the next process step...</description>
  <config>

    <!--information for the practitioner on how to adapt the thinXel-->
   <config:information>Please define a short instruction for the participants:</config:information>

   <config:rule>
    <!--a positive example on how to adapt the thinXel-->
    <positive-example>
      In this step you can decide if you would like to improve a given contribution or to generate a new contribution...

      Select activity 'Create Comment' to improve the given contribution by adding a comment that... (requirements).
      Select activity 'Create Contribution' to generate a new contribution that... (requirements).

      Please, click the button '(do-button-label)' to confirm your selection.
      Please, click the button '(cancel-button-label)' to select another contribution.
    </positive-example>

    <!--a negative example on how to adapt the thinXel-->
    <negative-example>
      Please select your next activity and confirm your selection.
    </negative-example>
   </config:rule>

   <!--instructions and information for the participant on how to execute the thinXel-->
   <config:instruction>
     In this step you can decide if you would like to improve a given idea or to use it as a stimuli to generate a new idea.

     Select the activity 'Create a Comment' to improve the given idea by adding an idea on how to implement this idea.
     Select the activity 'Create a New Idea' to generate a new idea that help us to solve our problem.

     Please, click the button 'Next Activity' to confirm your selection.
     Please, click the button 'New Idea' to select another idea.
   </config:instruction>

   <config:do-button-label value="Next Activity"/>
   <config:cancel-button-label value="New Idea"/>
  </config>
 </activity>


 <activity id="activity-comment" name="create a comment" type="create">

  <data-in-parameter id="process-task" name="process task" datatype="string"/>
  <data-in-parameter id="active-contribution" name="active contribution" datatype="string"/>
  <data-forward-parameter id="created-comment" name="created comment" datatype="string" />

  <description>... participants improve a given contribution...</description>
  <config>
   <config:information>Please define a short instruction for the participants:</config:information>

   <config:rule>
```

```xml
      <positive-example>
        In this step you can improve the given contribution by adding new information that... (requirements).

        Please, click the button '(do-button-label)' to add your contribution...
        Please, click the button '(cancel-button-label)' to select another contribution...
      </positive-example>

      <negative-example>
        Please improve a given contribution by adding new information.
      </negative-example>
    </config:rule>

    <config:instruction> </config:instruction>

    <config:do-button-label value="Do"/>
    <config:cancel-button-label value="Cancel"/>
  </config>
</activity>


<activity id="activity-contribution" name="create a contribution" type="create">

  <data-in-parameter id="process-task" name="process task" datatype="string"/>
  <data-in-parameter id="active-contribution" name="active contribution" datatype="string"/>
  <data-forward-parameter id="created-contribution" name="created contribution" datatype="string" />

  <description>... participants generate a new contribution...</description>
  <config>
    <config:information>Please define a short instruction for the participants:</config:information>

    <config:rule>
      <positive-example>
        In this step you can generate a new contribution that... (requirements).

        Please, click the button '(do-button-label)' to add a new contribution...
        Please, click the button '(cancel-button-label)' to select another contribution...
      </positive-example>

      <negative-example>
        Please create a new contribution
      </negative-example>
    </config:rule>

    <config:instruction> </config:instruction>

    <config:do-button-label value="Do"/>
    <config:cancel-button-label value="Cancel"/>
  </config>
</activity>


<!--the data-paths of the process template construction plan: brainstorming-->
<data-path id="d-p01" from="data-in-process-task:out" to="activity-contribution:process-task"/>
<data-path id="d-p02" from="data-in-process-task:out" to="activity-comment:process-task"/>
<data-path id="d-p03" from="data-in-list-contributions:out" to="generator-select-contribution:contributions"/>
```

```xml
<data-path id="d-p04" from="data-in-list-blocked-contributions:out" to="generator-select-contribution:blocked-contributions"/>
<data-path id="d-p05" from="generator-select-contribution:selected-contribution" to="data-forward-selected-contribution:in"/>
<data-path id="d-p06" from="generator-select-contribution:selected-contribution" to="storage-active-contribution:data"/>

<data-path id="d-p07" from="storage-active-contribution:data" to="activity-select:active-contribution"/>
<data-path id="d-p08" from="storage-active-contribution:data" to="activity-comment:active-contribution"/>
<data-path id="d-p09" from="storage-active-contribution:data" to="activity-contribution:active-contribution"/>

<data-path id="d-p10" from="activity-select:selected-activity" to="decision-activity-selected:selected-activity"/>
<data-path id="d-p11" from="activity-comment:created-comment" to="data-forward-generated-contribution:in"/>
<data-path id="d-p12" from="activity-contribution:created-contribution" to="data-forward-generated-contribution:in"/>


<!--the signal-paths of the process template construction plan: brainstorming-->
<signal-path id="s-p1" from="sender-get-contribution:signalout" to="generator-select-contribution:start"/>
<signal-path id="s-p2" from="generator-select-contribution:result" to="decision-contribution-selected:signal-contribution"/>


<!--the participant-paths of the process template construction plan: brainstorming-->
<participant-path id="p-p01" from="start:exit" to="sender-get-contribution:entry" group="false"/>
<participant-path id="p-p02" from="sender-get-contribution:exit" to="decision-contribution-selected:entry" group="false"/>

<participant-path id="p-p03" from="decision-contribution-selected:true" to="activity-select:entry" group="false"/>
<participant-path id="p-p04" from="decision-contribution-selected:false" to="end:entry" group="false"/>

<participant-path id="p-p05" from="activity-select:done" to="decision-activity-selected:entry" group="false"/>
<participant-path id="p-p06" from="activity-select:canceled" to="sender-get-contribution:entry" group="false"/>

<participant-path id="p-p07" from="decision-activity-selected:true" to="activity-comment:entry" group="false"/>
<participant-path id="p-p08" from="decision-activity-selected:false" to="activity-contribution:entry" group="false"/>

<participant-path id="p-p09" from="activity-comment:done" to="sender-get-contribution:entry" group="false"/>
<participant-path id="p-p10" from="activity-comment:canceled" to="sender-get-contribution:entry" group="false"/>

<participant-path id="p-p11" from="activity-contribution:done" to="sender-get-contribution:entry" group="false"/>
<participant-path id="p-p12" from="activity-contribution:canceled" to="sender-get-contribution:entry" group="false"/>

</processtemplate>
```

Listing 4.1: Semantical notation of the process template construction plan: brainstorm

An example of the use of XML and DTD to describe graphical elements of the collaboration modelling language is given by the Listing 4.1, which represents the semantical notation of the graphical process template construction plan *brainstorming* (shown in Figure 4.15). The semantical process model uses XML tags to define the data types of graphical elements like *data parameter* (Listing 4.1 / Line 14) or *storage place* (Listing 4.1 / Line 25). Furthermore, XML tags are used to configure graphical elements like a *generator* (Listing 4.1 / Line 33) by defining the type and the related input and output parameters. A decision element (Listing 4.1 / Line 43) contains, besides an input parameter, a condition construct which allows the process designer to express conditions for controlling the workflow of a collaboration process. This collaboration workflow is furthermore described by the XML tags *data-path* (Listing 4.1 / Line 164), *signal-path* (Listing 4.1 / Line 182) and *participant-path* (Listing 4.1 / Line 187), which define the connections between the graphical elements of the process model.

The Listing shows a more detailed configuration for the graphical elements *thinXel* (Listing 4.1 / Line 55). Resulting from the distinction between a logical and a physical process model, the semantical representation provides knowledge for the adaptation of a collaboration process template to a certain context and group constellation. Here, XML tags are used to capture and provide information which supports the adaptation of the given parameters and facilitation instructions. In this context, the concept of thinXels is used as an atomic instruction element which only contains those pieces of information that must be conveyed to the participants to perform the intended activities. Therefore, the semantical notation of a thinXel element includes a configuration block that contains the XML tags *config:information* and *config:rule* to provide information as well as positive and negative examples on how to define background information and instructions for a different context and group constellation. A practitioners can use these information to define the XML tag *config:instruction*, which contains descriptions and instructions for the participants of a specific collaboration process.

4.9.1 Rules for descriptive and instructional writing

The semantical notation of a collaboration process model needs to provide a large amount of data to support a practitioner in adapting a logical to physical process model. To reduce this amount of data, the thesis analyses the possibility to define rules for descriptive and instructional writing that simplify and standardised facilitator instructions and do not need to be documented for each of the used thinXel elements.

Rules for descriptive and instructional writing can be found in the research field of Controlled Natural Languages (CNLs); engineered languages that use a defined vocabulary, grammatical constructions, semantic interpretations, and pragmatics, which are found in a natural language such as English [Wyner et al., 2010]. Over the years more than 40 CNLs have been defined for the production of technical and user documentations [Adriaens and Schreors, 1992].

The thesis analyses the controlled language Simplified English [EAAI, 1995] as a common specification for language and writing style of technical documentation. Simplified English provides different generic rules that can be used to support a practitioner in adapting a logical to a physical process model. The thesis adapts common rules for descriptive and instructional writing in relation to the concept of a thinXel. The resulting rules, such as the requirements that an instruction needs to be as specific as possible as well as to describe only one atomic activity, build a first approach to support practitioner in descriptive and instructional writing. A detailed representation of the rules for descriptive and instructional writing is shown in the Appendix C.

4.10 Evaluation of the semantical notation of the collaboration modelling language

This section evaluates the semantical notation of the collaboration modelling language as an approach that can be used to describe logical and physical process models. The thesis investigates the application of the semantical process model in combination with the rules for descriptive and instructional writing [Knoll et al., 2011]. In this context, the following research question is formulated:

> *How does the semantical notation of a collaboration process design supports inexperienced users in adapting a logical to a physical process model?*

4.10.1 Expert interviews about descriptive and instructional writing

The thesis uses expert interviews to evaluate the rules defined for descriptive and instructional writing [Knoll et al., 2011]. The goal of these interviews was to ascertain the effective use of the rules to support inexperienced users in descriptive and instructional writing based on current experience of different experts in collaboration process design. The interview technique is chosen, because the experts are supposed to freely share their knowledge and opinions about the rules without constraints.

Seven experienced facilitators were interviewed over a period of two weeks, four of them were male and three were female. The facilitators age ranged from 25 to 48 years (M: 31.72, SD: 7.48). Their experience in designing and facilitating collaboration processes amounts between four to ten years (M:5.57, SD: 2.1). The amount of group processes guided was between 30 and 200 processes, with a group size of three up to 150 participants. The group processes tasks differed between small meetings, innovation processes in companies, coaching of specific techniques, briefings with customers, conferences, and brainstorming sessions. Furthermore, the experts have expertise with homogeneous and mixed groups including students, employees, managers, engineers, and designers.

In the first phase of the interviews, general questions were asked about the personal experience of a facilitator in designing and facilitating a collaboration process. The interview focused on descriptions and instructions facilitators use during a collaboration process. Almost all facilitators gave similar answers and reasons for the main steps of their process design, e.g. '*to explain the goal before you start with process instructions*'. They only differed in questions of detail. All of them use a structured and predetermined top-down approach for a collaboration process design. One facilitator offered a completely different process design with more degrees of freedom for the participants and no agenda. However, both possibilities were supposed to be successful regarding the goal of the collaboration process.

In the second phase of the interviews, a summarized list of the rules for descriptive and instructional writing was presented for feedback. This list contains the following rules:

Rule 01	*Give necessary background information before the instruction.*
Rule 02	*Use a tabular layout to present background information in a specific order.*
Rule 03	*Use a common sequence of atomic activities.*
Rule 04	*Use words that any participant of a group understands.*
Rule 05	*Write in a friendly manner.*
Rule 06	*Address the participants of a group by using you or your.*
Rule 07	*Describe only one atomic activity per instruction.*
Rule 08	*Make an instruction as specific as possible.*
Rule 09	*Keep an instruction as short as possible.*
Rule 10	*Specify what the participant has to do when the intended task of an instruction is completed.*
Rule 11	*Use only the active voice in an instruction.*
Rule 12	*Write an instruction as a request using the polite word 'please' before the verb.*

The facilitators considered most of the rules useful for collaboration process design. Some facilitators indicated different rules as not strictly necessary for descriptive and instructional writing, for example the rule '*address the participants of a group by using you or your*'. However, further requests showed that these differences are related to the facilitation style of each facilitator. None of the facilitators indicated further rules that need to be included. As a result, the thesis assumes that the presented list matches the experience of facilitators and can be used to support inexperienced users in descriptive and instructional writing.

4.10.2 Experiment to verify the adaptability of a logical process design

In an experimental environment, the thesis investigates the application of the semantical notation of the collaboration modelling language to support inexperienced users in adapting a logical to a physical process model. In order to investigate this research question, the thesis develops a software prototype (shown in Figure 4.16) that uses the Extensible Markup Language to read and adapt a semantical process model.

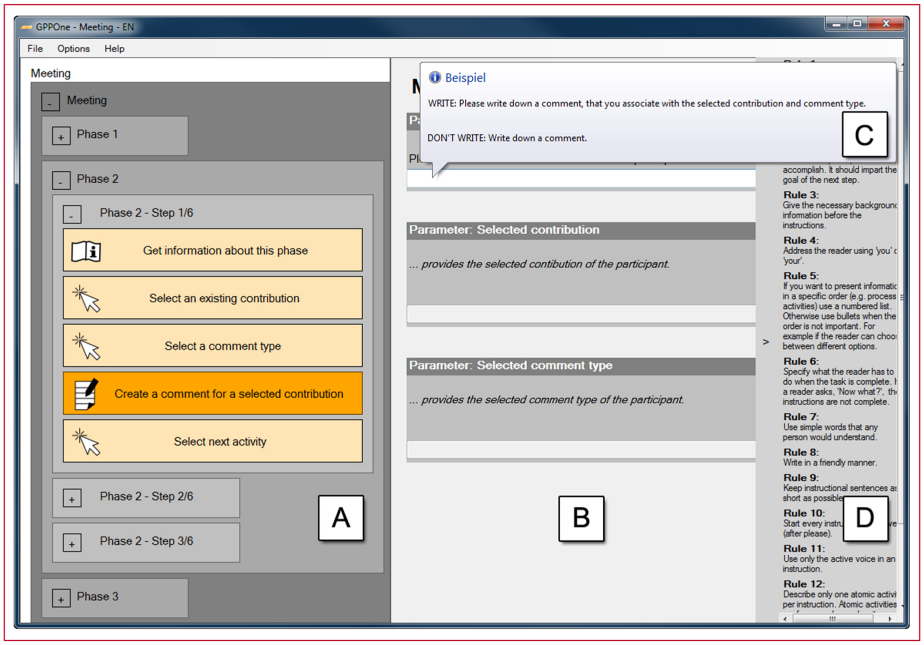

Figure 4.16: Interface of a software prototype for the configuration of a collaboration process model

By using predefined XML tags, the prototype provides a navigation tool (Figure 4.16 / Area A), which allows users to change the focus between the different phases of a collaboration process. A configuration tool (Figure 4.16 / Area B) provides different functionalities to adapt different process parameters and facilitation instructions of a selected process phase. Here, the prototype displays the given configuration blocks of a logical process model and provides for each parameter and instruction element a short description about the element and its relation to the collaboration process. Users can adapt the parameter and instructions to a certain context and group constellation by using the provided form fields. During this configuration, the prototype supports the user by two functionalities. A tooltip provides predefined positive and negative examples on how to describe background information and instructions (Figure 4.16 / Area C). Furthermore, an information window provides the summarized list of the rules for descriptive and instructional writing (Figure 4.16 / Area D).

During the experiment the software prototype was used to adapt three logical process models. These models were designed by a professional facilitator who has experience with the graphical and semantical notation of the collaboration modelling language. Two of the models defined an ideation process and one was intended to structure a meeting process. Each of the resulting process models combined thinkLets of different collaboration patterns, e.g. thinkLets for the generation of concepts, the organisation of concepts, and consensus building.

Thirty-six students from a large university participated individually in this experiment, fifteen women and twenty-one men. The students age ranged from 20 to 34 years (M: 24.14, SD: 3.31). They have different experiences with collaborative work. Thirty-one have participated before in a collaboration process; twenty of them have further experience with the use of ideation techniques. Eleven students have experience in facilitating a collaboration process.

During the experiment three scenarios were used for the configuration of the logical process designs. Two scenarios used logical process designs of an ideation process, which need to be adapted for the tasks '*to generate event ideas for a university*' and '*to generate software ideas for a mobile device*'. A third scenario used a logical process design of a meeting process for a group of students that needed to be adapted for the task '*to prepare an event for an university*'.

The experiment was split into two phases. Upon arrival, the participants received an introduction to descriptive and instructional writing using the predefined rules. Here, a facilitator demonstrated how to use the predefined list of rules for descriptive and instructional writing and trained the students in defining descriptions and instructions for a collaboration process.

In a second phase, the participants used the software prototype to adapt the logical process designs for the predefined scenarios. After an introduction on how to use the functionalities of the software prototype, the participants were requested to configure a logical process design with regard to one of the given scenarios. During this phase, no verbal communication was allowed between the participants.

The thesis used a questionnaire to collect the impressions of the participants with the configuration process. Furthermore, the resulting physical design models were compared with a process design that was adapted by an experienced facilitator.

Experiment results

An analysis of the questionnaires shows that most participants understood the rules for descriptive and instructional writing. They indicated that the provided rules and examples helped them during the configuration process. Most participants preferred the given step by step structure of the logical process design and the functionalities of the software application, which helped them to get a good overview of the process model.

However, some participants answered that they did not know how to use the provided rules to adapt the logical process design. They claimed that the generic presentation of process parameters and instructions is difficult to adapt for a certain scenario. As a result, not everyone was able to create a physical process model that is functional for the intended scenario. To improve the configuration process, 16 participants proposed to increase the degrees of freedom during the configuration process. Especially two participants felt restricted by the step by step guidance. One of them was familiar with the techniques used and group processes in general. Because of that he would have been able to create a group process with less guidance and more of his own experiences.

An analysis of the resulting physical process models shows a high similarity for most of the adapted parameters and instructions. However, not all participants produced a process model of the same level of quality. In contrast to participants who invest a large effort in defining new instructions by following the rules, some participants just copy the positive examples from the configuration block. Here, the analysis showed a relationship between the instruction design and the background knowledge of a participant. Participants with medium or higher experience with collaboration work and the used techniques were able to create more functional process models and needed less time to accomplish the task. These participants liked the concept of negative and positive examples.

In conclusion, most participants were able to understand the structure and techniques of the modeled collaboration process. The experiment shows some weaknesses in the use of rules to support the configuration of a logical process model. Some participants with less experience in designing collaboration processes were not able to use the presented rules to create a functional model for a given scenario. On the other hand, participants who were familiar with the techniques used, need more degrees of freedom during the configuration process.

The results support the assumption that the semantical notation in combination with the rules for descriptive and instructional writing can be used to support participants during the configuration of a logical design process. However, the effectiveness of adapting parameters and instructions was not as high as expected. In context of the rules for instructional writing, the resulting process instructions fulfill some rules more often than others. It might be helpful to underline those rules in a training to make clear how important they are.

4.11 Discussion of the research results

This chapter introduces a new modelling approach for collaboration processes called Collaboration Modelling Language (CML). The thesis sees the quality of facilitation is a key issue for collaboration success and proposes that a process model for collaboration needs to include a specification of the facilitation instructions, which define the collaboration workflow of the participants by a sequence of atomic activities. The concept of a thinXel is introduced as a new design approach for a reusable instruction element, which can be categorised into context and data-oriented thinXels. The thesis evaluates the effectivity of atomic activities for process description by analysing the effect of facilitator instructions variation on the outcome of a collaboration process in virtual groups. The results provide some indications that thinXel could support the appropriately use of a groupware technology for collaboration in global virtual groups.

Based on these results, the chapter introduces a modelling language for collaboration processes that make use of the pattern design approach given by the concepts of thinkLets and thinXels. A graphical notation is used as a language independent approach to increases the usability of a collaboration process model during the design of a logical process model (supports R-2). Here, the modelling language combines graphical representations of existing elements from process models like Event Driven Process Chains, Petri Nets, UML activity diagrams and Facilitation Process Model with a new representation for the concept of thinXels.

A semantical notation is used as a machine-readable process description to improve the reusability and transferability of a collaboration process model for different groupware technologies. Here, the Extensible Markup Language is used as an interchange format to describe the graphical elements of the collaboration modelling language in a machine-readable format (supports R-1). The resulting semantical notation can be used to describe a collaboration process model in a logical and physical design (supports R-2).

Resulting from the distinction between a logical and physical process model, the thesis introduces a knowledge transfer approach to transfer tacit knowledge and skills for the adaptation of a collaboration process template for a certain context and group constellation. This knowledge approach defines rules for descriptive and instructional writing and provides information for the adaption of a logical process design (supports R-3). An analysis of this approach shows first indications that the collaboration modelling language can support inexperienced users in adapting a logical to a physical process model.

Currently the Collaboration Modelling Language represents a first approach to describe a collaboration process like the ideation process of an innovation process in a graphical and semantical process model. However, a groupware technology is needed that can make use of the modelling language to provide functionalities that support the global virtual groups during collaboration. As a result, the next chapter will analyse the feasibility to design an adaptable groupware technology that uses the semantical notation of a collaboration process model to improve collaborative ideation processes in global virtual groups.


participant flow algorithm
adaptable groupware technology
collaboration process model
designing
conceptual design
collaborative ideation processes
process
generic user interfaces
global virtual groups
provides
introduced
different
predefined
software prototype
implementation
functionalities
group behaviours
collaboration collaboration process
basic
workflow management system
design
implement
group performance
requirements
activities
used
makes
specific
prototype
collaborative

Chapter 5

Designing an adaptable groupware technology

5.1 Overview

This chapter analyses the feasibility to design an adaptable groupware technology that uses the semantical notation of a collaboration process model to improve collaborative ideation processes in global virtual groups. Based on an analysis of given possible alternative design solutions and the introduced design approaches for a collaborative ideation process, the thesis defines basic and specific requirements for an adaptable groupware technology that provides functionalities to support the flexible adaptation of the technology for different tasks and group characteristics.

A conceptual design is introduced for an adaptable groupware technology that provides components for the use of a machine-readable collaboration process model to support the design, adaptation and execution of a collaborative process. Functional tests are used to evaluate the conceptual design in a formative process. Here, at different implementation stages, prototypes of the groupware technology are verified against the predefined basic and specific requirements.

5.2 A design approach for a technology-based solution

A research objective of this thesis is to improve the pre-development phase of an innovation process for global virtual groups using technological support. Therefore, the thesis analyses the feasibility of designing predictable and suitable ideation processes, which can be described in a machine-readable collaboration process model. The previous chapters introduces, besides a new design approach for collaborative ideation processes, a collaboration modelling language to describe a collaboration process model in a graphical and semantical notation.

This chapter analyses the feasibility of designing a groupware technology that uses the semantical notation of a collaboration process model to improve collaborative ideation processes in global virtual groups. The thesis uses a design science research approach adapted from the Information System Research Framework [Hevner et al., 2004] and the Design Science Research Cycle [Hevner, 2007] (introduced in chapter 1.3) to develop a technology-based solution for the given business need of an organisation to improve the pre-development phase of an innovation process. The involved research methods can be described as follows:

Situation of concern	*The situation of concern is analysed to understand the context of use for a groupware technology that uses a machine-readable collaboration process model.*
Definition of requirements	*A requirement analysis is used to define requirements for a groupware technology that improves collaborative ideation in global virtual groups.*
Design of artifacts	*Based on the defined requirements, a conceptual design of a groupware technology is developed that uses a machine-readable collaboration process model to support the flexible adaptation of the technology for different tasks and group characteristics.*
Evaluation of artifacts	*The designed artifacts are evaluated against the requirements in a formative process.*

The next sections will present the results of each of these research methods in more detail.

5.3 Situation of concern

The thesis focuses on profit and non-profit organisations, who operate in a global economy and require a steady portfolio of new products and market strategies to remain competitive. To manage an existing portfolio, organisations use a multi-stage process called innovation process that combines a variety of techniques and methods to recognise a need for innovation; to generate and evaluate new ideas; to design concepts and plan their development; to develop and test new concepts; and to produce and launch new products or services into the market [Cooper, 1988].

During the innovation process, organisations use collaboration to combine expertise and knowledge of employees and customers with complementary skills in order to obtain synergy effects. Due to the fact that global virtual groups comprise an important structural component in many multinational organisations, groupware technology is used to link experts across geographical distances and assists them during the innovation process.

The overall performance of the innovation process depends on the extent to which given knowledge resources of an organisation can be used to create new values for the organisation [von Krogh, 1998]. Especially, during the pre-development phase, unused knowledge resources can lead to poor ideas or wrong decisions which result in costly problems in later stages of the innovation process. Research [Elfvengren et al., 2009, Herstatt et al., 2004] indicates the pre-development phase of an innovation process as unstructured, fuzzy and hard to manage and requests the need for practical procedures and tools to support organisations during this phase.

To push research by a new technology-based solution, the thesis focuses on the use of groupware technology to support the pre-development phase of an innovation process. Global virtual groups are indicated as potential users, who use a groupware technology to generate and evaluate new product and service ideas. Therefore, a groupware technology needs to provide functionalities that support the divergent and convergent thinking processes of a participant during an ideation process.

5.4 Requirements for a technology-based design solution

The requirement analysis is used to define both basic and specific requirements for a groupware technology that uses a machine-readable collaboration process model to improve a collaborative ideation process in global virtual groups.

Basic requirements result from a literature analysis on collaboration and technological support for collaboration. In addition, different groupware technologies are analysed as alternative technology-based design solutions.

Specific requirements result from the introduced design approach for collaborative ideation processes (introduced in Chapter 3) and the modelling language for collaboration processes (introduced in Chapter 4) which should be implemented by a technology-based design solution.

5.4.1 Basic requirements for an adaptable groupware technology

The thesis adopts a taxonomy approach to analyse given groupware technologies as alternative design solutions for a groupware technology that improve collaborative ideation processes in global virtual groups. This taxomony provides a classification and comparison scheme for groupware technologies, which focuses on the core functionality, the supported actions and awareness indicators of a technology [Mittlemann et al., 2008].

As possible alternative design solutions, the thesis analyses the groupware technologies TeamSupport™[TeamSupport, 2010], Groupsystems™ThinkTank™[GroupSystems, 2010] and SAP™StreamWork™[SAP, 2010]. These technologies are selected since they are representative for different stages of experience in groupware development. For example, Groupsystems™is one of the global leaders in collaboration system design for innovation and decision-making. Similarly, SAP™is the market leader in enterprise application software, who launched in 2010 a collaborative platform for decision making called StreamWork™. In contrast, TeamSupport™is the product of a small startup company, who develops groupware technologies in cooperation with researchers in the field of collaboration design. The summarized comparison of the three groupware technologies is shown in Tables 5.1 and 5.2.

Teamsupport™, StreamWork™and ThinkTank™are web-based groupware technologies for ideation and decision making. Implemented as aggregated systems, a virtual workspace is provided that integrates a collection of tools to support different collaborative activities like data gathering, data analysis, decision making, consensus building and project planning. All groupware technologies allow a group of participants to contribute content as textual information. Furthermore, StreamWork™provides a collection of tools that use multimedia content. During the collaboration process, a group of participants can add and receive contributions; establish and change relationships among contributions and modify, delete or judge existing contributions. The identifiability ranges from full anonymity or pseudonym identification to full identification. Awareness of group participants is given by new contributions in the process and a list of participants. In addition, StreamWork™provides user profiles and a feed management system that allows participants to monitor the use of tools and the activities of other participants. Generated contributions are permanently available and can be exported or printed as a report. According to collaboration process design, all technologies provide the functionality to combine and save different tools as templates, which can be reused for similar collaboration processes.

In conclusion, the analysed groupware technologies provide web-based applications that support the cooperation, coordination and communication process of a group during collaboration. However, the composability and adaptability of the tools and functionalities provided can be a challenge for global virtual groups. None of the groupware technologies provide detailed guidelines which support inexperienced users in adapting and using a collaboration process. As a result, a global virtual group still needs expertise to design a collaboration process by selecting and combining the tools provided or by adapting process models to different tasks and group characteristics.

Attribute	TeamSupport™	StreamWork™	ThinkTank™
Core Functionality	- aggregated system: ideation - provides different tools to support ideation, decision making and consensus building	- aggregated system: decision making - provides different tools to support data gathering, data analysis, decision making, consensus building and project planning	- aggregated system: ideation - provides different tools to support ideation, decision making, consensus building and project planning
Content	- text	- hypermedia	- text
Relationship	- ordered list of contributions	- ordered list of contributions - collections of activity items - graphical relationship among contributions (tools: SWOT Analysis; Spider Web; Process Flow)	- ordered list of contributions - collections of activity items
Supported Actions			
Add	- contributions (text)	- contributions (tool related) - tools - action items	- contributions (text) - tools
Receive	- contributions (text)	- contributions (tool related) - action items	- contributions (text)
Associate	- contributions into categories and groups	- contributions into categories and groups - lists and decisions	- contributions into categories and groups - lists and decisions
Edit	- contributions (text)	- contributions (tool related) - action items - by process leader: tools	- contributions (text) - by process leader: tools
Delete	- contributions (text) - categories	- contributions (tool related) - categories - action items - by process leader: tools	- contributions (text) - categories - by process leader: tools
Judge	- in the module voting	- in the module voting and decision	- in the module voting

Table 5.1: Comparison of the groupware technologies: TeamSupport™, StreamWork™ and ThinkTank™ using the Taxonomy of Groupware Technologies by [Mittlemann et al., 2008] (Part 1/2)

Attribute	TeamSupport™	StreamWork™	ThinkTank™
Action Parameters			
Synchroncity	- immediate display of contributions to all participants (can be adapted) - participants can add content in parallel	- immediate display of contributions to all participants - participants can add content in parallel	- immediate display of contributions to all participants - participants can add content in parallel
Identifiability	- identification of contributor by login-name - can be adapted to full anonymity	- full identification	- identification of contributor by login-name - can be adapted to full anonymity
Access Control	- participation in a process by invitation - once invitation is accepted, all participants have both add and receive rights	- participation in a process by invitation - all participants can create new decision making processes	- participation in a process by invitation - process leader can define access control rights of the participants
Session Persistence	- for duration of session by default - if not deleted, permanently available - results can be exported as a report	- for duration of session by default - if not deleted, permanently available - results can be printed	- for duration of session by default - if not deleted, permanently available - results can be exported as a report
Alert Mechanisms	- no alert mechanism	- can be defined by different notification rules - notification by mail or on screen	- no alert mechanism
Awareness Indicators	- indicated by new contributions in the process - provide a list of participants	- indicated by new contributions in the process - provide a list of participants - provide user profiles - provide a feed management system to follow activities or participants by rss feeds, bookmarks and tags	- indicated by new contributions in the process
Process Adaption	- provide different tools - each tool can only be used once in a process - sequences of tools can be saved as templates	- provide different templates - no restriction on the combination of tools - sequences of tools can be saved as templates	- provide different templates - no restriction on the combination of tools - sequences of tools can be saved as templates

Table 5.2: Comparison of the groupware technologies: TeamSupport™, StreamWork™ and ThinkTank™ using the Taxonomy of Groupware Technologies by [Mittlemann et al., 2008] (Part 2/2)

The thesis defines the following basic requirements for an adaptable groupware technology that supports a collaborative ideation process in global virtual groups.:

BR-1 *The groupware technology needs to provide functionalities that support the cooperation, coordination and communication between the distributed group members.*

BR-2 *The groupware technology needs to provide different tools to support and combine collaborative activities that are needed to implement a collaborative ideation process.*

BR-3 *The groupware technology needs to provide functionalities that support the flexible adaptation of the technology for different tasks and group characteristics.*

BR-4 *The groupware technology needs to provide expert advice to support practitioners with low expertise in the design, adaptation and execution of collaboration.*

5.4.2 Specific requirements for an adaptable groupware technology

The thesis introduces a new design approach for collaborative ideation processes based on a given approach for collaboration process design (shown in Chapter 3.7). The new design approach combines a limited number of formal cognitive and social principles by enhancing the given concepts of Generate thinkLets and Modifiers by the concept Change of Perspective, which defines mental principles to stimulate the cognitive process of an individual for knowledge creation (shown in Chapter 3.5).

The thesis assumes that groupware technologies can make use of the underlying process logic of a collaboration process model to guide a global virtual group automatically through a collaboration process. A new modelling approach for collaboration processes is introduced called Collaboration Modelling Language (shown in Chapter 4.5), which defines the workflow of a collaboration process by the order and type of process activities, the data used and developed and the influence of events on the process activities. Here, the concept of thinXels is used as a new design approach for reusable instruction elements, which define the collaboration workflow of the participants by a sequence of atomic activities (shown in Chapter 4.3). The semantical notation of the Collaboration Modelling Language uses the Extensible Markup Language as an interchange format to describe a collaboration process model in a machine-readable format. To support virtual groups with low expertise in collaboration, the modelling language captures and transfers necessary knowledge for the adaption and execution of a collaboration process.

In conclusion, the thesis defines the following specific requirements for an adaptable groupware technology that supports the introduced design approach for collaborative ideation processes and the collaboration modelling language:

SR-1 *The groupware technology needs to provide tools that support the cognitive and social principles of the introduced design approach for collaborative ideation processes.*

SR-2 *The groupware technology needs to provide functionalities to load, adapt and execute collaboration process models using a machine-readable process description.*

SR-3 *The groupware technology needs to provide functionalities that support the adaptation and execution of a collaborative process by transferring tacit knowledge and skills.*

5.5 Conceptual design of an adaptable groupware technology

The thesis adopts the architecture of a workflow management system to develop a conceptual design for an adaptable groupware technology. In literature [Leymann and Altenhuber, 1994, Hollingshead, 1995, Georgakopoulos et al., 1995], a workflow management system is characterised by its functional components, which can be distinguishes in build-time and run-time functions (shown in Figure 5.1).

Build-time functions are used during the process design phase of a business process. Here, the workflow management system provides different analysis, modelling and definition tools to translate a business process from the real world into a formal process description.

At run-time, the process definition is interpreted and executed by the Workflow Enactment Service, which utilizes one or more local workflow engines. Run-time control functions are used for the management of the workflow process and the resulting interactions of human users and IT application tools for the activity steps involved.

Similar to a workflow management system, an adaptable groupware technology can provide functionalities to manage the order of execution of a sequence of work activities within an organisation. Here, the Collaboration Modelling Language (CML) can be used to define a process definition.

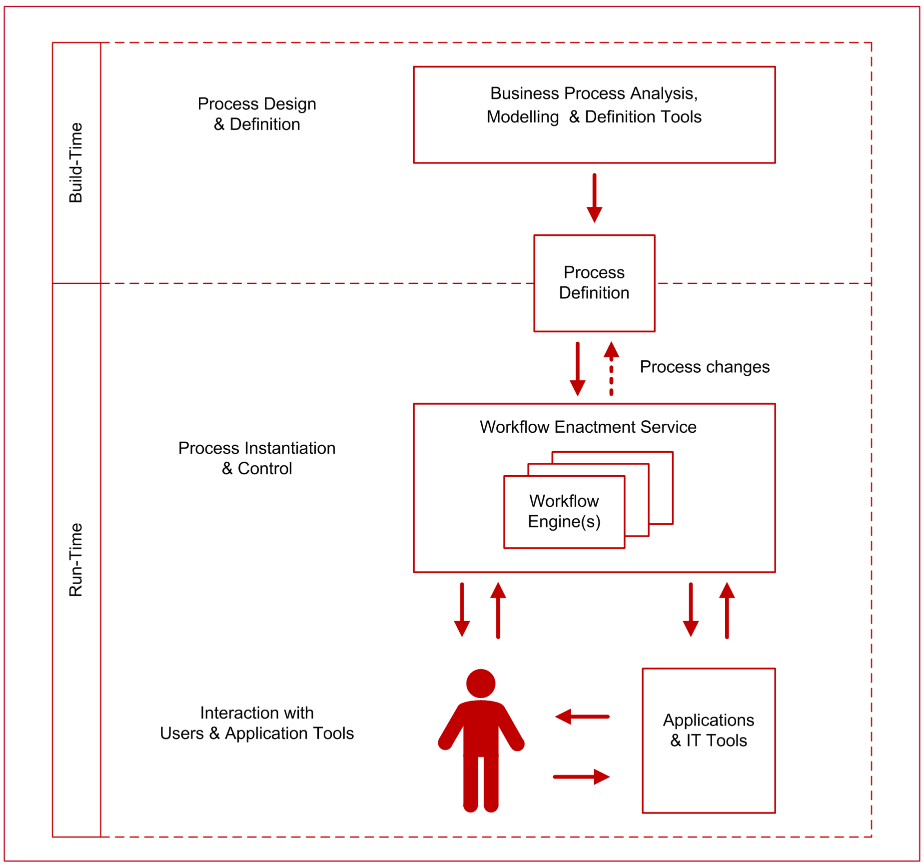

Figure 5.1: Characteristics of workflow management systems adapted from [Hollingshead, 1995]

The resulting conceptual design combines modules and interfaces for design, adaptation and execution of a collaborative process (shown in Figure 5.2). These modules are defined as follows [Knoll et al., 2009]:

ElementLib — *The module provides data structures and functions to describe, load and save a collaborative process model, which is described by the Collaboration Modelling Language.*

ProcessLib — *The module provides data structures and functions to manage the workflow of a collaboration process model.*

DataLib — *The module contains data structures and functions to provide, analyse and save data that is used or generated during a collaboration process.*

A prototype of an adaptable groupware technology is developed as a server application that links a global virtual group via the Internet and provides an activity of a collaborative process via a webpage. This server application makes use of the module *ElementLib* to provide a data structure that represents the elements of the CML.

The extensible markup language (XML) is used by a modelling tool to describe a collaborative process in a machine-readable process description. The module *ElementLib* uses the XML description to create objects for the CML elements against their specific configuration. The resulting objects are used by the module *ProcessLib* to compute the active position and the next step of a participant in a collaboration process.

During the execution of a collaboration process, the module *ProcessLib* stores each activity of a participant individually and exchanges this information with a groupware technology via the interface *ActivityMap*. This interface is used to compensate the access lag, which can result from the client-server communication.

The activity of an individual is defined by the configuration of a CML element thinXel in the XML data file. The groupware technology uses this information to provide and configure a webpage that allows the participant to execute the intended activity. The process data of a thinXel like the task or the topic for contributions are provided by the module *DataLib*, which is connected to a database that stores the contributions of the participants during the collaboration process.

In the next sections, the thesis discusses in more detail the runtime control functions of the module *ProcessLib*, which are used to manage the workflow of a collaboration process.

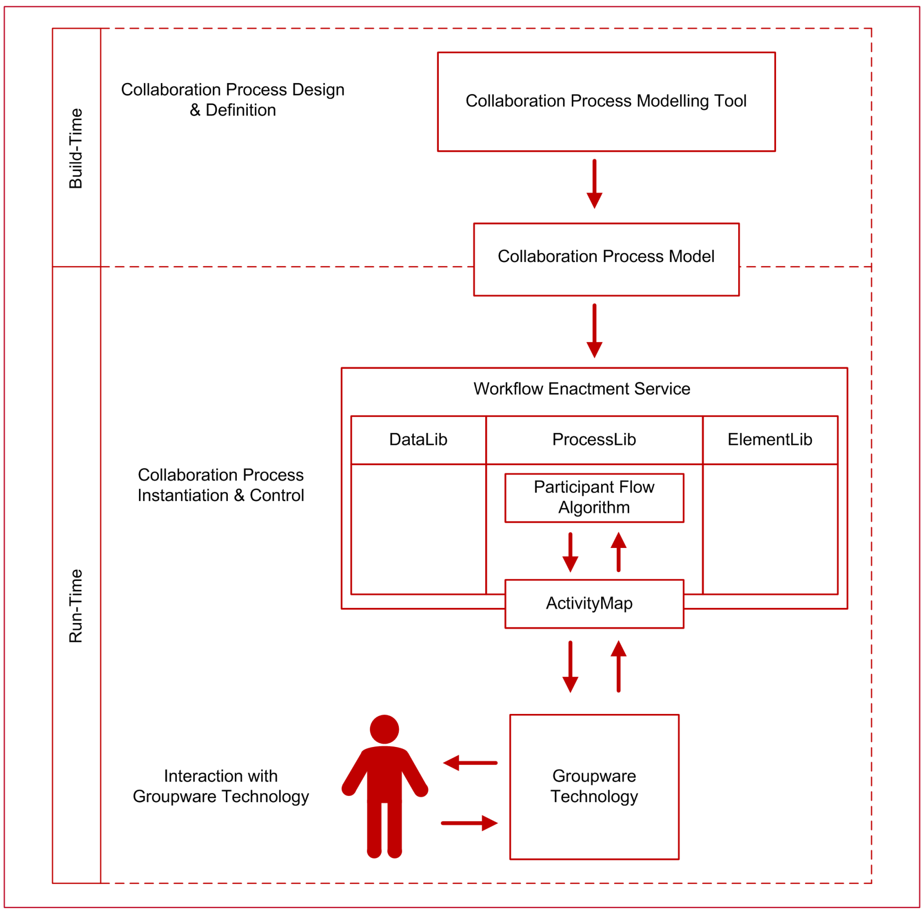

Figure 5.2: Characteristics of a groupware technology system using a collaboration modelling language

5.5.1 A participant flow algorithm to manage the workflow of a collaboration process

The thesis introduces a *Participant Flow Algorithm* [Knoll et al., 2009] that makes use of the elements of the CML to manage the workflow of a collaboration process. The module ProcessLib uses this algorithm to compute the active position and the next step of a group participant in a collaboration process.

According to the CML, the workflow of a collaboration process can be different for an individual and a group of participants. As a result, the Participant Flow Algorithm distinguishes between the following workflows:

Individual Flow *The workflow represents the sequence of activities of an individual participant. These activities can be executed independently from the activities of the other participants.*

Group Flow *The workflow represents the sequence of activities of a group of participants. The participants activate the elements of the CML simultaneously and will only be guided to the next element as a group.*

Different elements of the CML are used to describe the individual and group flow of a collaboration process (see Chapter 4.5 for the elements: Decision, Transition, Sender, Response, thinXel, ProcessTemplate and thinkLet). For example, the element *ThinkLet* is used to describe the activities of a group. The elements *ThinXel* and *ProcessTemplate* are used to describe activities of the individual workflow. The process elements *Decision* and *Sender* can be used to describe both workflows. The same situation exists for the element *Response* that sends an interruption signal to the elements of a *ThinkLet* and *ProcessTemplate* to abort the current activity of a group or an individual and collects the participants via the element *Transition*. As a result, the element *Transition* represents a connection element between the individual and group flow of a collaboration process. Here, individual participants can be added to a group or a group process can be divided into different processes. The Participant Flow Algorithm supports this property of the element *Transition* by a Synchronization Algorithm, which monitors the state of the collaboration process.

Summarized, the Participant Flow Algorithm includes the following components:

Participant Algorithm *This algorithm computes the next step of an individual based on the active element of a participant in the collaboration process.*

Group Algorithm — *This algorithm computes the next step of a group of participants based on the active element of the group in the collaboration process.*

Synchronization Algorithm — *This algorithm monitors the state of the individual and group process and switch between the participant and group algorithm based on the current type of the participant flow (individual or group flow).*

The components of the Participant Flow Algorithm are illustrated in a state graph shown in Figure 5.3. This state graph represents the possible states of an individual or a group of participants for the elements of the CML that define the steps of a collaboration workflow. The *Group Algorithm* uses the following group states:

atGroupEntry — *The group state where the group is at the entrance of the element.*

atGroupExit — *The group state where the group is at the exit of the element.*

These states are similar to the states of an individual flow but are extended by the property of the element *thinXel*. This element represents an intended activity of an individual that can be aborted or executed. Therefore, the element *thinXel* requires input data from the individual to resume the individual flow to the next element. As a result, the thesis defines the following states for the *Participant Algorithm*:

atEntry — *The individual state where the participant is at the entrance of the element.*

atExit — *The individual state where the participant is at the exit of the element.*

inActivity — *The individual state where the participant is in the element thinXel.*

A change of state results from the steps of the participants in the collaboration process. These steps are illustrated and defined in Figure 5.4 and Table 5.3 by the elements of the CML. Here, the element *Transition* represents an exception, which cannot be activated by the entry of a participant or a group. The activation of this element is provided by

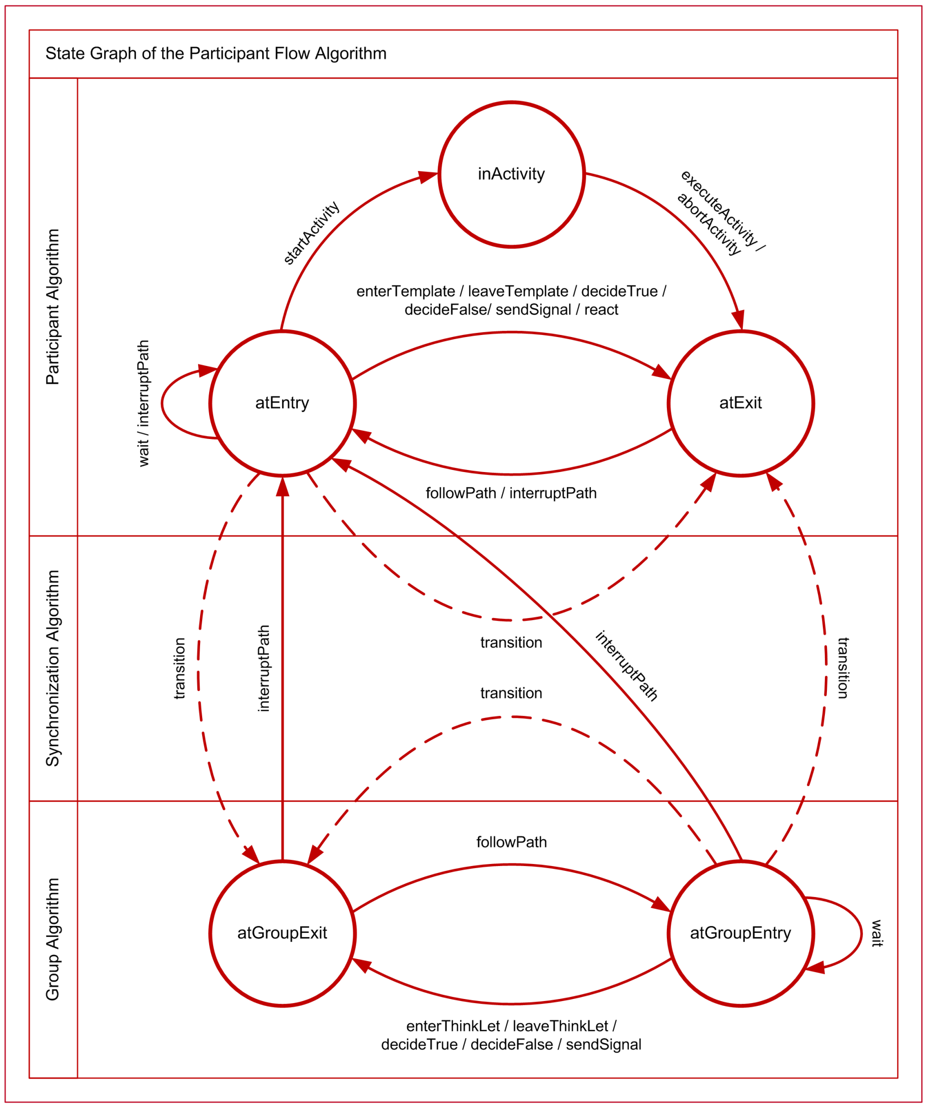

Figure 5.3: State Graph of the Participant Flow Algorithm

the Synchronization Algorithm that monitors each activity of the collaboration process. After each change of the collaboration process, the algorithm verifies if the predefined conditions of the element *Transition* are fulfilled. In that case the algorithm will activate the element *Transition* which can lead to a switch between the participant and group algorithm.

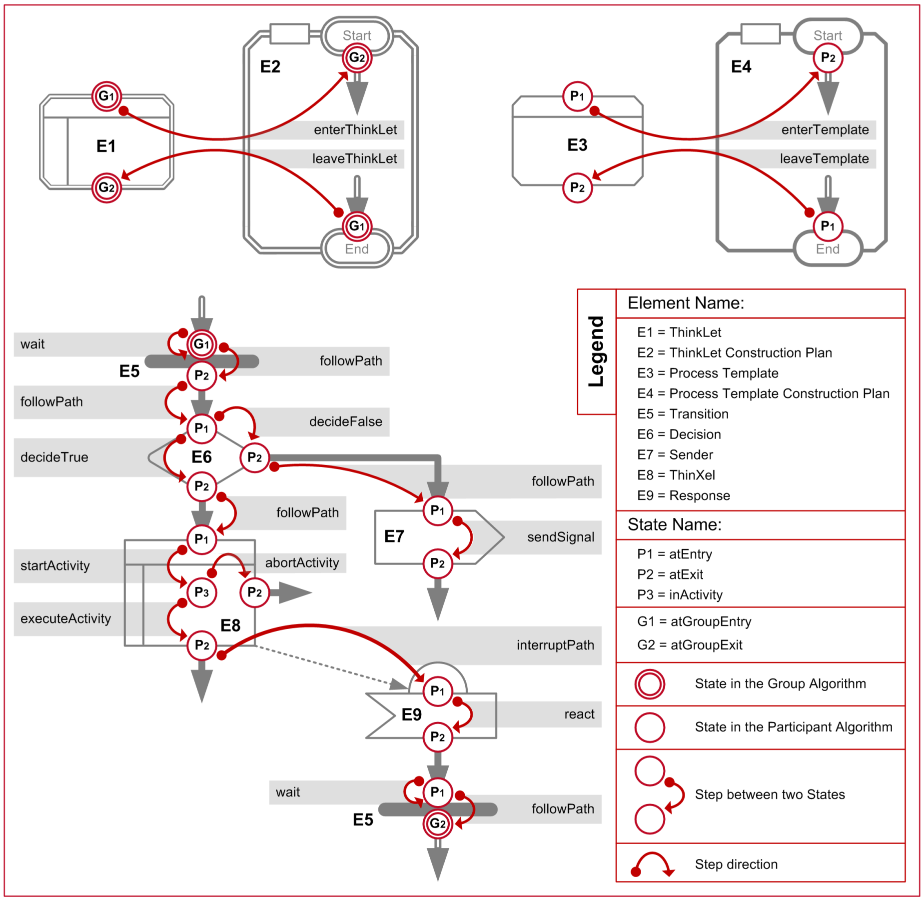

Figure 5.4: Description of the steps of the Participant Flow Algorithm using the graphical elements of the CML

In conclusion, the Participant Flow Algorithm provides a control function, that can be used to manage the workflow process of a collaboration process. In the next section, the thesis discusses the components of the groupware technology that use the presented Workflow Enactment Service.

Step	Element of the CML	Description	Input state	Output state
enterThinkLet	ThinkLet (Start)	the activity to enter the element ThinkLet	atGroupEntry	atGroupExit
leaveThinkLet	ThinkLet (End)	the activity to leave the element ThinkLet	atGroupEntry	atGroupExit
enterTemplate	Process Template (Start)	the activity to enter the element Process Template	atEntry	atExit
leaveTemplate	Process Template (End)	the activity to leave the element Process Template	atEntry	atExit
decideTrue	Decision	making a positive decision for the element Decision	atEntry atGroupEntry	atExit atGroupExit
decideFalse	Decision	making a negative decision for the element Decision	atEntry atGroupEntry	atExit atGroupExit
sendSignal	Signal	the activation of a signal by the element Signal	atEntry atGroupEntry	atExit atGroupExit
followPath	Participant Flow Group Flow	the step between two elements that are connected by the element Participant Path	atExit atGroupExit	atEntry atGroupEntry
wait	Transition	the activity to wait for the activation of the element Transition	atExit atGroupExit	atEntry atGroupEntry
interruptPath	Response	interrupt the active activity and guide the participant to the element Response	atExit atGroupExit	atEntry
react	Response	the activity to guide a participant to a new Participant Path by the element Response	atEntry	atExit
startActivity	ThinXel	represents the activity to enter the element ThinXel	atEntry	inActivity
executeActivity	ThinXel	represents the execution of the intended activity of the element ThinXel	inActivity	atExit
abortActivity	ThinXel	represents the abortion of the intended activity of the element ThinXel	inActivity	atExit

Table 5.3: Description of the steps of the Participant Flow Algorithm in relation to the graphical elements of the CML

5.5.2 Components of an adaptable groupware technology

The prototype of an adaptable groupware technology provides different components to load, adapt and execute a collaborative process model.

Generic webpages to implement atomic activities of a collaboration process model

The thesis develops a set of generic user interfaces, which represent common activities of an individual during a collaborative ideation and decision making process (see requirement BR-2). Similar to existing groupware technologies, these user interfaces are implemented as webpages that allow the participants to contribute and share content as textual information. According to the concept of a thinXel (introduced in section 4.3), these webpages represent possible user interfaces for the context and data-oriented activities of an individual.

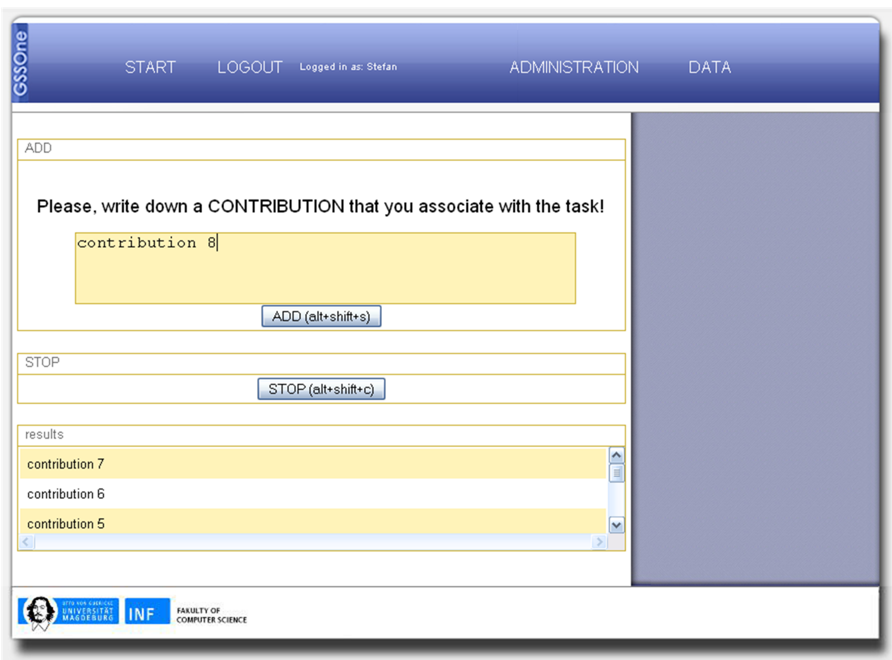

Figure 5.5: User interface of the data-oriented thinXel: create a contribution

Context-oriented activities are implemented as webpages with the intention to create a working environment for the collaboration process. Resulting webpages provide textual information to explain the constraints, goals and the intended working process of a collaboration process. Furthermore, the webpages provide functionalities to modify the working environment by requesting the individual to select a textual concept from a list or to decide which activity should be done next.

Data-oriented activities are implemented as webpages with the intention to change the existing dataset of the collaboration process. Resulting webpages provide functionalities to create a textual contribution, to enhance an existing textual contribution or to establish the relationships between two textual contributions.

Context and data-oriented activities of an individual are defined by the configuration of the element *thinXel* in the XML data file. The prototype uses this information to select and configure a webpage that allows the participant to execute the intended activity. An example is the webpage for the data-oriented thinXel *create a contribution* (shown in Figure 5.5), as an element of the process template construction plan *Brainstorming* (shown in Chapter 4.7 and Chapter 4.9).

```
1
  <?xml version="1.0" encoding="utf-8"?>
3 <!DOCTYPE cml SYSTEM "cml.dtd">

5 <activity id="activity-contribution" name="create a contribution" type="create">

7  <data-in-parameter id="process-task" name="process task" datatype="string"/>
   <data-in-parameter id="existing-contributions" name="existing contributions" datatype="string"/>
9  <data-forward-parameter id="created-contribution" name="created contribution" datatype="string-list"/>

11 <description>...participants generate a new contribution...</description>
   <config>
13  <config:information>Please define a short instruction:</config:information>

15  <config:rule>
     <positive-example>
17    In this step you can generate a new contribution that... (requirements).

19    Please, click the button '(do-button-label)' to add a new contribution...
      Please, click the button '(cancel-button-label)' to select another contribution...
21   </positive-example>

23   <negative-example>
      Please create a new contribution
25   </negative-example>
    </config:rule>
27
    <config:instruction>Please, write down a CONTRIBUTION that you associate with the $process-task$</config:
         instruction>
29
    <config:do-button-label value="ADD"/>
31  <config:cancel-button-label value="STOP"/>
   </config>
33 </activity>
```

Listing 5.1: Semantical notation of the data-oriented thinXel: create a contribution

The Listing 5.1 shows the semantical representation for the data-oriented thinXel: *create a contribution*. Here, the semantical notation uses the XML tag to refer to a webpage of the type *create* (shown in Listing 5.1 / Line 5). This webpage is created as a template that provides an information area to display a facilitation instruction (defined by the XML tag in Listing 5.1 / Line 28), an input area to submit new contributions, a result area for existing contributions (defined by the XML tag in Listing 5.1 / Line 8) and the two buttons: *ADD* and *STOP* (defined by the XML tags in Listing 5.1 / Lines 30, 31). The button *ADD* represents the execution of the indented activity. The participant can abort this activity by pressing the button *STOP*.

The prototype of an adaptable groupware technology makes use of the developed webpages to implement the mental principles of the introduced design approach for collaborative ideation processes as a sequence of context- and data-oriented activities that build on each other. For example, a possible implementation of the mental principle Jumping (shown in Chapter 3.6.1) is the following activity sequence:

Activity 01 *Read the creative task and the intended working process.*
A context-oriented webpage to provide textual information.

Activity 02 *Generate a characteristic attribute of the creative task.*
A data-oriented webpage to create a textual contribution.

Activity 03 *Select the next activity: Activity 02 or Activity 04*
A context-oriented webpage to decide on the next activity.

Activity 04 *Select a characteristic attribute of the creative task.*
A context-oriented webpage to select a textual contribution from a list.

Activity 05 *Generate analogous situations with the same attribute.*
A data-oriented webpage to create a textual contribution.

Activity 06 *Select the next activity: Activity 04, Activity 05 or Activity 07*
A context-oriented webpage to decide on the next activity.

Activity 07 *Select a analogous situation.*
A context-oriented webpage to select a textual contribution from a list.

Activity 08 *Generate possible solutions in the analogous situation.*
A data-oriented webpage to create a textual contribution.

Activity 09 *Select the next activity: Activity 07, Activity 08 or Activity 10*
A context-oriented webpage to decide on the next activity.

Activity 10 *Select a possible solution.*
A context-oriented webpage to select a textual contribution from a list.

Activity 11 *Generate ideas by applying the solution to the creative task.*
A data-oriented webpage to create a textual contribution.

Activity 12 *Select the next activity: Activity 10, Activity 11 or Activity 13*
A context-oriented webpage to decide on the next activity.

Activity 13 *Show generated ideas for the creative task.*
A context-oriented webpage to provide textual information.

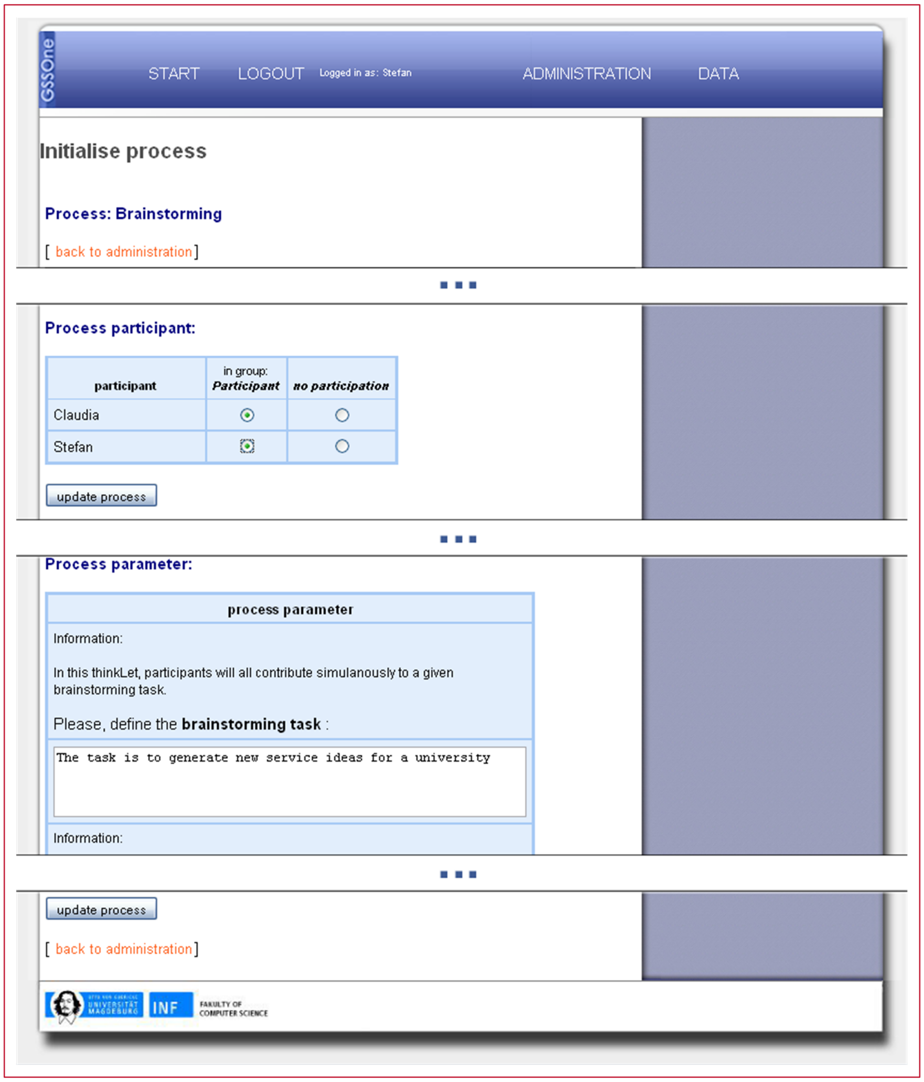

Figure 5.6: User interface of the configuration component to load and adapt a collaboration process model

Component to load and adapt a collaboration process model

The thesis implements different functionalities that support the adaptation and execution of a collaborative process. A configuration component is provided to load, store and adapt a collaboration process model based on the XML syntax (shown in Figure 5.6). Similar to the software prototype presented in Chapter 4.10.2, this module provides functionalities to adapt the logical process design to a certain context and group constellation by using form fields to configure the elements of the CML.

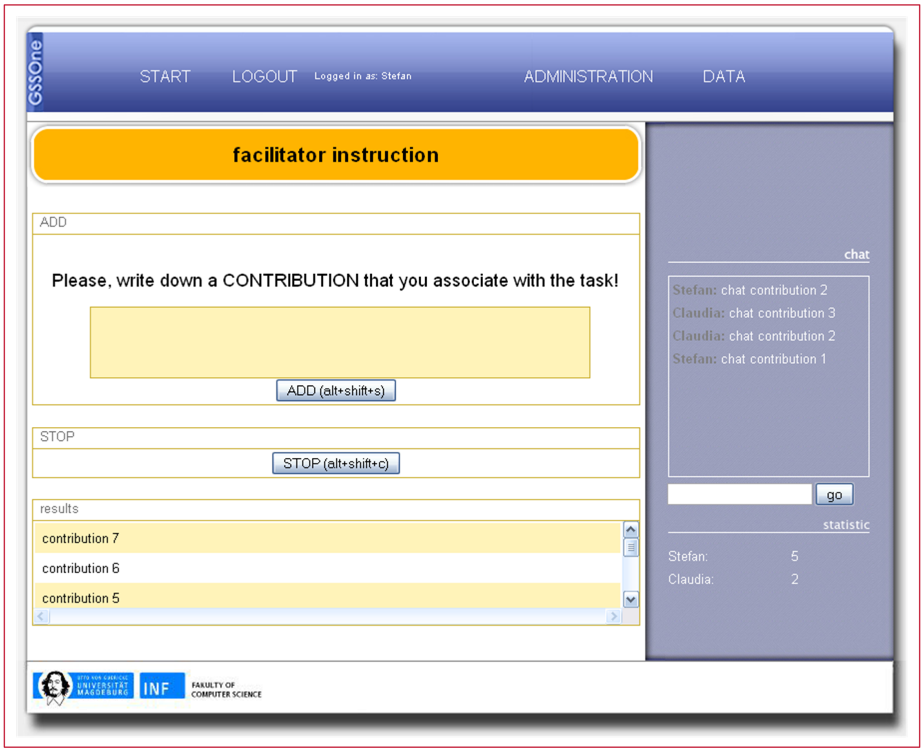

Figure 5.7: User interface of the data-oriented thinXel: create a contribution using the intervention modules for chat, facilitation instruction and statistic

Component to monitor and intervene in a collaboration process

Based on the ActivityMap, the thesis develops a component to monitor the activities of the participants during a collaboration process. Furthermore, the component provides functionalities to intervene directly in a process to handle negative group behaviours and support group performance in a collaboration process. Here, the groupware technology provides different modules that can be connected to the webpage of an active activity. These modules are independent of the logical process design and can be extended by a software engineer.

In a first phase of the implementation, the prototype of an adaptable groupware technology provides the following modules: the module *chat* to support group communication, the module *facilitation instruction* to support group coordination by providing information that is not defined by the collaboration process model and the module *statistic* to influence the negative phenomenon Social Loafing. These modules can be be flexibly combined by the practitioner during the collaboration process (see Figures 5.5 and 5.7).

5.5.3 Summary

The conceptual design of an adaptive groupware technology provides different components to load, adapt, execute and monitor collaboration processes based on the CML. The Participant Flow Algorithm is used to guide a virtual group automatically through a predefined collaboration process. During the collaboration process, generic webpages represent common atomic activities, defined by the CML element thinXel, which can be combined to a sequence of activities to implement ideation processes using the introduced mental principles. Finally, the groupware technology provides functionalities to adapt the webpage of an atomic activity by different modules, which can be used to handle negative group behaviours and support group performance in a collaboration process.

5.6 Evaluation of the groupware technology

The thesis uses functional tests to verify the groupware technology in an formative process. At different implementation stages, prototypes of the adaptable groupware technology are verified against the predefined basic and specific requirements.

5.6.1 Functional tests to verify basic functionalities

At an early implementation stage, the groupware technology was verified against basic functionalities like to adapt and execute a collaboration process model or to manage and guide the workflow of a collaboration process [Hoerning, 2007]. During the experiment, a software prototype was used to execute three models of the following collaboration processes: the thinkLet LeafHopper [Briggs and de Vreede, 2003], the mental principle Jumping [Knoll and Horton, 2011c] and the discussion technique Six Hats [de Bono, 2000]. The models were designed by a professional facilitator, who has experience with the graphical and semantical notation of the collaboration modelling language.

Twenty-three distributed students from different universities participated as a global virtual group in this experiment. Upon the login to the prototype, the participants were informed via a text chat about the task of the experiment. They received an introduction to the functionality of the prototype and were instructed to follow the presented instructions on the screen. During the experiment, contributions of the participants were recorded with timestamps.

Feasibility of the participant flow algorithm

In the first phase of the experiment, the thesis used the thinkLet LeafHopper to evaluate the implementation of the Participant Flow Algorithm. Here, the collaboration process model describes a divergent process with the goal to create contributions for a brainstorming task by using different topics to organise the contributions.

During the experiment, the model split the group of participants into individual processes and guided them automatically through the collaboration process. Each participant worked with his own instance of the collaboration process. The described process steps of the instance were private and allowed a participant to execute the process independently of the activities of others. The participants were allowed to generate and share concepts for a list of topics provided.

An analysis of the contribution created shows that each participant could switch between the provided topics. The participants could generate and share contributions and were guided automatically by the prototype through the predefined participant flow. This observation supports the feasible implementation of the Participant Flow Algorithm.

Adaptation of a collaboration process model

In the second phase of the experiment, the thesis used the mental principle Jumping to evaluate the assumption that a collaboration process model can be adapted and executed to different parameters. Here, the collaboration process model describes a divergent process with the goal to create concepts for a given creative task by retrieving knowledge from similar situations. The model defines a step-by-step sequences of actions to guide the activation and use of analogous situations.

During the experiment, the virtual group was divided into two groups. Each group executed the collaboration process with different tasks and break conditions. One group was guided automatically to the next phase of the mental principle if a specific number of contributions was created and the other group after a specific time period.

An analysis of the contribution created and the timestamps shows that each group could create and share contributions for each of the predefined phases of the mental principle. Furthermore, the software prototype could analyse the conditions and guide the participants automatically to the next phase after the predefined condition is fulfilled.

Intervention in a collaboration process model

In the last phase of the experiment, the thesis used the discussion technique Six Hats to evaluate the assumption that a facilitator can influence the participant and data flow during a collaboration process. Here, the collaboration process model describes a divergent process that uses different categories for contributions to support the participants in their discussion of different ideas.

During the experiment, the collaboration process model split a user group into a facilitator and a group of participants. The facilitator selected from different categories to define the type of contributions which needed to be generated by the participants. The selected category was provided to the participants, who generated and shared contributions in a collaboration process. During this process, the facilitator monitored the generated contributions to get an overview of the process and to change the category if needed.

An analysis of the contributions created and an interview with the facilitator shows that the facilitator could change the participant flow of a group by selecting a new category. The participants could create and share contributions for each of the selected categories.

Conclusion

The experiment shows that the software prototype fulfills some of the predefined basic and specific requirements for an adaptable groupware technology. The prototype provides basic functionalities to load, adapt and execute collaboration process models using a machine-readable process description (see SR-2). Experts can predefine the logical design of a collaboration process including instructions to support practitioners with low expertise in the adaptation and execution of a model (support of BR-4). A defined collaboration process model can be configured for different tasks and group characteristics by adapting the parameters of a logical process design (support of BR-3). During the collaboration process, each participant was guided automatically by the described participant flow. To implement a collaborative ideation process, activities are provided which allow participants to create, organise and share contributions (support of BR-2). Furthermore, a facilitator can influence the participant and data flow of a collaboration process, which supports the cooperation and coordination between distributed group members (support of BR-1).

5.6.2 Functional tests to verify the feasibility to support ideation

During the iterative implementation process of the groupware technology, different modules were developed and evaluated in a one-semester undergraduate student project [Magdeburg, 2012]. The primary purpose of these modules was to improve the execution of a collaborative process by supporting group communication, group coordination and group awareness. During the project, modules for a group chat, facilitation instructions and statistics were implemented. These modules can be activated independently and combined during a collaboration process and allow a practitioner to handle negative group behaviours like Social Loafing by involving social comparison [Shepherd et al., 1995] and to support group performance by giving facilitation instructions [Wong and Aiken, 2003].

The resulting groupware technology was verified in a functional test against the feasibility to support a collaborative ideation process in a virtual group. During the experiment, the groupware technology was used to execute two collaboration process models for ideation, which uses the mental principles Jumping and Dumping [Knoll and Horton, 2011c]. These models combine a divergent process of generating ideas and a convergent process to reduce and organise the pool of generated ideas. The convergent process is implemented by using the thinkLets *PinTheTailOnTheDonkey* and *PopcornSort* [Briggs and de Vreede, 2003]; thinkLets of the pattern of collaboration Reduce and Organize. The models were designed by the students in cooperation with a professional facilitator, who has experience with the graphical and semantical notation of the collaboration modelling language.

Ten students from a large university participated in groups of five persons in an virtual ideation process. Upon arrival, a group of five participants was informed verbally about the creative task of the experiment. They received an introduction to the functionality of the groupware technology and each participant was seated in front of one computer. The facilitator informed the participants verbally to generate ideas for a given creative task by only following the presented instructions of the collaboration processes. No verbal communication was allowed between the participants during the experiment, but they were allowed to use the module *chat* to communicate with each other. Furthermore, the facilitator could activate the module *facilitation instruction* to present additional instructions or information to the participants, which are not defined by the collaboration process model. During the experiment, contributions of the participants were recorded with timestamps. Furthermore, a questionnaire was used to document the impressions of the participants about the ideation process.

In the first part of the experiment, a group of five participants executed a collaborative ideation process using the mental principle Jumping. To generate ideas for a given creative task, the ideation phase supports the participants in analogical thinking by providing a step-by-step sequence of actions which guide the activation and use of analogous situations. Generated ideas were reduced and organised to guide the attention of the participants on ideas, which fulfill the requirements of the creative task. The group improved the selected ideas by adding new details on how to implement them. The collaboration process finished with a ranking to identify an order of preference among the elaborated ideas.

In the second part of the experiment, another group of five participants executed a collaborative ideation process using the mental principle Dumping. Here, the ideation phase supports the participants in generating new ideas by providing step-by-step sequences of actions to guide the activation and reversal of assumptions. Similar to the first part of the experiment, ideas were reduced and organised to guide the attention of the participants on ideas that fulfill the requirements of the creative task. The group improved and ranked the selected ideas to identify an order of preference among the generated ideas.

An analysis of the contributions created shows that each group could create and share contributions for each of the predefined phases of the ideation process. During the whole collaboration process, the participants were guided automatically by the prototype through the predefined participant flow. The evaluation of the questionnaire shows that the participants understood the provided facilitator instruction, and did always know how to use the groupware technology. In the ideation phase, most participants found the mental principles useful to generate ideas for the creative task. The analysis of the elaborated ideas shows that all selected ideas fulfill the predefined requirements of the creative tasks.

According to the implemented modules, the facilitator was able to independently activate and combine the modules during the collaboration processes. The participants were able to use the module *chat* to communicate with each other. Facilitator instructions provided by the module *facilitation instruction* were recognised by the participants and allowed the facilitator to provide additional information, which were not defined by the collaboration process model.

Conclusion

The experiment shows that the software prototype supports some of the predefined specific requirements for an adaptable groupware technology. The prototype supports the execution of collaborative ideation process using the mental principles Jumping and Dumping (support of SR-1). These collaboration processes combine divergent and convergent phases which can be described in a machine-readable process description (support of SR-2). By using a machine-readable process description, experts can predefine the logical design of a collaboration process for ideation including instructions and stimuli to support participants with low expertise during the ideation process. During the execution of a collaboration process, the module *facilitation instruction* can be used to provide additional instructions or information to the participants, which are not defined by the collaboration process model (support of SR-4).

5.7 Discussion of the research results

The chapter defines basic and specific requirements for an adaptable groupware technology that uses the semantical notation of a collaboration process model to improve collaborative ideation processes in global virtual groups. A conceptual design of an adaptable groupware technology is introduced which adopts the architecture of a workflow management system and combines components for the design, adaptation and execution of a collaborative process. A key component of this design is the Participant Flow Algorithm, that makes use of the underlying process logic of a collaboration process model to compute the active position and the next step of the participants in a predefined collaboration process.

Based on the Participant Flow Algorithm, different functionalities were implemented by a software prototype to monitor and guide a virtual group automatically through the collaboration process. This prototype provides a set of generic user interfaces to implement common atomic activities, which can be combined to a sequence of activities to implement collaborative ideation processes which makes use of the introduced mental principles. Finally, the prototype provides functionalities to adapt the user interface by different modules, which can be used to handle negative group behaviours and support group performance in a collaboration process.

Functional tests were used to evaluate the conceptual design in a formative process. Here, at different implementation stages, prototypes of the groupware technology were verified against the predefined basic and specific requirements. The results show that the current implementation of an adaptable groupware technology can be used to implement collaborative ideation processes in global virtual groups. However, further research is needed to analyse and compare the groupware technology to alternative design solutions.


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Chapter 6

Discussion of the research results

6.1 Overview

This chapter discusses the benefit of the research results. With regard to the research gaps identified in collaboration process design, the thesis provides an overview of the research results and discusses their possible applications for industry and research. The chapter closes with an outlook on future research.

6.2 Discussion of the design approach for collaborative ideation processes

A research objective of this thesis is to improve the pre-development phase of the innovation process for global virtual groups using technological support. The thesis focuses on Collaboration Engineering as an interesting and suitable approach for designing collaboration processes that can make use of technological support. However, from the literature, it remains unclear if the given design approach provides all possible approaches to guide the cognitive and social process of a group during ideation. The thesis regards this as a research gap in the research field of collaboration engineering.

To close this research gap, a creative cognition approach is used to analyse the underlying mental principles of given idea generation techniques. This approach describes an idea generation techniques by the three ingredients:

Algorithm — *defines a sequence of formal steps that guides the cognitive activities of an individual.*

Format — *defines the use of material or tools and how individuals can use them for interaction during the ideation process.*

Setting *defines how possible social phenomena can be affected by changing the Format to create an environment that supports the ideation process.*

The thesis uses the ingredients to analyse the intended cognitive and physical activities of an individual for the provided instructions of common idea generation techniques. The analysis shows that given idea generation techniques can be formalised and categorised with regard to their mental principles; a cognitive mechanism that supports the activation of areas of the knowledge network by using external stimuli. These mental principles are:

Jumping *refers to a cognitive mechanism called analogical thinking, in which the individual retrieves knowledge from different situations or problems to generate ideas.*

Dumping *refers to a cognitive mechanism of challenging characteristic attributes of the creative task to generate a new perspective that can be used to generate ideas.*

Pumping *refers to a cognitive mechanism called application, which represents the adaptive use of existing knowledge in its habitual context to generate new ideas.*

The thesis formalises the mental principles by the concept *Change of Perspective*, which defines the principles as sequences of formal steps that will be used to guide the cognitive activities of the individual. A design approach for collaborative ideation processes is introduced that make use of a design pattern approach to capture given work tactics, which influence the cognitive and social activities of a group during ideation. As a result, a collaborative ideation process can be defined by a combination of the following concepts:

Change of Perspective *defines the mental principle to guide the cognitive activities of the individuals.*

Generate thinkLet *defines the collaboration process of a group by rules on how to share ideas that emerge during the cognitive process of the individuals.*

Modifier *defines variations of the collaboration process in order to affect possible behaviours.*

The design patterns provide information on when to choose a concept with regard to the given creative task or group constellation. A resulting collaborative process for ideation is described by a formal script of steps and instructions that can be used to guide a group in a face-to-face as well as in a virtual environment.

The thesis assumes that the design approach can be improved by understanding the influence of external stimuli on the cognitive activities and the resulting ideas. This knowledge can be used to provide guidelines for the design of a collaborative ideation process that make use of the mental principles. As a result, the thesis analyses the influence of external stimuli characteristics on the outcome of an ideation process using the mental principle Jumping. Based on a literature research on analogical thinking, the thesis introduced a new approach to characterise external stimuli for the mental principle Jumping by the properties *typical* and *relevant*. The research results show first indications that stimuli characteristics have an impact on the outcome of an ideation process and can be used to define guidelines for the design of a collaborative ideation process.

6.2.1 Limitations of the research results

A number of limitations exist for the research results. Currently, the concepts of the design approach capture given knowledge of a small number of facilitation experts to provide guidelines for their selection and combination. More expert interviews are needed to evaluate and refine more specific guidelines for the design of predictable and suitable ideation process for the pre-development phase of the innovation process. Furthermore, the research results show first indications that stimuli characteristics have an impact on the outcome of an ideation process. However, further research is needed to focus on the relationship between stimuli, mental principles and resulting ideas to define more detailed rules how to use stimuli for the design pattern *Change of Perspective*.

6.2.2 Applications of the research results for industry

With regard to the innovation process of an organisation, innovation managers can make use of the introduced approaches to support ideation in the pre-development phase of an innovation process. Here, the research results can be applied in different ways.

One application is the use of the ingredients approach to characterise and classify given idea generation techniques to support the design of an ideation workshop. Currently, several books characterise and classify idea generation techniques along different dimensions [Higgins, 1994, VanGundy, 1988, 2005]. For example, VanGundy [VanGundy, 1988] subdivides idea generation techniques into group and individual techniques and uses the dimensions: whether the idea generation process is verbal or silent; whether ideas are produced by forced relationships or free association; and whether the technique employs stimuli that are related or unrelated to the creative task. Innovation managers use these dimensions to select idea generation techniques that support the generation of multifaceted ideas. However, the cognitive process of a participant is a complex process, which differs from person to person. No general statement can be made about the acceptance and use of a selected idea generation technique for a whole group of participants, which makes an ideation process unpredictable. To consider possible preferences of the participants, innovation managers need to select and combine idea generation techniques that support different cognitive processes.

In contrast to given classification approaches, the ingredients approach provides by the the mental principles a detailed representation how given idea generation techniques use external stimuli to guide the cognitive process of a group of participants. Innovation managers can use the presented analysis of common idea generation techniques to now more efficiently select and combine idea generation techniques that use different mental principles and thereby consider the possible preferences of the participants.

Another application is given for the introduced design approach for a collaborative ideation process. Instead of using existing idea generation techniques, innovation managers can now use the design approach to create new idea generation techniques that better fit the strategic goals of an ideation workshop. In contrast to the given design approach of collaboration engineering [Kolfschoten et al., 2011, Briggs et al., 2006], the thesis introduces the design pattern *Change of Perspective* as a new concept for the design of a collaborative ideation process. Here, *Change of Perspective* defines the mental principles which guide the cognitive process of the individuals during ideation. These mental principles represent the skeleton of an idea generation technique and can be adapted to the given resources and group constellations by the concepts *Generate thinkLet* and *Modifier*.

A possible example application is the innovation process of an organisation that needs to introduce a new product to remain competitive. During the pre-development phase, the innovation manager wants to generate new product ideas based on existing resources in the organisation to reduce development costs and time. By analysing the design patterns of *Change of Perspective*, the innovation manager identifies the change of perspective *Pumping* as a mental principle to guide the cognitive activities of a group during the collaborative ideation process. This mental principle represents an appropriate choice, because it can be used to focus on specific concepts of the creative task like existing resources in the organisation. The innovation manager uses the design pattern *Generate thinkLets* to define how the group should share possible product ideas that emerge during the use of the change of perspective *Pumping*. To handle possible social phenomena that could influence the performance of the ideation process, the given group constellation is analysed and possible design patterns *Modifier* are selected. The selected design patterns are combined and documented as a handbook, which describes an idea generation technique by a formal sequence of collaborative process steps, facilitation instructions and stimuli that should be used to guide the cognitive activities of a group.

Besides the design of idea generation techniques for a face-to-face workshop, innovation managers can use the design approach to develop an ideation workshop that uses groupware technology. Here, the innovation managers can take advantage of the property that the design pattern *Change of Perspective* describes a mental principle as a question-and-answer process that can be implemented with given groupware technologies. With regard to the provided technology, innovation managers may have the choice of media (video, image or audio file) for presenting the stimuli, and how the participants will contribute their ideas (mind map, wiki or electronic brainstorming). As a result, an ideation workshop could benefit from the mental principles and groupware technologies.

6.2.3 Applications of the research results for research

Creativity research can use the introduced cognitive approach to analyse and compare idea generation techniques with regard to their active ingredients. Here, research can focus on the relationship between the given ingredients *Algorithm*, *Format* and *Setting* and the characteristic of resulting ideas. Research results can be applied to the research field of collaboration process design and innovation management to define new guidelines for the selection and use of an appropriate idea generation technique for a given innovation task or a specific group constellation. Furthermore, the understanding of the different ingredients can help researchers to analyse collaborative ideation in a virtual environment. Current idea generation techniques are designed for a face-to-face workshop and their technological implementation often remains unclear. By analysing the use of technological support with regard to the ingredients of existing idea generation techniques, researchers can identify and develop new groupware technologies that provide new functionalities to support the collaborative ideation in a virtual environment.

Besides given idea generation techniques, the introduced cognitive approach can be used to analyse and compare collaboration techniques, like decision making or project planning techniques with regard to their active ingredients. Here, researchers can use the ingredient approach to analyse how given collaboration techniques support the cognitive process of an individual, which represents the mental activities of an individual to generate data; and the social process of a group, which represents the interaction process between the group participants. Research results can be used to define new design patterns for the collaboration process design other than the application field of innovation management.

6.3 Discussion of the collaboration modelling language

The thesis analyses the feasibility of a new modelling approach that formalises a collaboration process into a machine-readable process description. The research objective is to support the appropriate use of a groupware technology for collaboration in a virtual environment. Here, the thesis assumes that a groupware technology can make use of the underlying process logic of the collaboration workflow to configure tools and functionalities of the technology automatically. The thesis analyses given models for process description and proposes that a modelling language for collaboration needs to describe different pieces of process information:

Process Activity — *The order and type of the activities of a participant with a defined role in a collaborative process.*

Process Data — *The type and value of the data elements that will be used or developed by a specific collaborative activity.*

Process Event — *The influence of events on the activities of the collaborative process.*

The given design approach of Collaboration Engineering represents an interesting approach for designing a collaboration process model. Here, the concept of a thinkLet provides abstract rules to describe the activities of the participants during collaboration. According to process activities, the thesis claims that the quality of facilitation is a key issue for collaboration success. However, some abstract rules of given thinkLets leave open the question, which facilitation instructions should be used to achieve the intended actions. To compensate this weakness, the thesis proposes that a process model for collaboration needs to include a specification of the facilitation instructions. This would support practitioners without facilitator experience in executing a collaborative process in a more efficient way. As a result, the thesis introduces the concept of a thinXel as a new design approach for a reusable instruction element that represents an atomic activity of a participant. These atomic activities can be categorised into:

Context-oriented thinXels — *which represent instruction elements with the intention to create a working environment for the collaboration process.*

Data-oriented thinXels — *which represents instruction elements with the intention to change the existing dataset of the group process.*

The thesis analyses the use of atomic activities to define the workflow of a collaboration process. Furthermore, the thesis focuses on the effect of thinXel on the outcome of a collaborative ideation process using technological support. The research results provide some indication that atomic instruction elements keep the participants more focused on the intended collaboration process as by providing information about different activities in a single instruction element.

The thesis introduces a modelling language for collaboration that uses the concepts of thinkLet and thinXel. As a language independent approach, the modelling language uses a graphical notation to increase the usability of a collaboration process model during process design. A semantical notation is used as a machine-readable process description that describes the collaboration workflow for a groupware technology. Here, the Extensible Markup Language is used as an interchange format to describe the graphical elements of the collaboration modelling language in a machine-readable format. The resulting collaboration process model can be describe in a logical and physical design:

A logical process model	*represents a template of a collaboration process that contains a general description of group activities for a common collaborative task.*
A physical process model	*represents a specific collaborative process that contains detailed descriptions of collaborative activities for a specific task and group constellation.*

A knowledge transfer approach is introduced to support the design of a physical process model by adapting a logical process model for a certain context and group constellation. This knowledge approach defines rules for descriptive and instructional writing and provides guidelines for the adaption of a logical process model.

6.3.1 Limitations of the research results

A number of limitations exist for the research results. The graphical and semantical notation of the collaboration modelling language represents one possible way to describe a collaboration process model. Currently the given modelling language approach is being used in different student projects. Further research is needed to analyse the possible application of the modelling language for collaboration process design in organisations. In this context, the thesis shows first indications that a knowledge transfer approach can be used to transfer tacit knowledge and skills for the adaptation and use of a collaboration process model. However, the research results show some weaknesses in the use of rules to support the configuration of a collaboration process model. As a result, more expert interviews and user studies are needed to evaluate and refine the given concept and rules of the knowledge transfer approach.

6.3.2 Applications of the research results for industry

The approaches introduced can be used by organisations to support the design of collaboration in the innovation process. One application is the use of the graphical notation to support the identification and discussion of process requirements during the design phase of a collaboration process. In contrast to given approaches for process modelling like the Business Process Modelling Notation [White, 2004], Petri Nets [van der Aalst, 1998] and UML activity diagrams [Ambler, 2005], the introduced modelling language for collaboration provides a more detailed description of a collaboration process. Besides using graphical elements to represent patterns of collaboration, the graphical notation introduces a clear visual distinction between a process flow of an individual participant and a group of participants moving synchronously through a collaboration process. These properties are new in a process modelling language and allow an innovation manager to structure collaboration processes of the innovation process into well known patterns as well as to visualise concurrent processes of the participants in a simple form. Furthermore, the collaboration workflow is defined by the order and type of process activities, the data that is used or developed and the influence of events on the process activities. During the design phase, an innovation manager can use this detailed process information to detect deadlocks in the activity and data workflow early on, which could support the validation of a collaboration process model.

Another application is given for the semantical notation to document and share collaboration process models. Here, organisations can use the Extensible Markup Language to describe a collaboration process in a machine-readable format. In contrast to given semantical approaches like the XML Process Definition Language [WMC, 2008], the introduced modelling language for collaboration provides tacit knowledge and skills for the adaptation and use of a collaboration model. This is due to the fact that the quality of facilitation is a key issue for the success of collaboration processes like ideation, which use facilitation to guide the generation of multifaceted ideas. As a result, the semantical notation of a collaboration activity uses instruction elements to provide information on how to define background information and instructions for different contexts and group constellations. This property is new in semantical process model and can support practitioners without facilitator experience in adapting and using a collaborative process model in a more efficient way.

6.3.3 Applications of the research results for research

Similar to the applications for industry, collaboration researchers can use the introduced approaches of a collaboration modelling language to design, document and share collaboration process models for different application fields. A further application is given for the concept of a thinXel that can be used to analyse the influence of facilitation instructions on a collaboration process. Collaboration research indicates a positive effect of facilitation on the process satisfaction, meeting effectiveness, group cohesiveness and usability of groupware technologies [Clawson et al., 1993, Niederman et al., 1993, den Hengst et al., 2007, Wong and Aiken, 2003]. However, little is known about the effects of style and complexity of a facilitation instruction on the performance of a collaboration process. The thesis assumes that the concept of thinXels can be used to define a shared knowledge base for research to analyse these effects. Here, a thinXel defines an atomic instruction element that categorises and defines the relationship between a facilitation instruction and an intended activity of a participant in a collaboration process. Researchers can use a set of thinXels as reference points to describe the variation of facilitation instructions analysed and further to compare the effect of this variation to a given set of thinXels. For example, the complexity of a facilitation instruction can be defined by the number of instruction elements that will be provided at the same time.

A possible example application of this approach is the analysis of the influence of stimuli on an ideation process. Most publications on creativity (like [Lynch et al., 2009, Hender et al., 2002, Santanen et al., 2000, Gallupe et al., 1992]) provide no detailed information about the facilitation instructions that were used during an experiment. As a result, the possible effect of style or complexity of facilitation instructions used on the experiment results is not described, which makes it difficult to compare the results of different experiments. To compensate this weakness, researchers can make use of the concept of a thinXel to explicitly and precisely describe an experiment as a scientific protocol that uses instruction elements to define the facilitation instructions of an experiment. The resulting scientific protocol can be used to repeat or compare existing experiments. Furthermore, by changing the stimuli used in an existing experiment, researchers can use the scientific protocol to analyse the influence of stimuli characteristics on the ideation process. Research results can be used to define guidelines for the selection and use of external stimuli to guide the cognitive process of a group of participants.

6.4 Discussion of the adaptable groupware technology

The thesis analyses the feasibility of designing an adaptable groupware technology that makes use of the introduced approach of a collaboration modelling language to improve collaboration in global virtual groups. The thesis assumes that the underlying process logic of a collaboration process model can be used to monitor and guide a virtual group automatically through a collaboration process. Here, similar to a workflow management system, a groupware technology can provide functionalities to support the flexible adaptation of the technology for different tasks and group characteristics.

The thesis introduces a conceptual design of an adaptable groupware technology that based on the architecture of a workflow management system and provides different modules for the use of the introduced approach of a collaboration modelling language. These modules are:

ElementLib *The module provides data structures and functions to describe, load and save a collaborative process model.*

ProcessLib *The module provides data structures and functions to manage the workflow of a collaboration process model.*

DataLib *The module contains data structures and functions to provide, analyse and save data that is used or generated during a collaboration process.*

Based on the conceptual model, a prototype of an adaptable groupware technology is developed as a server application that links a global virtual group via the internet. This prototype provides different components to load, adapt, execute and monitor a collaboration process that is described by the semantical notation of the collaboration modelling language.

A key component of the prototype is the *Participant Flow Algorithm*, an approach to compute the active position and the next step of a participant in a predefined collaboration process. This algorithm makes use of the underlying process logic of a collaboration process model and distinguishes between the workflow of an individual and a group of participants. Furthermore, the algorithm reflects the property of the collaboration modelling language to allow a switch between the individual and the group flow. Summarized, the *Participant Flow Algorithm* combines the following components:

Group Algorithm	*to compute the next process step for a group of participants based on the active element of the group in the collaboration process.*
Participant Algorithm	*to compute the next step for an individual based on the active element of the participant in the collaboration process.*
Synchronization Algorithm	*to monitor the state of the individual and group process and to switch between the participant and group algorithm.*

To support the flexible adaptation of a groupware technology for a predefined collaboration process, the thesis makes use of the property of the collaboration modelling language to define the collaboration workflow by a sequence of atomic activities, which are represented by the concept of thinXels. Here, the prototype provides a set of generic user interfaces, which represent common context and data-oriented thinXels. During the execution of a collaboration process, the prototype uses the information about the type and configuration of a thinXel element to select, provide and configure webpages that allow the participants to execute the intended activities of a collaboration workflow.

Besides the flexible adaptation of a groupware technology for a predefined collaboration process, the thesis develops different components to intervene directly in a collaboration process to handle negative group behaviours and support group performance in a collaboration process. Here, the prototype provides different modules that can be connected to the webpage of an active activity. These modules are independent of a collaboration process model and provide functionalities to support group communication, group coordination and group performance.

The thesis uses functional tests to evaluate the conceptual design in an formative process. Here, the prototype of the groupware technology is verified at different implementation stages against the predefined basic and specific requirements. The research results show first indications that the conceptual design can be used to develop adaptable groupware technologies that provide functionalities to support a virtual group during a collaborative ideation process.

6.4.1 Limitations of the research results

A number of limitations exist for the research results. The prototype represents one possible implementation of the conceptual design of an adaptable groupware technology. Currently, the prototype was used in some student projects to verify the feasibility of using an adaptable groupware technology to support a collaborative ideation process in a global virtual group. However, case studies in organisations are needed to analyse and compare the conceptual design against alternative design solutions. Furthermore, research is needed to analyse the application of an adaptable groupware technology for collaboration other than the ideation process. In this context, research needs to evaluate and refine the given set of generic user interfaces and modules with regard to their feasibility to support the intended collaboration activity of an individual as well as to support group communication, group coordination and group performance.

6.4.2 Practical applications of the research results for industry

The approaches introduced can be used by organisations to support collaboration in global virtual groups by using technological support. With regard to pre-development phase of the innovation process, the conceptual design can be used to develop an adaptable groupware technology that provides functionalities to support a virtual groups in using the technology to identify customer needs or generate ideas for new products and services of an organisation. In this context, organisations can use the introduced modelling language for collaboration to predefine the workflow of a collaborative ideation process by experts in collaboration process design. In contrast to given groupware technologies like a workflow management system [Georgakopoulos et al., 1995], the conceptual design uses a modelling language to capture and transfer knowledge about collaboration. Here, a collaboration process designer can use the modelling language to predefine the activation and configuration of user interfaces that allow the participants to execute the intended activities of a collaboration workflow. This property is new in a groupware technology and supports global virtual groups in using the technology in an appropriate way.

6.4.3 Applications of the research results for research

With regard to collaboration research, the conceptual design of an adaptable groupware technology can be used to analyse and improve technological support for collaboration. Here, researchers can focus on the relationship between the intended activities of a collaboration workflow and their implementation by a groupware technology. Research results can be applied to the research field of human computer interaction to define guidelines for the design of user interfaces that support less experienced users during collaboration. These guidelines could extend given pattern approaches for the design of groupware technologies [Schümmer and Lukosch, 2007]. For example, design patterns can provide guidelines for software developers on how to implement and support recurring activities of a collaboration workflow by generic user interfaces. In this context, design patterns can further make use of the introduced knowledge transfer approach to support the users of a groupware technology by transferring knowledge on how to define process parameters and facilitation instructions for the adaptation of a generic user interface.

Besides the design and adaptation of a collaboration process, collaboration researchers can use the conceptual design to analyse how groupware technology can be used to monitor and support group communication, group coordination and group performance during collaboration. Currently, the prototype provides different modules to monitor the collaboration process and to intervene directly in the process to handle negative group behaviours. These modules are implemented independently of the generic user interfaces and can be combined flexibly during the collaboration process. Researchers can use this property of the prototype to design and evaluate new approaches on how to affect possible group behaviours like Evaluation Apprehension or Social Loafing. Here, researchers can extend the given set of modules to analyse their possible effect on a collaboration process during different experiments. In this context, the collaboration modelling language can be used to describe the experiments as a scientific protocol, which allows researchers to repeat or compare the experiments results. Resulting knowledge can be used to define new guidelines on how groupware technology can support collaboration.

6.5 Future research

In conclusion, the thesis provides different contributions that can be used in future research to improve collaboration in global virtual groups in general and for the pre-development phase of an innovation process in particular. Here, the thesis sees three interesting directions for future research.

Future research on the design approach for collaborative ideation processes

The first area of research is to further improve the design of a predictable and suitable ideation process for the pre-development phase of the innovation process. Currently, the introduced design approach for collaborative ideation processes captures knowledge about the cognitive and collaborative process of a group during ideation. However, the given concepts of the design approach only capture knowledge of a small number of facilitation experts. The thesis assumes that organisations will need far more detailed guidelines to design predictable and suitable ideation processes, especially for global virtual groups which uses technological support.

As a result, future research will analyse the concepts *Change of Perspective*, *Generate thinkLet* and *Modifier* in more detail to evaluate and refine the given guidelines of the design approach. For example, the relationship between stimuli, mental principles and resulting ideas will be analysed to understand how to define and select stimuli for the design patterns *Change of Perspective*. In this context, given innovation processes will be analysed to define guidelines for the design of a collaborative ideation process in relation to a given innovation goal of an organisation. Furthermore, future research will use the prototype of an adaptable groupware technology to develop and analyse new modules to support group communication, group coordination and group performance during ideation. Resulting knowledge will be used to define rules on how the functionalities of a groupware technology should be used to improve the ideation process.

Future research on the collaboration modelling language

The second area of research is the use of the collaboration modelling language to capture and share knowledge about collaboration. Besides using the introduced modelling approach to design a collaboration process in a graphical and semantical notation, the thesis sees further potential in its use to document and analyse a collaboration process. The thesis assumes that information about the context and execution of a collaboration process can help researchers to get a deeper and better understanding of collaboration. Resulting knowledge can be used to develop new guidelines for the design and execution of a collaboration process. However, the given modelling approach does not capture information about the context of a collaboration process. To compensate this weakness, the thesis proposes the redesign of the collaboration modelling language.

Currently, an ontology approach is analysed to capture and share knowledge about collaboration [Knoll et al., 2012, 2010]. By definition, an ontology is an formal specification of the terms and relations between them in a domain of interest [Gruber, 1993]. It defines a common vocabulary and a common understanding of information in a domain, which allows the sharing of information between people and software agents. The thesis uses the collaboration modelling language to build a common vocabulary for collaboration. The resulting Collaboration Ontology [CollaborationOntology, 2010] represents a new approach to capture, share and re-use knowledge about collaboration.

Future research will analyse the use of the presented ontology for information retrieval and machine learning approaches. Here, data collected from previous collaboration processes, like innovation processes will be used to learn relations between a collaboration process and the needed resources and participants. Based on the relations learned, new guidelines for the design of a collaborative ideation process could be developed.

Future research on the conceptual design of an adaptable groupware technology

A third area of research is the use of the conceptual design of an adaptable groupware technology to support collaboration in dynamic environments. The thesis introduces a conceptual design that makes use of a the underlying process logic of a predefined collaboration workflow to monitor and guide a virtual group automatically through a collaboration process. This approach works well in static environments, where the resources and participants of a collaboration process are known before hand. However, the given conceptual design can not support collaboration in dynamic environment like a maintenance process, which can be characterised by varying goals and resources as well as changing participants. Here a new conceptual design of a groupware technology is needed that adapts and designs the collaboration workflow during runtime.

As a result, future research will analyse the feasibility to design a groupware technology that supports collaboration in dynamic environments. Here, new approaches will be analysed to design and adapt a collaboration process at runtime. For example, future research will focus on the use of data streams as a possible approach to define and analyse the context of a collaboration process. Furthermore, a rule concept will be developed that allows a collaboration process designer to define rules to detect the need for adaptation and to change the collaboration workflow.


appendix
design pattern
change of perspective
rules for composition
generate thinklet
rules for descriptive writing
rules for instructional writing
social modifier
direct jumping
parallel split
dumping
random jumping
process modifier
simple merge
comparative
onepage
commenting
branchbuilder
pumping
activity loop
freebrainstorm
anomymity
leafhopper
identification

Appendix A

Concepts of the design approach for collaborative ideation processes

A.1 Design pattern: Changes of Perspective

Change of Perspective Directed Jumping

Intent: Activates knowledge by jumping to similar situations and uses it to generate new ideas:

- Participants activate knowledge of the creative task.
- Participants activate knowledge of analogous situations.
- Participants transfer knowledge of analogous situations to the creative task.

Context: Choose this change of perspective:

- to generate ideas for technical and incremental innovations like small product or service improvements.
- to support the generation of ideas for a creative task that others might have solved before.

Solution Input:

- a creative task

Output:

- a set of possible solutions for the creative task

Setup:

1. Ensure that participants understand the creative task.
2. Ensure that participants understand the change of perspective.

Process:

1. Let participants collect characteristic attributes of the creative task.
2. Let participants collect analogous situations with the same characteristic attributes.
3. Let participants collect similar creative tasks for the given analogous situations.
4. Let participants collect solutions how the analogous creative tasks has been or might be solved.
5. Let participants collect ideas how this solution can be applied to the original task.

Change of Perspective — Random Jumping

Intent: Activates knowledge by jumping to random situations and uses it to generate new ideas:

- Participants activate knowledge of the creative task.
- Participants activate knowledge of random situations.
- Participants transfer knowledge of random situations to the creative task.

Context: Choose this change of perspective:

- to generate ideas for radical, market, technical and incremental innovations.
- to support the generation of ideas for a creative task where no solution approach exists.

Solution

Input:

- a creative task

Output:

- a set of possible solutions for the creative task

Setup:

1. Ensure that participants understand the creative task.
2. Ensure that participants understand the change of perspective.

Process:

1. Let participants collect random situations.
2. Let participants collect characteristic attributes of the random situations.
3. Let participants collect ideas how the characteristic attributes can be used to solve the creative task.

Change of Perspective **Dumping**

Intent: Activates knowledge by challenging assumptions of the creative task and uses it to generate new ideas:

- Participants activate knowledge of the creative task.
- Participants challenge knowledge of the creative task.
- Participants activate new knowledge by thinking of consequences for the creative task.

Context: Choose this change of perspective:

- to generate ideas for radical innovations.
- to support the generation of ideas for a creative task where policies or assumptions can be challenged.

Solution

Input:

- a creative task

Output:

- a set of possible solutions for the creative task

Setup:

1. Ensure that participants understand the creative task.
2. Ensure that participants understand the change of perspective.

Process:

1. Let participants collect characteristic attributes of the creative task.
2. Let participants challenge the characteristic attributes.
3. Let participants collect consequences that results from the new assumption.
4. Let participants collect ideas how the consequences can be used to solve the creative task.

Change of Perspective: Pumping

Intent: Activates knowledge by focusing on specific concepts of the creative task and uses it to generate new ideas:

- Participants activate knowledge of the creative task.
- Participants activate new knowledge by focusing on specific concepts of the creative task.

Context: Choose this change of perspective:

- to generate ideas for market, technical and incremental innovations.
- to support the generation of ideas for a creative task where abstract solution approaches are available.

Solution Input:

- a creative task

Output:

- a set of possible solutions for the creative task

Setup:

1. Ensure that participants understand the creative task.
2. Ensure that participants understand the change of perspective.

Process:

1. Let participants select aspects of the creative task to focus on.
2. Let participants focus on aspects of the creative task.
3. Let participants collect ideas how the creative task may be solved.

A.2 Design pattern: Generate thinkLet

ThinkLet Name: OnePage

Intent: Generate a set of contributions and share them by using a public storage place:

- all participants generate contributions in parallel on one topic.
- all participants add contributions to a public storage space.
- all participants share contributions by using the same public storage place.

Context: Choose this thinkLet:

- to generate less than 80 contributions on one topic.
- when 5 or fewer participants will generate contributions together.
- when 6 or more participants will generate contributions together for fewer than 10 minutes.
- to support back-channel communication among distributed participants.

Do not choose this thinkLet:

- to generate more than 80 contributions on one topic.
- to generate contributions on more than one topic at a time.
- when 6 or more participants will generate contributions together until they run out of ideas.

Solution

Input:

- a topic
- a defined contribution specification

Output:

- a set of contributions in response to one topic and a defined contribution specification

Setup:

1. Ensure that the participants understand the collaborative process.
2. Ensure that participants understand the topic.
3. Ensure that participants understand the contribution specification.

Process:

1. Provide a single public storage space for all contributions.
2. Let participants add in parallel any number of contributions to the shared public storage space.
3. Let participants add only contributions that match the topic.
4. Let participants add only contributions that match the contribution specification.
5. Let participants read the contributions of others for inspiration.

ThinkLet Name: FreeBrainstorm

Intent: Generate a set of contributions and share them by randomly swapping private storage places:

- each participant generates one contribution in parallel on a common topic or one topic of a topic list.
- each participant adds one contribution to a private storage space.
- all participants share contributions by randomly swapping private storage places.

Context: Choose this thinkLet:

- when 6 or more participants will generate contributions together until they run out of ideas.
- to make participants with narrow, parochial views quickly to see the big picture.
- to make the group to diverge quickly from comfortable patterns of thinking, to push them farther and farther afield in search of new ideas.

Do not choose this thinkLet:

- if you are pushing for depth rather than breadth in the resulting contributions.
- when 5 or fewer participants will generate contributions together until they run out of ideas.

Solution: Input:

- a topic / topic list
- a defined contribution specification

Output:

- a set of contributions in response to a topic / topic list and a defined contribution specification

Setup:

1. Ensure that the participants understand the collaborative process.
2. Ensure that participants understand the topic / topic list
3. Ensure that participants understand the contribution specification.

Process:

1. Provide for each participant a private storage place for contributions of a common topic or one topic of a topic list.
2. Let participants add in parallel one contribution to the private storage place they received.
3. Let participants add only contributions that match the topic of the private storage place they are working on.
4. Let participants add only contributions that match the contribution specification.
5. Let participants randomly swap private storage places.
6. Let participants read the contributions of others for inspiration.
7. (Repeat starting with step 2)

ThinkLet Name: LeafHopper

Intent: Generate a set of contributions and share them by swapping private storage places in response to a participant choice:

- each participant generates contributions in parallel on one topic of a topic list.
- each participant adds contributions to a private storage space.
- all participants share contributions by swapping private storage places.

Context: Choose this thinkLet:

- to generate contributions on several topics at once.
- when participants have different levels of interest or expertise in the different topics.
- when it is not important to assure that every participant contributes to every topic.

Do not choose this thinkLet:

- when it is important to assure that the participants address topics in a specific order.
- when it is important to assure that every participant contributes to every topic.

Solution: Input:

- a topic list
- a defined contribution specification

Output:

- a set of contributions in response to a topic list and a defined contribution specification

Setup:

1. Ensure that the participants understand the collaborative process.
2. Ensure that participants understand the topic list.
3. Ensure that participants understand the contribution specification.

Process:

1. Provide for each topic of the topic list a private storage place for contributions.
2. Let participants choose the private storage place to which they will contribute.
3. Let participants add in parallel any number of contributions to the private storage place they chose.
4. Let participants add only contributions that match the topic of the private storage place they are working on.
5. Let participants add only contributions that match the contribution specification.
6. Let participants change private storage place as interest and inspiration dictate.
7. Let participants read the contributions of others for inspiration.
8. (Repeat starting with step 3)

thinkLet BranchBuilder

Intent: Generate a hierarchically organized set of contributions and share them by swapping private storage places in response to a participant choice:

- each participant generates contributions or subcontributions in parallel on one topic of a topic list.
- each participant adds contributions and subcontributions hierarchically to a private storage space.
- all participants share contributions and subcontributions by swapping private storage places.

Context: Choose this thinkLet:

- to capture and organize subaspects of one or more well-understood issues.
- to build a hierarchical outline describing the anatomy of an issue or topic.

Do not choose this thinkLet:

- with poorly-understood, complex, ill structured issues.

Solution: Input:

- a topic list
- a defined contribution specification

Output:

- a set of contributions in response to a topic list and a defined contribution specification

Setup:

1. Ensure that the participants understand the collaborative process.
2. Ensure that participants understand the topic list.
3. Ensure that participants understand the contribution specification.

Process:

1. Provide for each topic of the topic list a private storage place for contributions.
2. Let participants choose the private storage place to which they will contribute.
3. Let participants add in parallel any number of contributions or subcontributions to the private storage place they chose.
4. Let participants add only contributions that match the topic of the private storage place they are working on.
5. Let participants add only subcontributions that match the selected contribution of the private storage place they are working on.
6. Let participants add only contributions that match the contribution specification.
7. Let participants change the private storage place as interest and inspiration dictate.
8. Let participants read the contributions and subcontributions of others for inspiration.
9. (Repeat starting with step 3)

A.3 Design pattern: Social Modifiers

Modifier Anonymity

Intent Generate an environment that reduce the fear of negative evaluation which may cause participants to withhold controversial contributions during the collaboration process.

Context: Choose this Social Modifier:

- to reduce Evaluation Apprehension: the fear of participants to be criticized for a contribution.
- when controversial contributions are needed.
- when the group shows a trend to criticise each other's contributions.

Do not choose this Social Modifier:

- when the group shows a tendency for Social Loafing: participants expends less effort because they believe their contributions to be dispensable and not needed for group success.

Solution:

- in a face-to-face environment, a higher degree of anonymity can be achieved with pen and paper or assistants who digitize the contributions before they are shared by the group.
- in a virtual environment, groupware technology can be configured to hide the authorship of a contribution.

Modifier Identification

Intent Generate an environment that enable the identification of different perspectives from different parties during the collaboration process.

Context: Choose this Social Modifier:

- to reduce Social Loafing: participants expends less effort because they believe their contributions to be dispensable and not needed for group success.
- when ownership of ideas is important to stimulate sharing of ideas.

Do not choose this Social Modifier:

- when the group shows a tendency for Evaluation Apprehension: the fear of participants to be criticized for a contribution.

Solution:

- in a face-to-face environment, a higher degree of identification can be achieved by a verbal communication or by tagging a contribution with the authors name.
- in a virtual environment, groupware technology can be configured to show the authorship of a contribution.

Modifier Nominal

Intent Generate an environment where participants first follow a single train of thought without interruption before they share their contributions

Context: Choose this Social Modifier:

- to reduce Distraction: participants are disrupt from concentrating on the task by the contributions of other participants.
- to stimulate depth of contributions rather than breadth.

Do not choose this Social Modifier:

- to stimulate breadth of contributions rather than depth.

Solution:

- in a face-to-face environment, participants first contribute their ideas to a private list for a predetermined period of time. Once this time period has elapsed, the participants ideas are pooled on a single, shared list.
- in a virtual environment, groupware technology can be configured to display other contributions only on demand.

Modifier Dealing

Intent Generate an environment where specific participants work on specific topics to ensure specific experts address specific topics or improve time efficiency.

Context: Choose this Social Modifier:

- to stimulate experts to address specific topics.
- to improve time efficiency by splitting the full scope of the task over random sub-groups.

Do not choose this Social Modifier:

- when each participant needs to contribute to all topics.

Solution:

- in a face-to-face environment, the areas of contribution for each participant can base upon the expertise of each participant. Participants are only allowed to contribute to their specific areas.
- in a virtual environment, groupware technology can be configured to assign specific categories to specific participants.

Modifier Osborn

Intent Generate an environment where participants generate a large number of contributions which are not subject to any restrictions.

Context: Choose this Social Modifier:

- to reduce Evaluation Apprehension: the fear of participants to be criticized for a contribution.
- to generate contributions like raw ideas, which are not subject to any restrictions.
- to support the individual to provide any kind of contributions.

Do not choose this Social Modifier:

- to generate contributions which are subject to restrictions.

Solution:

- during the collaboration process, the participants should follow the following rules: 1) focus on quantity, 2) to withhold criticism, 3) welcome unusual contributions, and 4) to combine and improve contributions.

A.4 Design pattern: Process Modifier

Modifier	Limited Input
Intent	Generate an environment to improve time efficiency by limiting the number of contributions of each participant.

Context: Choose this Process Modifier:

- to improve time efficiency.
- to generate a small number of contributions which are subject to restrictions.

Do not choose this Process Modifier:

- to generate a large number of contributions, which are not subject to any restrictions.

Solution:

- during the collaboration process, the participants are instructed to generate a defined number of contributions, which fulfill a defined set of criteria.

Modifier	Comparative
Intent	Generate an environment where the quality of contributions will be increased over the time.

Context: Choose this Process Modifier:

- to improve time efficiency.
- to stimulate depth of contributions rather than breadth.

Do not choose this Process Modifier:

- to stimulate breadth of contributions rather than depth.

Solution:

- during the collaboration process, the participants are instructed to generate only contributions, which are better along some criteria than the contributions already collected.

Modifier Commenting

Intent Generate an environment to elaborate on or evaluate contributions.

Context: Choose this Process Modifier:

- to surface various assumptions that are associated with specific contributions
- to increase understanding between the participants for specific contributions
- to stimulate depth of contributions rather than breadth.

Do not choose this Process Modifier:

- to stimulate breadth of contributions rather than depth.

Solution:

- during the collaboration process, the participants are instructed to generate only contributions as a response to a previous contributions. These contributions can be comments and assumptions on a contribution, which helps to elaborate on or evaluate the contribution.

Modifier: Qualitative Evaluation

Intent: Generate an environment to elaborate on or evaluate contributions according to specific criteria.

Context: Choose this Process Modifier:

- to surface various assumptions that are associated with specific contributions
- to increase understanding between the participants for specific contributions
- to stimulate depth of contributions rather than breadth.

Do not choose this Process Modifier:

- to stimulate breadth of contributions rather than depth.

Solution:

- during the collaboration process, the participants are instructed to generate only contributions as a response to a previous contributions using a set of specific criteria. For example, these contributions can be comments and assumptions according to specific criterion about some specification of the contributions.

Appendix B

Concepts of the graphical notation of the collaboration modelling language

B.1 Rules for the composition of the modelling constructs

Pattern: Activity Sequence

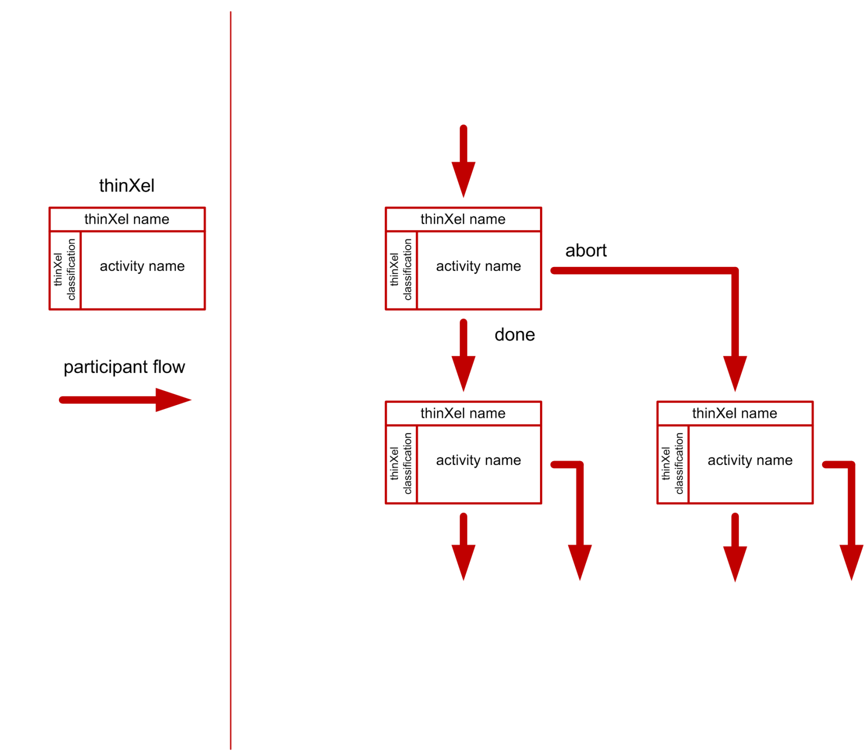
Description: An activity in a workflow process is enabled after the execution or abortion of another activity in the same workflow process.

Examples:

- Activity *create: contribution* is executed after the execution of the activity *read: process task*.
- An idea will be assessed after the selection of an idea from a list.
- Activity *create: question* is executed after the execution of the activity *read: process information*.
- Activity *select: criterion* is executed after the abortion of the activity *create: contribution in relation to a given criterion*.

Implementation: The activity sequence pattern is used to model consecutive steps of atomic activities in a workflow process. The implementation involves linking two *thinXels* with a *participant flow* arrow.

Graphical representation:



Pattern: Collaboration Pattern Sequence

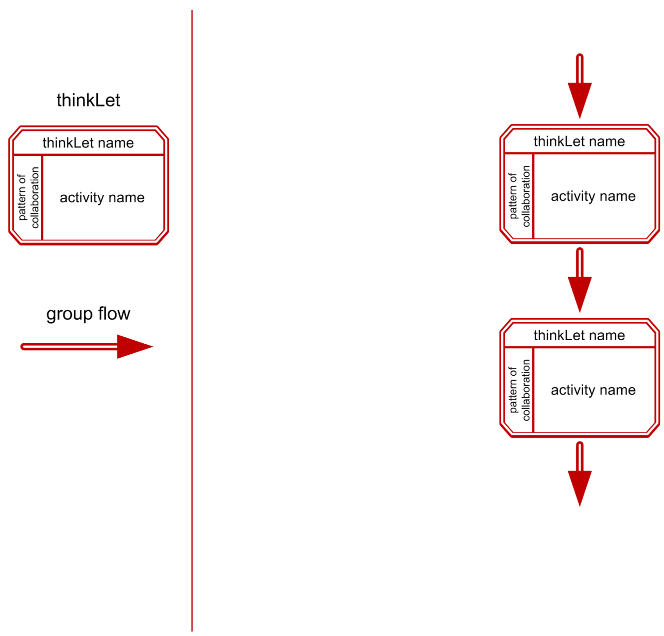
Description: A collaboration pattern in a workflow process is enabled after the execution of another collaboration pattern in the same workflow process.

Examples:

- Collaboration pattern *generate: elaborate* is executed after the execution of the collaboration pattern *generate: create*.
- The essence of the concepts will be captured after the collection of known concepts from individual group members.
- ThinkLet *RichRelations* is executed after the execution of the thinkLet *FreeBrainstorm*.

Implementation: The collaboration pattern sequence is used to model consecutive steps of collaboration patterns in a workflow process. The implementation involves linking two *ThinkLets* with a *Group Flow* arrow.

Graphical representation:



Pattern: Parallel Split

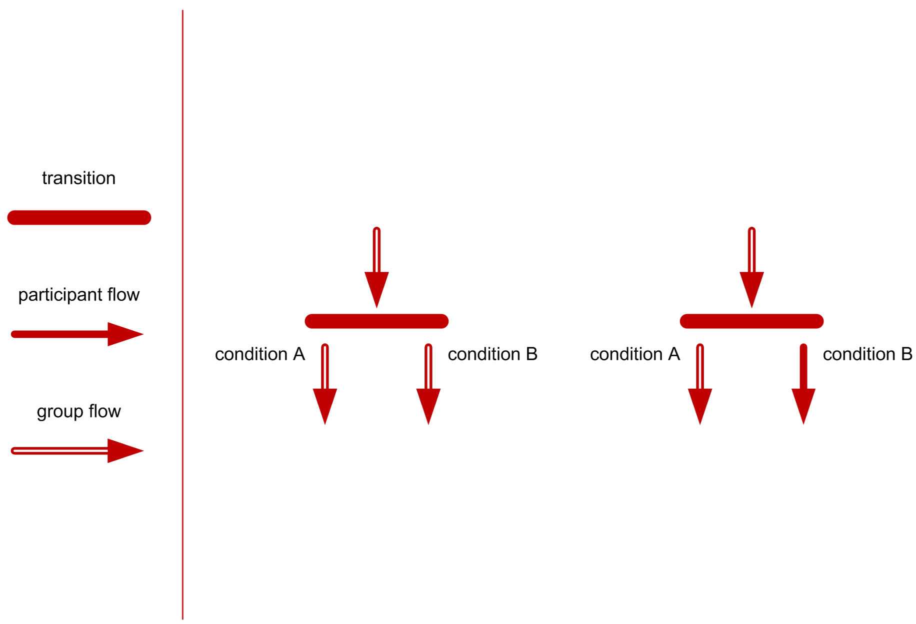
Description: A point in the workflow process where a group process splits into multiple processes which can be executed in parallel by a group or an individual.

Examples:

- The execution of the collaboration pattern *generate: create* enables the use of different thinkLets in relation to the group characteristics.
- After the registration the process claims two parallel processes: one for selecting a contribution (by a moderator) and one for discussing a selected contribution (by the group).
- After the registration the process claims two parallel processes: one for generating ideas using prompts and one for generating ideas using no prompts.

Implementation: The parallel split pattern is used to split a *group flow* into multiple *group flows* or *participant flows* under a set of conditions by using the element *transition*.

Graphical representation:



Pattern: Synchronization

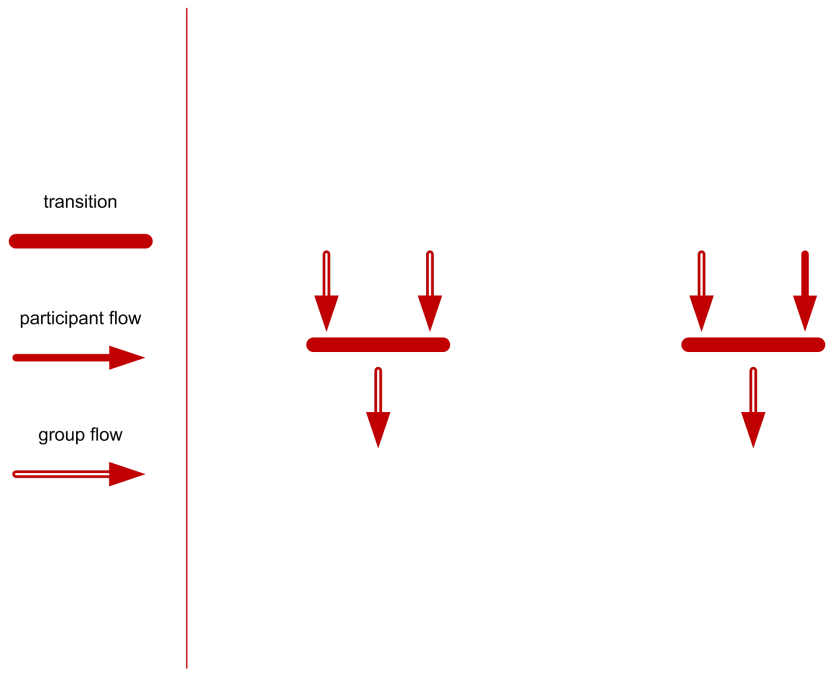
Description: A point in the workflow process where multiple parallel groups or individuals converge into one group.

Example:

- Collaboration pattern *reduce: select* is enabled after the completion of both thinkLets *FreeBrainstorm* and *LeafHopper*, which were executed in parallel by two different groups.

Implementation: The synchronization pattern is used to converge multiple *group flows* or *participant flows* into one *group flow* by using the element *transition*.

Graphical representation:



Pattern: Exclusive Choice

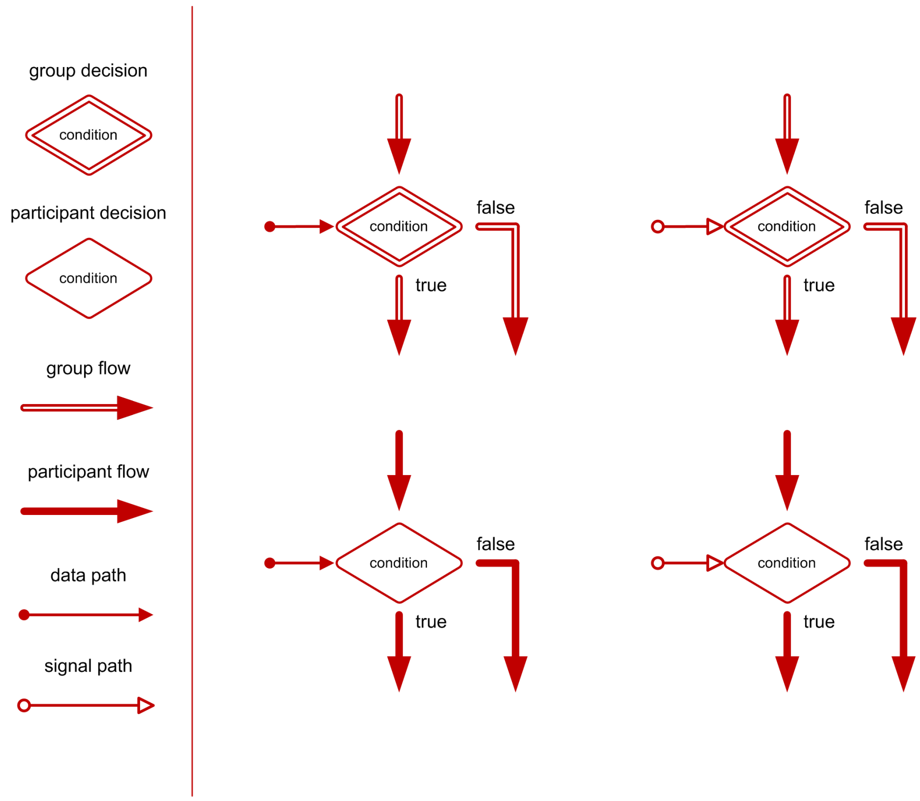
Description: A point in the workflow process where, based on a workflow control data or signal, one of several process paths is chosen.

Examples:

- Activity *select: next step* is followed by either the activity *create: contribution* or the activity *select: category*.
- Based on the generated ideas, the group will execute the collaboration pattern *generate: create* or the collaboration pattern *reduce: abstract*.

Implementation: The exclusive choice pattern is used to change the *group flow* or *participant flow* in relation to a workflow control data or signal. The choice is implemented by the binary element *decision* that is connected with a *data path* or *signal path*.

Graphical representation:



Pattern: Simple Merge

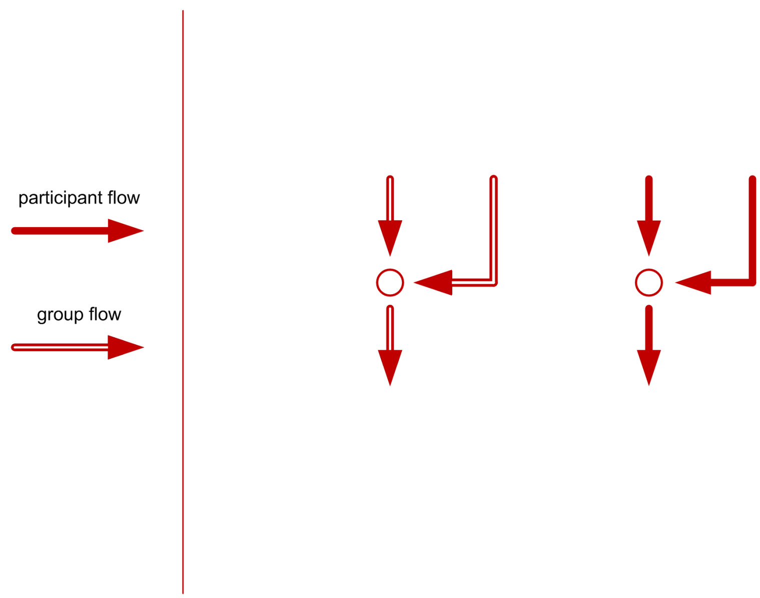
Description: A point in the workflow process where two or more alternative workflow paths come together without synchronization.

Examples:

- Activity *grow: contribution* is enabled after either the activity *create: contribution* or the activity *select: contribution* is executed.
- After the collaboration pattern *generate: create* or the collaboration pattern *generate: gather* is executed the contributions will be summarized.

Implementation: The simple merge pattern is used to converge multiple workflow paths into one workflow path. The pattern is implemented by the elements *group flow* and *participant flow*.

Graphical representation:



Pattern: Activity Loop

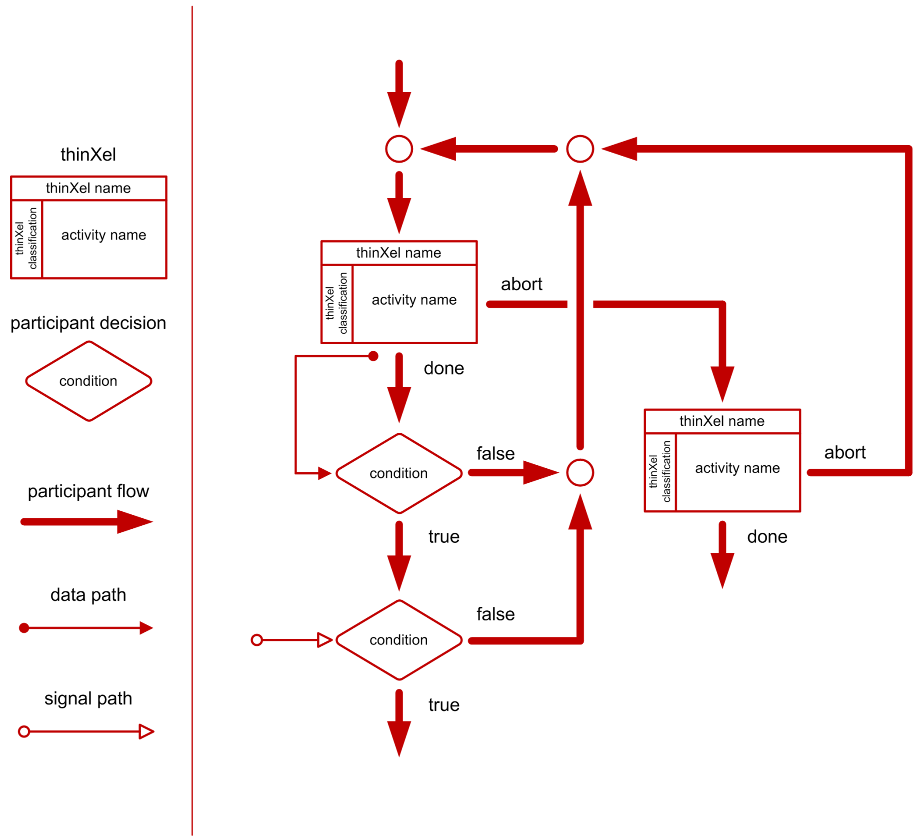
Description: A point in the workflow process where one or more activities can be executed repeatedly.

Examples:

- Activities *select: contribution* and *grow: contribution* are executed repeatedly until each contribution is expanded.
- Activity *select: criterion* is executed again after the abortion of the activity *create: comment*.

Implementation: The activity loop pattern is used to model consecutive steps of atomic activities that can be done repeatedly. An activity loop can be implemented by using patterns like *Exclusive Choice* or *Simple Merge* in combination with the elements *thinXel*, *participant decision*, *participant flow*, *data path* and *signal path*.

Graphical representation:



Pattern: Collaboration Pattern Loop

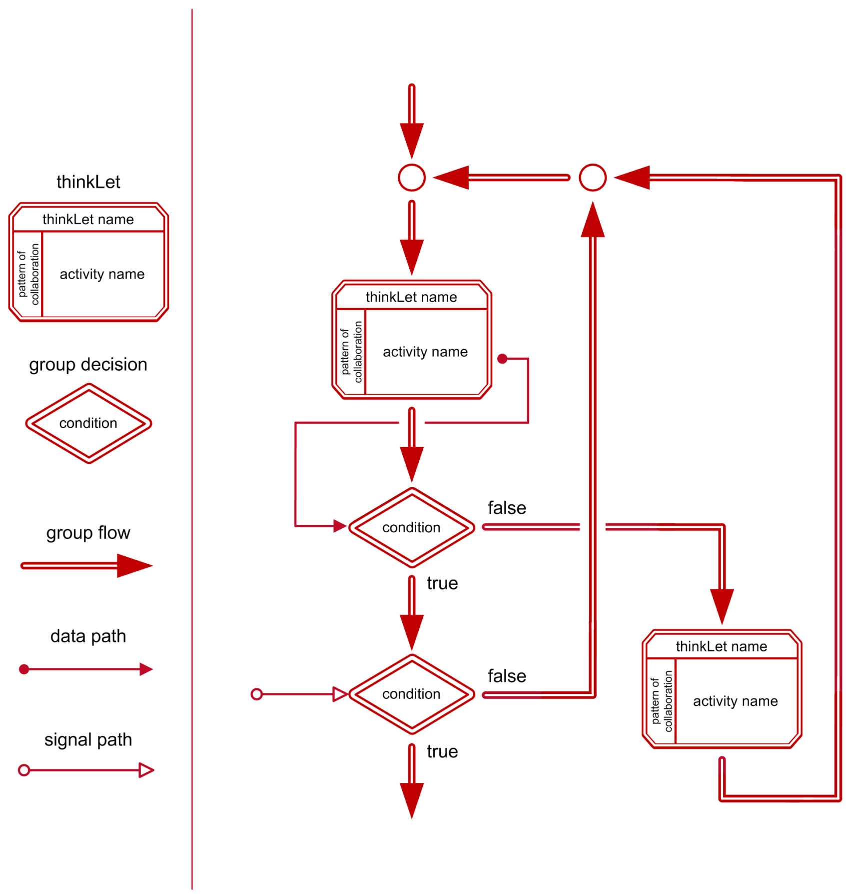
Description: A point in the workflow process where one or more collaboration pattern can be executed repeatedly.

Example:

- ThinkLets *FreeBrainstorm* and *LeafHopper* are executed repeatedly until a pre-defined number of contributions is generated.

Implementation: The collaboration pattern loop is used to model consecutive steps of collaboration that can be done repeatedly. A collaboration pattern loop can be implemented by using the pattern *Exclusive Choice* and *Simple Merge* in combination with the elements *thinkLet*, *group decision*, *group flow*, *data path* and *signal path*.

Graphical representation:



Pattern: Cancel Activity Sequence

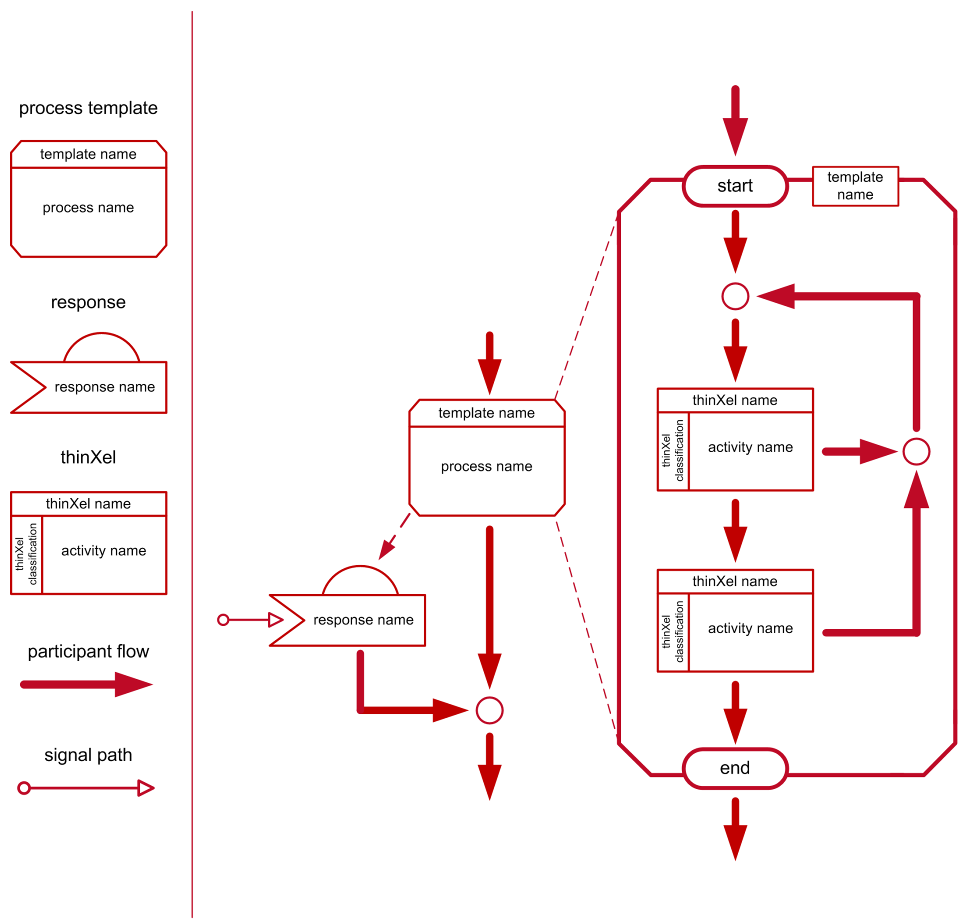
Description: A point in the workflow process where, based on a workflow control signal, an enabled activity sequence is aborted.

Examples:

- Process template *generate ideas* is aborted because the time limit is exceeded.
- Facilitator aborts the parallel workflow processes of the participants to synchronize them for the next collaboration pattern.

Implementation: The cancel activity sequence pattern is used to disable an activity sequence and change the Participant Flow in relation to a workflow control signal. The pattern can be implemented by using the element *process template* that represents an activity sequence and the element *response*.

Graphical representation:



Pattern: Cancel Collaboration Pattern Sequence

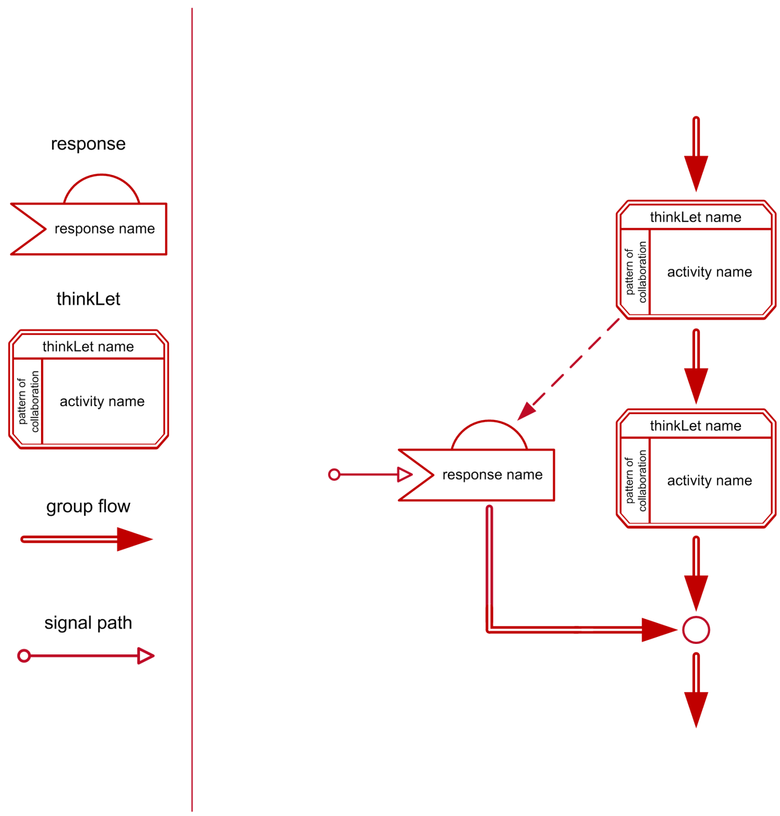
Description: A point in the workflow process where, based on a workflow control signal, an enabled collaboration pattern sequence is aborted.

Example:

- ThinkLet *FreeBrainstorm* is aborted by the facilitator because a predefined number of contributions has been generated.

Implementation: The cancel collaboration pattern sequence pattern is used to interrupt a collaboration pattern and change the group flow in relation to a workflow control signal. The pattern can be implemented by using the element *thinkLet* and the element *response*.

Graphical representation:



Pattern: Working with Local Data

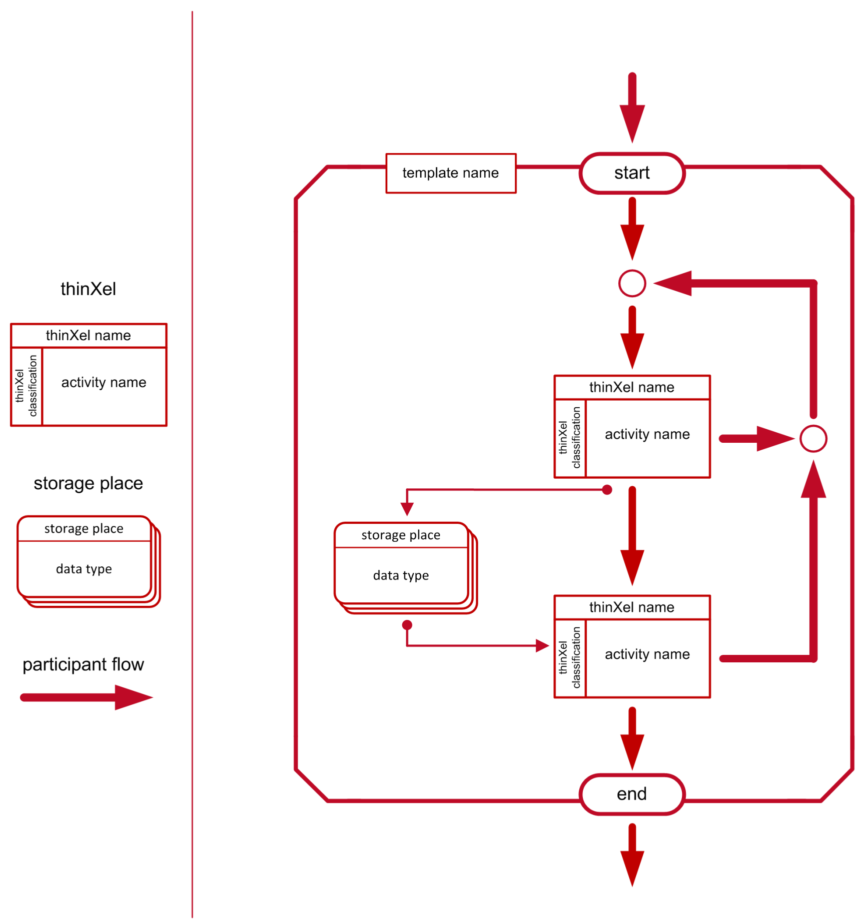
Description: A data element in the workflow process that is accessible for an individual in a local environment to store data that should not be shared with other participants.

Example:

- Process template *generate comments* provides a storage place *private comments* to store comments of an individual that should not be shared with the group.

Implementation: The working with local data is used in a local environment. The pattern can be implemented by using the element *storage place* inside the element *process template*.

Graphical representation:



Pattern: Working with Global Data

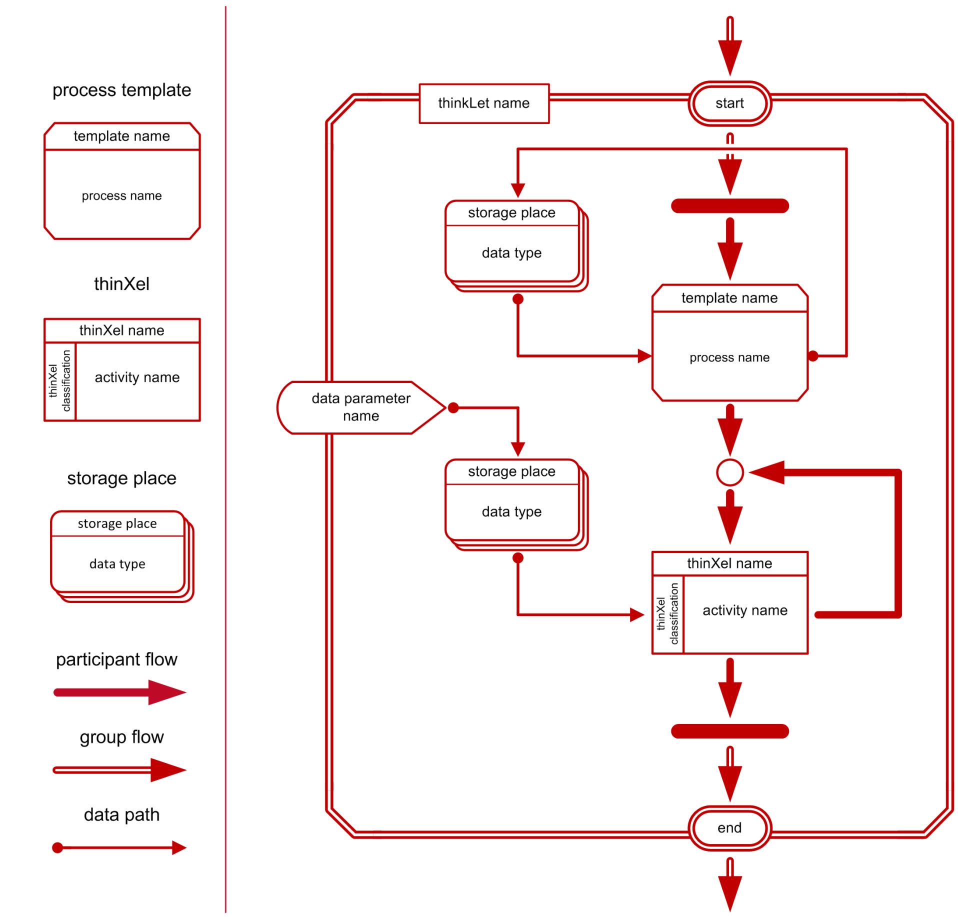
Description: A data element in the workflow process that is accessible for a group in a global environment to store data that should be shared with other participants.

Example:

- Process template *generate ideas* is connected with a storage place *ideas* to store and share ideas of different participants.
- ThinkLet *FreeBrainstorm* uses a storage place *creative task* to provide the creative task to all participants of the group.

Implementation: The working with global data is used in a global environment. The pattern can be implemented by using the element *storage place* outside the element *process template* or inside the element *thinkLet*.

Graphical representation:



Appendix C

Concepts of the semantical notation of the collaboration modelling language

C.1 Rules for descriptive and instructional writing

Rules for Descriptive Writing

The Basic Philosophy

The purpose of descriptive writing is to give information to the participants, not instructions. A description contains only those pieces of information that must be conveyed to the participants to know the goal of the collaboration process and to get an overview about the activities during the collaboration process. A description will be read by participants to accept the activities that must be done to reach the group goal.

Sentences Length

RULE D.01: **Keep descriptively sentences as short as possible**

The maximum length of a descriptively sentences is 25 words.

RULE D.02: **Vary the sentence length and constructions to keep the description interesting.**

A series of short sentences with the same construction is boring and irritating to read. Thus, you should try to vary the sentence lengths and constructions in descriptive writing. Use connecting words to join separate sentences instead of writing long sentences. This will result in two or more independent clauses instead of a long sentence.

Paragraphs

RULE D.03: **Use paragraphs to show your reader the logic of the text.**

Each paragraph is a unit of closely related information that is separated from other units of information by white space. The participants can see the boundaries of such a unit of information and can then relate the unit to other similar units of information.

RULE D.04: **Each paragraph must have only one topic.**

Each paragraph must have only one topic. The paragraph must deal with that topic in a logical manner and must make the relationship between sequences of information clear to the participants.

RULE D.05: **Always starts the paragraph with the topic sentence.**

The first sentence of the paragraph tells the participants what the paragraph is about. This 'topic sentence' allows the participants to relate the paragraph to other information they have just read. After the topic sentence, the remaining sentences must go on to develop the topic, to give additional facts, or to discuss particular aspects. Each sentence must add new information and must connect this information logically to what was stated in previous sentences.

RULE D.06: **The maximum length of a paragraph is 6 sentences.**

Besides showing the logic of a text, paragraphs can be used to make a description more interesting to the participants. Different lengths of paragraphs help the practitioner to keep the participants attention.

RULE D.07: **Use keywords to make the relationship between sentences and paragraphs clear.**

To build up information in a paragraph slowly, logically and coherently, you should try to show the relationship between the contexts given in different sentences. This can be done by using connecting words such as 'thus', 'but', 'and', 'this', 'that', 'those', 'so', 'as a result', and also by careful repetition keywords.

How to Write a Description

RULE D.08: **Describe only one collaboration pattern per description.**

Collaboration Engineering classifies a collaboration processes into six key patterns of collaboration.

Generate:	Move from having fewer to having more concepts in the pool of concepts shared by the group
Reduce:	Move from having many concepts to a focus on fewer concepts that the group deems worthy of further attention
Clarify:	Move from having less to having more shared understanding of the concepts and of the words and phrases used to express them
Organize:	Move from less to more understanding of the relationships among concepts the group is considering
Evaluate:	Move from less to more understanding of the relative value of the concepts under consideration
Build Consensus:	Move from having fewer to having more group members who are willing to commit to a proposal

These patterns can be used to divide a group process into different parts. Each part includes different information and activities to engender the collaboration pattern. A description should describe these information and activities to the participants. By describing more collaboration pattern into one description, the description can overwhelm the participant. In this case the participant can misunderstand the described information. Therefore, a description should present information for one collaboration pattern at a time.

RULE D.09: **Start a description with the name of the collaboration pattern that should be reached.**

The name of a collaboration pattern tells the participants what the description is about. This 'pattern name' allows the participant to relate the given information to a known pattern. After the pattern name, the description must go on to develop the information and activities to reach the intended collaboration pattern. Each sentence must add new information, and must connect this information logically to what was stated in previous sentences.

RULE D.10: **Use a tabular layout to present background information in a specific order.**

The tabular layout of text with standard punctuation can help to show the relationship between two or more complex actions or events. This is clearer than writing long sentences. Use a numbered list, if you want to present background information in a specific order. Otherwise use a bulleted list when the order is not important.

Rules for Instructional Writing

The Basic Philosophy

The purpose of instructional writing is to give instructions to the participants which lead to the activities that have a well-defined function in the context of the group goal. These instructions contain only those pieces of information that must be conveyed to the participants to perform the intended activities. An instruction will be read by the participants who need to know what activities must be done to reach the group goal.

Sentences Length

RULE I.01: Keep instructional sentences as short as possible

The maximum length of an instructional sentences is 20 words.

RULE I.02: Write only one instruction per sentence

If you put more instructions into one sentence, the practitioner will overwhelm the participant. In this case the participant can misunderstand an instruction. Therefore, the practitioner must present instructions one at a time. This will let the participant complete one activity before they start another.

Example:

WRITE:	(1)	Please select an issue from the cluster.
	(2)	Please write down an idea, which you associate with the selected issue.
NOT:		Please select an issue from the cluster and write down an idea, which you associate with the selected issue.

Verbs

RULE I.03: Use the verb in the imperative form

Write the verb in the imperative ('commanding') form to emphasizes that the participant must do a certain action. Other, less direct forms of instructions leave confusion as to whether something must be done or is already done.

Example:

WRITE:	Please select an idea from the cluster.
NOT:	An idea can be selected from the cluster.
WRITE:	Please write down an idea that you associate with the selected issue.
NOT:	An idea is to be written down, which you associate with the selected issue.

How to Write an Instruction

RULE I.04: Describe only one atomic activity per instruction

An atomic activity is an activity that is common to the participants. The participants know what they should do. Some activities are not common to the participants and represent a combination of different atomic activities. For example, the activity discuss represents a combination of the activities: explain the issue, collect comments and collect proposals for a solution. In this case an instruction still leaves open the question which atomic activities should be done and in which order these activities should be executed. Atomic activities are for example: READ, WRITE, SELECT, PUT, SAY, DRAW, LISTEN, TELL, MEMORIZE, WATCH, CALCULATE, REPEAL, THINK, ASSOCIATE.

Example:

WRITE: Please read the given idea.

Please think about the issue of the given idea.

Please write down a comment how that you associate with the issue.

Please read the comments of other participants.

Please write down a proposal that you associate with the known comments.

NOT: Please discuss the given idea with the other participants.

RULE I.05: Use a common sequence of atomic activities

A mental model is an internal scale-model representation of an external reality. It is built from knowledge of prior group processes and describe the way that the user perceives that the group process work. A practitioner can use a mental model to describe a sequence of atomic activities which is common to the participants. A sequence of activities (A -¿ B -¿ C) is common when all participants perceive that activity C follow activity B and that activity B follow activity A.

Example:

WRITE: Please take a pen and some sheet of paper to collect an idea.

Please write down an idea.

Please attach your idea to the whiteboard.

NOT: Please write down an idea.

Please attach your idea to the whiteboard.

Please take a pen and some sheet of paper to collect an idea.

RULE I.06: **Make an instruction as specific as possible**

An instruction describes an atomic activity and does specifically how to do the action by the participants. A practitioner specifies an instruction by:

- Specify the work equipment that is needed to execute the intended activity.
- Specify the element that is applied by the activity.
- Specify the condition under where the activity is applied.
- Specify the goal of the activity.

This specification of an instruction describes all information which a participant needs to execute the intended activity.

Example:

WRITE:	Please write down an idea on a sheet of paper. (Specified work equipment)
NOT:	Please write down an idea.
WRITE:	Please take a pen and some sheet of paper to collect your comments. (Specified goal)
NOT:	Please take a pen and some sheet of paper.
WRITE:	Please select an element from the list of comments. (Specified element)
NOT:	Please select an element.
WRITE:	Please write down a comment that you associate with the idea. (Specified condition)
NOT:	Please write down a comment.

RULE I.07: **Use only the active voice in an instruction**

What is 'active' or 'passive' voice?

In the active voice, the subject of the sentence does the action of the sentence ('A' does 'B). In the passive voice, the subject of the sentence receives the action ('B' is done by 'A').

Example:

ACTIVE:	The participant writes down an idea.
PASSIVE:	The idea is written down by the participant.

How do you change a passive construction to the active?

To change a passive construction to the active, you can use these methods: When the agent (the person that does the action) is identified in the sentence, put this agent at the beginning of the sentence, as the subject. The subject must always be the noun that does the action of the sentence. Furthermore, change the verb to the imperative ('commanding') form.

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Magdeburg, den 19. November 2012

Stefan Werner Knoll