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Information Support Services for Intermediation Tasks of Collaborative Networks

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Abstract: Companies in collaborative networks require intermediation to perform. The collaborative network forms the breeding environment for the configuration of a Virtual Enterprise that can handle a business request. This configuration task can be supported by IT services. For collaborative networks such as production networks focused on non-digital services and products we propose to assign specific intermediation tasks to a human network moderator supported by these IT services. The obvious support is targeted for the configuration of the Virtual Enterprise i.e. the search and selection from the available products, services, and competences found among the network participants. The configuration decision can jeopardize the network performance by harming the trust necessary to build new Virtual Enterprises. Through a further intermediation task trust can be inspired and promoted in the network. This article shows how the configuration is supported by a Decision Support Service and how a Transparency Support Service supports the downloading and acceptance of decisions in collaborative networks. The article outlines the IT supportive service system and exemplifies the use by a scenario example. Results on intermediation in collaborative networks can prove helpful for general service science problems.

Keywords: Service Science, Virtual Organizations, Collaborative Work, Network Moderation and Intermediation, Decision Support, Organizational Trust
Categories: L.6.2, L.6.1, H.3.5, H.4.2, K.4.4

1 Introduction

Today, companies seek to improve their competitive position by collaborating with other companies in *Collaborative Networks* [Camarinha-Matos, 05a], [Gandori, 95] that are expected to provide many potential benefits [Davidow, 93], [Heck, 07], [Österle, 01], [Jarillo, 93]. The benefits include: reduction of costs due to economy-of-scale effects, access to new markets and extra resources, better access to partner expertise, faster collaboration forming, and creation of new business opportunities by acting together with other members like one big player.

There exist different kinds of collaborative networks where the members collaborate in different areas such as knowledge sharing and joint product development [Braha, 04]. It also can be observed in the networking practice that network members collaborate on the operational level [Saxena, 09]. That is, several members of a network jointly process business transactions such as inquiries and orders from the market. The joined customer order fulfilment processes of collaborative networks typically deliver a composite product or service for which the involved members contribute individual parts and services [Gizanis, 06]. Therefore, such joined fulfilment processes in networks can imply what is often referred by researchers of the service science community as dynamic service composition from available service instances [Sycara, 03], [Küster, 07].

The collaborative provisioning of composite products and services can lead to cross-organizational processes with high complexity [Mulder, 06]. The subset of network members that participate in these processes for a specific business opportunity form a temporary alliance referred to as *Virtual Enterprise (VE)* [Camarinha-Matos, 05a]. A VE is terminated in a controlled way when the order resulting from the business opportunity is completed.

The long term success of collaborative networks depends on a number of different factors including an effective intermediation and maintenance of a proper level of trust within the network [Kumar, 96], [Riemer, 03], [Holland, 98]. Through the use of corresponding IT based services [Camarinha-Matos, 05b] such as a service for open information sharing within the network [Thimm, 10] it is possible to effectively support efforts targeted on these factors. The aspects of IT services make the field of collaborative networks an interesting area of investigation from a service science point of view. In our research we have outlined new IT based services for an effective intermediation of collaborative networks with a special focus on inter-mediation by a human network moderator [Pereira-Klen, 05], [Sherer, 03], [Harbilas, 02]. We especially consider the situation where a moderator carries out sensitive decisions on behalf of the entire network. The decisions we are focusing on concern the configuration of VEs which are sensitive due to their direct impact on the economic benefits of the network members [Thimm, 09], [Bittencourt, 05]. The impact of these decisions on the members' enthusiasm for the network and thus their support for collaboration with other network members leads to special requirements that are to be reflected in the design of support services. We exemplify these considerations in the two support services described in this article which we refer as *Decision Support Service (DSS)* and *Transparency Support Service (TSS).*

The DSS enables moderators to effectively perform VE configuration decisions – that is dynamic service composition decisions. The moderator is given the possibility to start from an initial search profile for a VE. A search profile consists of different hard and soft constraints for evaluating and selecting network members. A ranked set of configuration alternatives is generated and returned as search result. By performing several iterations with modified constraints the problem space is explored and more and more assurance about the choice of the best fitting VE is gained. Note that the search profile contains both company related criteria and also criteria that refer to the network as a whole. These criteria are especially useful when addressing the more long term strategic goals and policies of the network such as an equal revenue distribution between the participating companies within the network.

The TSS automates the dissemination of information about VE configuration decisions in order to enable a trust promoting spirit within the network [Thimm, 10]. When a proposed VE configuration alternative is chosen from the DSS's result list the moderator can use the TSS to automatically generate rich decision explanations for distribution within the network. The richness of explanations includes comprehensive background information, information about the anticipated impact of the decision on the network and on the company. The explanations not only inform about the rationale for each VE configuration decision they also contain data useful for benchmarking as well as for aligning business-level functional properties and quality properties. Both services are based on a comprehensive data repository on which complex data analyses are performed.

This introductory section is followed by a section in which major characteristics of collaborative networks are described. Major aspects of intermediation in collaborative networks by a human moderator are analyzed in the third section. Section four contains our approaches for IT based support services for network moderators. How networks can obtain benefits from these proposed services is described in section five through a corresponding application example. The results of our research and also some related work are discussed especially from a service science [Chesbrough, 06] perspective in section six. Open issues are addressed and our conclusions are presented in section seven.

2 Collaborative Networks – Principles, Trust, Intermediation

The organizational form of a collaborative network consists of a set of individual companies having joined their forces in order to strengthen their competitive position and as an aggregate to obtain a better performance. Examples of joined forces can be directed towards joined product development, joined production, joined purchasing, and knowledge sharing among the members. Collaborative networks have especially gained attention in the manufacturing sector where these networks are often referred as *Production Networks* [Riedel, 07], [Dangelmaier, 06].

Recall from earlier that a VE (Virtual Enterprise) refers to a subset of the members of a collaborative network that is launched to form a temporary alliance. The principle goal of every VE is to perform a joined product or service provisioning for an outside customer [Camarinha-Matos, 05a]. A network member can potentially participate in several VE in parallel. However, the configuration of VE needs to consider the resource utilization of the members in order to enable a smooth service or product provisioning to the customer and avoid conflicts within the network.

In order to better cope with demand fluctuations in markets and to be less dependent on individual network members in collaborative networks the members might have some overlap. Overlaps are intentionally considered and they concern typically the network members' competences, capabilities, markets, and technical equipment and facilities. The overlaps and the collaboration aspect of networks bring a double-relation among the network participants [Bengtsson, 99]. On the one hand network participants are called to cooperate with each other which is regarded as a cooperation relation among network participants. However, on the other hand there often co-exists a competitive relation between the network participants, too [Gomes-Casseres, 94]. This is especially the case if there is an overlap in the competencies or/and in the target markets of the network participants.

Trust in Collaborative Networks. The issue of trust within collaborative networks is an important factor of success for networks as all participants demand stable and trustworthy cooperation structures. "Trust not only prevents opportunism, but also creates opportunities" is stated by Lemmergaard [et al., 2008, p. 419] where the authors are investigating design for trust in a virtual community of practice. The community of practice resembles the collaborative network investigated here. Different types of trust can be the object. If the cooperation structures meet the requirements of the network participants then system confidence is entailed [Pennington, 04]. If deficiencies exist in system confidence reliance conflicts in the network can easily occur [Kumar, 96]. In addition to trust in the system (i.e. system trust) there is also a need for personal trust between the individual partners. This type of trust which is called personal trust is referred to being a function of relatively rational decision-making processes [Shapiro, 87].

As it has been revealed in research studies, collaborative networks can only be successful if their inherent potential for conflicts is adequately addressed and appropriate precautionary measures are taken to detect and avoid conflicts [Miles, 95], [Holland, 98]. For example, often conflicts in networks are resulting from the above mentioned dual type of relations being cooperators and also competitors. Further causes for conflicts and distrust in networks are described in [Ring, 94]. According to this study any excessive formalization and monitoring of the terms of inter-organizational relationships can lead to conflicts and distrust among the parties. This is partly caused by the situation that the network partners strive to maintain their unique identities and autonomy at the same time they are part of a growing web of interdependencies.

Our research is established on the assumption that the area of potential tension in networks, particularly distrust and lack of confidence, can be counteracted effectively with an appropriate provisioning of information. We assume that system confidence and personal trust can be inspired and grow through an appropriate information provisioning to the network participants [Holland, 98]. Evidence for this assumption can be found in the proposed *Business Networking Architecture* [Österle, 01].

Intermediation. According to the description of network management given in [Riemer, 06] network management "… has to deal with the collection, combination and allocation of labour and tasks, knowledge and resources, as well as benefits and profits among network members". Considering this description it is possible to derive concrete intermediation tasks that need to be completed in order to promote a successful collaboration of companies in collaborative networks. Table 1 contains several examples of such intermediation tasks. The requirements for intermediation of collaborative networks concern all phases of networks [Riemer, 06] i.e. the initiation phase when forming the network, the operational phase where network members are configured to VEs, and the termination phase which is concerned with a controlled closing of the network.

The execution of intermediation tasks often requires globally information sharing within the network. For example, the request management task implies that information about external requests are shared. The configuration management task requires a sharing of information about VE that have been configured and also corresponding background information. The process management task can imply that status information about ongoing collaborative business processes are delivered to the participating network members. Apart from information sharing through an active information provisioning the requirement of effective information sharing in collaborative networks is often addressed through the use of a dedicated repository for information and knowledge sharing [Won, 2003]. Examples for repository objects that can be accessed by all network members include information about the expertise and capabilities of the members, information about pre-planned products and services that are offered by the network to the market, and information about rules, regulations, and processes of the network. In addition to globally shared objects typically the repository also contains objects that can only be accessed by a specific subset of the network members. For example, detail order specific information can only be accessed by the members of the corresponding VE.

Intermediation Task	**Description**
Configuration Management	Managing the configuration of VE that includes the selection of proper partners from the network.
Conflict Management	Monitoring conflict indicators and handling of conflicts.
Trust Management	Managing conformance of the network members' actions to the rules and regulations of the network. Manage open information sharing and transparency.
Process Management	Managing the development and execution of (collaborative) business processes in the network. Examples are the process of handling external business requests and the collaborative order fulfilment process.
Continuous Improvement	Evaluating the business strategy, regulations, and business processes of the network. Identifying and managing alignments in these and other areas.
Partner Management	Identification of new partners and their inclusion into the network. For example, this could be part of an alignment of the entire network. Partner management is also concerned with the alignment of individual network members to given business-functional properties and quality properties.

Table 1: Examples of intermediation tasks

The intermediation complexity – that is the set of intermediation tasks and the degree of sophistication of these tasks - depends on a number of criteria. For example, drivers of complexity are the number of network members and the complexity of the jointly offered products and services. The intermediation complexity is furthermore influenced by the specific phase(s) of the product life cycle and the types of business processes in which the partners collaborate. The degree of overlap among the network members adds to the complexity of intermediation as well.

Information Technology Usage for Intermediation. Intermediation tasks can be completed without any involvement of *Information Technology (IT)*. For example, ad hoc tasks for which no IT support has been pre-planned tend to be manually completed. However, in order to perform intermediation tasks efficiently there is often an inevitable need for the use of IT. The involvement of IT within the completion of intermediation tasks can concern both general purpose and tailored (i.e. specialized) tools and services [Riemer, 03]. A further difference concerns the extent to which the completion of the intermediation task is automated. Some sort of automation is included in tailored services but it can reach a separate class when most elements or even the entire task is automatically completed by IT components. Based on these criteria a differentiation model for intermediation tasks can be derived that consists of the three complementary classes contained in Table 2.

Class 3: intermediation tasks fully or to a large extend automatically completed by tailored tools and services
Class 2: intermediation tasks completed by support of tailored tools and services
Class 1: intermediation tasks completed by support of general purpose collaboration and communication tools and services

Table 2: Classification of intermediation tasks in terms of IT use

The first class of intermediation tasks refers to tasks that are supported through general purpose collaboration and communication tools such as email, web conferencing tools, wikipedias, cross-organizational work flow management systems, and shared document repositories. The second class with tailored IT tools and services, are often the instantiation stage of collaborative networks involving specific planning tools and search engines for locating proper network partners. Search can draw from semantic technologies such as ontologies and specific methods for searching in public standardized business directories in which company profiles are described. The third class concerns intermediation tasks that are fully or at least to a large extent automatically completed by tailored IT tools and services. Typical examples can be found in the area of online auctions where the entire auctioning processes are completed automatically through a corresponding service. The two specific services proposed for moderators of collaborative networks in the remainder of this article are also intended to support intermediation tasks that belong to the third class. More complex examples can especially be found in areas with primarily digital services such as given in the online publishing business [Giaglis, 02]. This includes specific services for dynamic service composition from available digital service instances [Osman, 08] and services for a dynamic adaptation of composite services [Geihs, 09].

IT tools and services also bear the potential to support trust building and promotion as well as conflict prevention and mitigation in networks [Clark, 99]. Take for example the rating/scoring approach of platforms for Internet auctions. An example for an intermediation service for networks targeted on trust and conflict prevention is a service for a frequent provisioning of up to date trust indicators. Such a service will need to monitor collaboration processes and log corresponding data in a specific repository from which indicators are computed and delivered to the network. Especially indicators can be provided to guide network members for a proper alignment of their business-level functions and quality properties of their offered products and services.

3 Intermediation through a Human Network Moderator

Collaborative networks need to address a complex set of intermediation tasks that refer to different phases of the network's lifecycle. In general, by the notion of *intermediary* we refer to an instance within a network that is in charge of these intermediation tasks. In today's networking practice such as in the German networks "Produktionsnetzwerk Neumünster" (PNW) [PNW, 10] and the "Automobilzulieferer Sachsen 2005" (AMZ) [Scholta, 05] often the intermediary corresponds to a human. The role of human intermediaries and their tasks have been the subject of several research studies [Riemer, 06], [Sydow, 05].

A variety of different notions are used in the literature to refer to a person acting as an intermediary: network broker, manager, coordinator, mediator, facilitator, auditor, or moderator [Sherer, 03], [Pereira-Klen, 05], [Thimm, 09], [Harbilas, 02]. In this article we use the notion of *network moderator* or in short *moderator* to refer to a person that performs a set of strategic and operative level intermediation tasks related to and on behalf of the network. In order to allow for an effective completion of these tasks a fast access to a reliable information base and specialized tools are required [Holland, 98]. By IT moderation management we mean a set of strategic and operative tasks that are carried out by the moderator by proper IT based support services in order to meet the objectives of the network.

Networks that are moderated by human moderators need to be aware of the potential problems that can arise from human intermediation. Due to the specific role of a moderator the members are likely to pay close attention to whatever is performed by the moderator. Especially, the moderator's decisions that affect the observer's own company will be closely monitored and critically evaluated. The expected immediate reaction to any subjectively viewed unfair treatment or non-neutral decision will result in accusations towards the moderator. Even the most reliable moderator can become the victim of such accusations. It takes a lot of effort to deal with such accusations and to restore a general acceptance of the moderator by all members if such problems occurred. On the other hand it is not a choice to just ignore if members are dissatisfied with the moderator. It will not work to just expect that the dissatisfaction will vanish as time goes by even though the dissatisfied members will most likely benefit from favourable moderation results in the future. A growing potential for conflicts and a spirit that is discouraging trust and confidence into collaboration can be the result of the dissatisfaction and thus develop into a severe threat for the network.

In our research we focus on the important intermediation task where it is expected from the moderator to choose members from the network in order to form a VE. Recall from earlier that collaborative networks imply a reoccurring need to perform such a VE configuration decision since for any new business opportunity of the network – such as a request for quotation or request for offer - a new VE needs to be formed. Some researchers propose that the moderator should act as a coordinator of a distributed group decision process. That is, the VE configuration decision is performed by the members themselves, for example, based on an electronic voting protocol. Others suggest that the moderator should organize corresponding reverse auctioning processes [Hess, 02]. In principle, these approaches imply that full responsibility for the final decision is given to the network members. A further general scheme for VE configuration decisions is to let the moderator in a single-person decision approach perform the decision on behalf of the network. In the remainder of this section we analyse this third decision scheme and then discuss an approach to obtain acceptance for such a scheme by network members. Figure 1

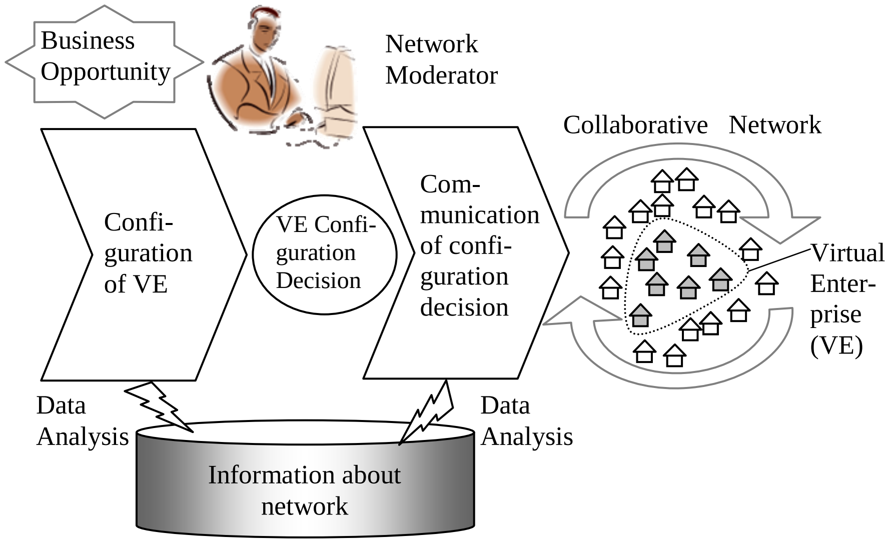

Figure 1: The two focused moderation management tasks

provides an illustration of the two moderation management tasks that we propose as a result of this investigation.

VE Configuration Decision as a Single Person Moderator Decision. It is a logical prerequisite of the "Single Person" decision scheme that the moderator is endowed with the corresponding decision power. The moderation management task of completing a VE Configuration Decision calls the moderator to carefully evaluate possible configuration alternatives and finally to decide what VE alternative will be assigned to the business opportunity (see Figure 1). It is a logical objective of the moderator to configure a VE that precisely fits to the given business opportunity. Therefore, the network members' profiles and competences, resource utilization states, and other company specific criteria are to be considered in this task. For this reason, in our scheme the configuration of a VE imposes to the moderator a complex multi-criteria decision problem [Thimm, 09]. Both hard and soft selection criteria that relate to single network members are to be considered. Furthermore, criteria that relate to the network as a whole need to be taken into account. Not only are the number of selection criteria increasing with the size of the network; the number and complexity of the offered products, and the number of interdependencies between the network members such as overlapping competences between companies are also growing fast. Furthermore, the criterions' relevance for the VE configuration are also changing over time as a result of market changes as well as affected by changes in the relations among the network members.

We have recognized in an earlier research project [Rasmussen, 09], [Thimm, 09] that in today's networking practise many networks of especially smaller and medium sized companies tend to use the "Single Person"- scheme for VE configuration decisions. It is possible that this tendency results from the fact that smaller and medium sized companies cannot afford the time needed for a participation in complicated group decision or negotiation processes. Instead these companies tend to accept a dictum of the moderator with respect to VE configuration decisions as long as the decisions comply to the rules defined by the network and as long as transparency and traceability of these decisions is guaranteed. The moderator can here be regarded as an arbitrator. However, if these prerequisites are not followed accusations of the moderator can rapidly arise and develop into a threat for the entire network.

Obtaining Acceptance for the Moderator's Decision Choice. It lies in the human nature that members of collaborative networks will feel uncomfortable if configuration decisions concerning VEs are not properly communicated. Therefore, we consider the communication of such decisions to the network participants as an important moderation management task (see Figure 1). We transfer to this specific context the results of a recent investigation of different modes of communication especially the mode of *robust decision downloading* [Clampitt, 07]. In this mode the information about decisions are conveyed to those who have not been directly involved in the decision making process. The communicative focus will be on: 1) how and why the decision was made, 2) what alternatives were considered, 3) how the decision fits with the organizational mission, 4) how the decision impacts the organization and employees. The availability of these information items will lead to better decision transparency and acceptance.

Research on organizational justice has shown that robust decision downloading will lead to advantageous implications such as stronger support of and commitment to the organization from the employees, a higher identification with the organization, and an employee perception that the organization is well managed and headed in the right direction [Clampitt, 07]. In our research we assume that these findings to a large extent validly can be transferred to explaining VE configuration decisions in collaborative networks. We assume that the members of collaborative networks – here companies of smaller and medium size - can be compared to the individual employees in the classical decision downloading context.

Robust decision downloading in collaborative networks is especially useful for decisions that influence the economic situation of the network members [Jarvenpaa, 99]. The configuration of VEs implies a separation of the network members into two groups: One group of members will benefit because they will be assigned to the task and thus experience or at least expect a revenue opportunity. The other part of network members cannot expect benefit from the decision because they are not selected to participate in the VE. The group of non-benefiters can be further divided into network members that for more obvious reasons have not become a member of the VE. For example, they might not offer any service or product needed for the fulfilment of the business request. However, the group of non-benefiters can also consist of companies that offer exactly the services and products needed and have therefore been considered for the VE but for other less obvious reasons have not been selected for the VE. For example, they might have participated in many previous VEs or they might have been explicitly excluded as potential collaboration partners by other members that are definitely needed for the VE.

It is especially demanding to communicate the VE configuration decisions to the group of non-benefiters. In our view a proper communication mode will contribute to a broad acceptance for the configuration decision within the network. This will in the long run be beneficial for a pro-networking spirit and an open and trustful collaboration climate. Consider that network members rather frequently will belong to the group of non-benefiters. This is due to the fact that required competencies and configuration criteria for VEs will be different from business request to business request.

4 Proposed Moderation Management Services

In the following, we describe two information support services that are intended to support moderation management tasks. The first service is the *Decision Support Service (DSS)* for VE configuration decisions. This service enables the moderator to explore and evaluate VE configuration alternatives in order to find the best fitting decision alternative which the moderator is then called to choose. Our second service is the *Transparency Support Service (TSS)* which provides an automated preparation and dissemination of information related to VE configuration decisions to the network (the "robust decision downloading" from section three).

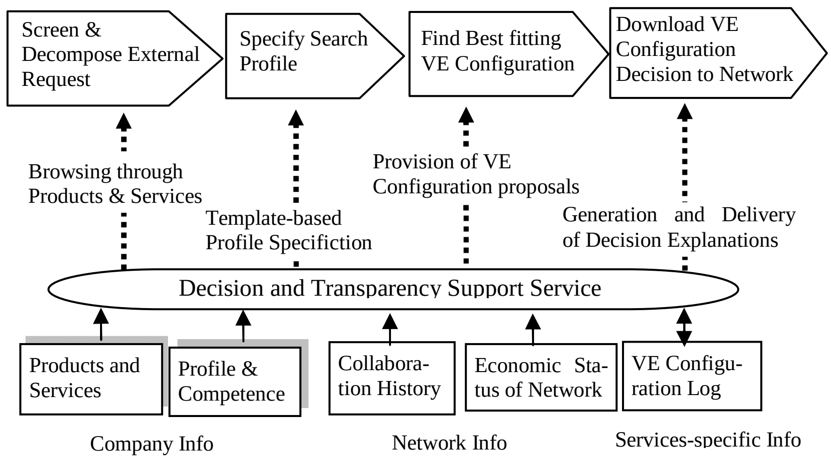

Figure 2: Conceptual view of proposed services

Overview of Proposed new Services. Figure 2 contains a conceptual view of the proposed services. The four activities (pentagons) at the top of the drawing correspond to decision making and decision downloading steps that are supported by the services. A general principle for decision support systems is the foundation in the form of a well maintained comprehensive information base. In Figure 2 the information base corresponds to the boxes at the bottom of the drawing. Each of the boxes stands for a specific category of information. These information bases concern the product and service offerings of the network members and also their company profiles, manufacturing capabilities, competences, and collaboration preferences.

Note that some of these aspects can be described in a standardized format such as eCl@ss and UNSP/SC [Hepp, 06]. The information base also stores the collaboration history of the company network, i.e. records describing previous VEs including information about the corresponding requests and the collaboration results. The information base also contains the economic status of the company network as a whole. This economic status is described in terms of typical key performance indicators such as opportunity and order backlog of the sales channel, cash balance, resource utilization, and stock levels [Parmenter, 10]. Furthermore, recorded moderator sessions are also stored within the information base. Example data that is logged include search profiles, intermediate internal processing results, and the final ranking of alternative VE creation proposals. As it is explained in the remainder of this section our proposed services make substantial use of the information base by applying data analysis. The analyses performed by the DSS are geared at the generation and scoring of VE configuration proposals. The analyses of the TSS are targeted at the composition of decision explanations that include individualized company-specific information.

Decision Support Service (DSS). The creation of a new VE is performed in three steps. Only the basic principles of these steps are described in the following. A more comprehensive description of these steps can be found in [Thimm, 09].

In the first step, the external business request is screened and decomposed into a set of *fulfilment steps*. We - so far - consider the following three categories of fulfilment steps: provision of raw materials or required parts, manufacturing process completed on given parts, complementary service process. For each fulfilment step the needed competences are identified. The DSS allows the moderator to browse through corresponding categories of competences and also to browse through the set of network members as defined within the information base. The envisioning and analysis of this information through the DSS and also the consideration of other information sources is performed to prepare the decomposition of the business request. Using the thus gained information, the moderator will decompose the request into a corresponding set of fulfilment steps together with a set of needed competencies for each step.

In the second step, an initial search profile for the demanded VE is specified which states the needed fulfilment steps and a set of criteria for selecting companies and evaluating possible VE alternatives. The predefined selection criteria of the template are divided into hard and soft selection criteria. Hard selection criteria consist of *inclusion constraints* and *exclusion constraints*. Through the definition of such constraints particular companies are definitely included in or excluded from the targeted VE. We therefore refer to these criteria as *collaboration constraints*. Soft selection criteria are used for scoring single companies and VE configuration alternatives. We refer to these criteria as *configuration criteria*. At the current stage of our research we consider as criteria for scoring single companies the financial power, production/service quality, price level, and collaboration experience. The current set of criteria for scoring entire VE configuration alternatives includes the geographical proximity of the VE members, the current state of revenue distribution and workload distribution within the network. A numeric weight is assigned to each of these predefined criteria of the search profile template. In general, by prioritizing the different criteria through weights the moderator may flexibly customize the scoring process of the DSS to address individual requirements. Once the search profile is fully defined it is submitted by the moderator to the DSS which concludes the second step.

In the third step the DSS first generates for the given search profile the valid VE alternatives that meet the hard selection criteria. Following that the alternatives are scored with respect to their goodness of fit to the soft selection criteria. This computational step includes a comprehensive data analysis of the information base in order to compute corresponding scores. In turn, the scoring result is prepared in the form of a ranked list of VE alternatives which is presented to the moderator for further evaluation. Either this will lead to another iteration starting with a modified search profile or a decision is made for one of the proposed VE alternatives in the result list. The final decision is declared to the DSS where the decision and all preceding interactions between the moderator and the DSS are recorded for later analysis by the TSS.

Transparency Support Service (TSS). Based on the TSS well prepared information regarded as *decision explanations* of the rationales behind the VE configuration decisions will be automatically generated and distributed in the network. Among others the data generated by the TSS enable projections into future states of the network as a whole and also into future states of the individual network members. In addition to inspiring acceptance for the given decision the feedback information also includes company specific information. Thus, the explanations are also useful for the purpose of benchmarking and for investment decisions (e.g. concerning production facilities or employee skills). An automated generation of the decision explanations is enabled by a machine processible representation of the moderator's final decision and the path from the initial search profile over all the completed iterations up to the final choice.

For each VE configuration decision an explanation which contains the search profile as specified by the moderator is prepared and delivered to the network. In general the content of these decision explanations is referred as the *Search Profile View*. Two further decision explanations are delivered to the network for each VE configuration decision. They contain the *Search Result and Criteria Evaluation View* and the *Decision Impact View*, respectively. A concrete example for each of the three types of decision explanations is given in the next section that presents an application scenario for our services.

The Search Result and Criteria Evaluation View are intended to clarify the reasons for the final decision. In particular company specific arguments are provided as to why their company became part of the VE or, in the opposite case, why their company was not selected. The Decision Impact View is based on a projection of quantitative data into the future. This view clarifies the anticipated consequences of the given VE configuration decision for both the network as a whole as well as for single members of the network. In order to allow insights into the possible decision impact on the network qualitative and quantitative indicators are described in terms of their current status and their assumed future development.

In general the indicators of the above mentioned views are either shared information and refer to the network or they are private information and refer to a specific company to which the view will be delivered. Table 3 contains a first set of indicators currently considered. They are either referring to obvious economic indicators or to proposed collaboration-specific aspects of the decision [Camarinha-Matos, 05c].

Indicator	**Explanation**
Economic Indicators	
Revenue	Revenue obtained by entire network in the current business year.
Member Revenue	Mean revenue obtained per member in the current business year.
Revenue Distribution	Description of revenue distribution within the network in the form of values on an ordinal scale that ranges from unbalanced, slightly unbalanced, and balanced.
Utilization	Description of degree of utilization of the resources. The value domain is an ordinal scale ranging from low, normal, up to high. The description of the future development is based on a separation into short term, medium term, and long term development of the utilization.
Inventory	Description of amount of material on stock stated by a value of an ordinal scale ranging from low, normal, up to high. The future development is described in terms of an ordinal scale ranging from short term and medium term to long term.
Collaboration-Specific Indicators	
VE Size	Size of VE in terms of number of participating companies. The minimum, mean, and maximum values refer to all VEs that occurred in the network.
Company VE Size	Size of VE in terms of number of participating companies. The values refer only to those VEs in which the company itself participated in.
VE Value	Overall monetary business value associated with VEs. The minimum, mean, and maximum values refer to all VEs that occurred in the network.
Company VE Value	Overall monetary business value associated with VEs. The values refer only to those VEs in which the company itself participated in.
Waiting Time	Time span in days that participants of a terminated VE need to wait until they become again a participant of another VE. The minimum, mean, and maximum values refer to all VEs that occurred in the network.
Company Waiting Time	Time span in days as above but only those VEs are considered in which the company itself participated in.

Table 3: Indicators considered for decision explanations

The TSS generates decision explanations in the form of reports that are composed of both textual information and graphical visualizations of indicators. The generated reports are stored in a specific repository from which they can be retrieved by the network members.

Prototype. A first standalone prototype of our proposed services has been devised and is partially being implemented. Figure 3 shows the major components of the prototype for which we apply the typical technologies of web-based multi-tier software architectures in combination with the JAVA programming language and other JAVA technologies.

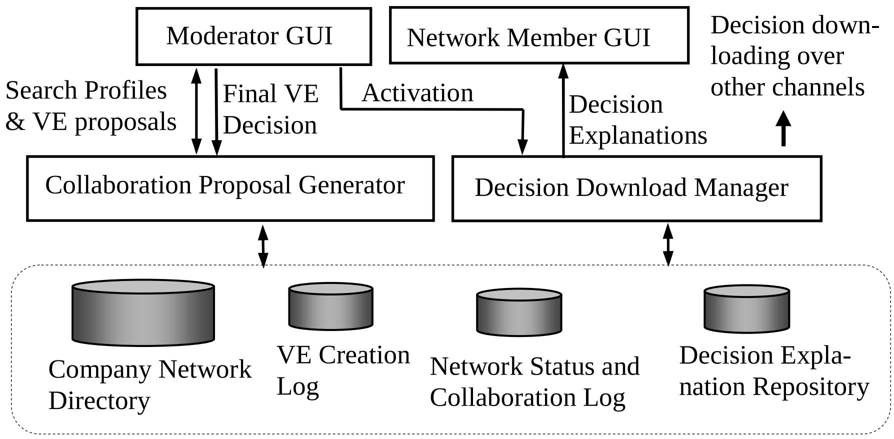

Figure 3: Architecture of prototype

The prototype offers a web browser-based front-end to moderators. Likewise, the network members are provided with a web browser-based front-end specialized on the visualization of the decision explanations.

The components of the prototype database are logically divided into the four repositories shown at the bottom of Figure 3. The *Company Network Directory* contains descriptions of the companies in terms of their product and service offerings and also their competencies and technical abilities. The *VE Creation Log* contains recorded sessions in which VE proposals have been generated by the system according to search profiles. The third data repository named *Network Status and Collaboration Log* contains data about the economic status of the network and also about collaborative processes and business transactions as completed within the network. Decision explanations are administered in the *Decision Explanations Repository*.

The *Collaboration Proposal Generator* takes the Search Profile of the moderator and completes a sophisticated orchestration algorithm. A resulting ranked list of VE alternatives is delivered to the moderator. During such a moderator session the Collaboration Proposal Generator records data about search profiles, processing steps of the orchestration algorithm together with intermediate results, and proposed VE alternatives. These data are stored in the VE Creation log for the automatic generation of decision explanations.

The *Decision Download Manager* is called interactively from the moderator GUI. The chosen alternative is selected from the ranked list of alternatives presented to the moderator. This selection is recorded in the VE Creation log and the Decision

Download Manager is activated when the moderator has confirmed the selection. The Decision Download Manager then retrieves information from the database to generate the corresponding reports. The generated reports are made available in the Decision Explanations Repository where they may be accessed by the network members. The members are automatically notified by the Download Manager through email announcements. The common general parts of these emails contain general information about the new VE and the corresponding business request. The receiver-specific parts of the emails consist of individually generated access information given in the form of an URI [Berners-Lee, 05] address. Through this access information the members can retrieve their reports from the Decision Explanation Repository at any later point in time.

5 Application Scenario

In the following we describe an application scenario to illustrate the functionality of the proposed moderation management services. We assume a fictitious collaborative network named Seat-Tec-Net. Note that the characteristics described in the following to a large extent correspond to characteristics of existing networks such as the German networks *Production Network Neumünster* [PNW, 10] and the network *Automobilzulieferer Sachsen 2005* [Scholta, 05].

The fictitious Seat-Tec-Net network is specialized on the joint development, production, and sales of passenger seats. The common product portfolio is organized into the four product lines: plane seats, ship seats, bus seats, and train seats. Each product line offers customers a choice from a set of standardized configuration variants based on a corresponding set of standardized product parts and production steps that to a large extent are produced by the Seat-Tec-Net members themselves. The network also offers customers complementary services such as shipping and installation services. For the reasons discussed earlier there exists an intentional overlap between the different network members in terms of their competences to perform fulfilments steps required for the production of seats. Table 4 contains for each network member (given in columns) the specific fulfilment steps that they are able to contribute to the fulfilment of a customer order.

The standardized product portfolio of the network implies that for every offered product variant both a corresponding Bill of Material (BOM) and a production process are defined. The basic principle is that a manufacturing process is decomposed into corresponding fulfilment steps for which the required competencies are specified.

We presuppose that the Seat-Tec-Net network is called to deliver to the shipyard Volcano Ships a quotation for 400 passenger seats of standard seat model Ocean Convenience which features an integrated infotainment system. In our further scenario description we present how the moderator uses our proposed services for the forming of a corresponding VE (through the DSS) and also the dissemination of corresponding background information to the network members (through the TSS).

Table 5 contains the fulfilment steps that are considered by the moderator for the customer's request for quotation together with corresponding competences. Note that the rather crude competence descriptions in a real situation would contain more complex descriptions with very specific technical terms. The fulfilment steps 1 to 7 in Table 5 directly correspond to the steps defined in the corresponding manufacturing process. The steps 8 and 9, however, refer to complementary services considered by the moderator individually for the given request for quotation. We assume that the shipyard has inquired to include shipment and installation of the requested seats in the offer.

Fulfilment step	SUM Microoelectronics	E-Wizards	Iron Experts	The Heavy Group	Metal Gurus	The Cushioners	Padding Park	Precision Experts	AdvancedFineMechaniscs	World of Color	Paint-it	Delword	FTS	Instal-Ex
providing raw material or product parts														
Production of electronic parts	x	x												
Production of bolt metal parts			x	x	x									
Production of seat upholsteries						x	x							
Production of seat belts						x		x						
Production of precision engineering parts								x	x					
manufacturing process completed on given parts														
Multi-layer painting of metal parts										x	x			
Final assembly of seats								x	x					
complementary service														
Shipping of seats												x	x	
Installation of seats						x		x						x

Table 4: Seat-Tec-Net companies and their competences

No.	**Fulfilment step**	**Required competences**
1	production of metal seat frames	production of bolt metal parts
2	painting of metal seat frames	multi-layer painting of metal parts
3	production of seat upholsteries	production of seat upholsteries
4	production of circuit systems	production of electronic parts
5	production of monitors	production of electronic parts
6	production of seat belts	production of seat belts
7	final assembly of seats	final assembly of seats
8	shipment of seats	shipping of seats
9	installation of seats	installation of seats

Table 5: Required fulfilment steps and competences

The moderator in a first step specifies a search profile for the needed VE based on the search profile template of the DSS. This step includes especially the selection of a corresponding set of fulfilment steps from the available choices provided by the DSS. Other considerations are also relevant for the needed VE and are described through corresponding collaboration constraints and configuration criteria:

- The network member "SUM Microelectronics Ltd." has to be included in the VE as this is explicitly stated by the shipyard.
- The network member "Iron Experts Ltd." is to be excluded from the VE. Again on the shipyards request.
- Two company-related configuration criteria have to be considered: "Collaboration Experience: 0.6" and "Financial Power: 1.0". The scoring of individual members will be performed with respect to these two criteria and their assigned weights, respectively.
- The configuration process needs also to reflect two network-related configuration criteria: "Equally Balanced Revenue: 0.8" and "Equally Balanced Workload: 1.0".

1. Fulfilment Steps	
production of metal seat frames	
painting of metal seat frames	
production of seat upholsteries	
production of circuit systems	
production of monitors	
production of seat belts	
final assembly of seats	
shipment of seats	
installation of seats	
2. Collaboration Constraints	
Include constraints	*SUM Microelectronics*
Exclude constraints	*Iron Experts*
3. Configuration Criteria	
Company related criteria	*Collaboration Experience: 0.6*
	Financial Power: 1.0
Network related criteria	*Equally Balanced Revenue: 0.8*
	Equally Balanced Workload: 1.0

Table 6: Report containing the search profile view

The initial search profile is processed by the DSS which will result into a list of scored VE alternatives. Let us assume that the moderator will not perform further iterations and directly decide for the highest scoring VE alternative. This decision is in turn downloaded to the network by the TSS which implies that decision explanations are generated and delivered to the network members. As the TSS supports three different types of decision explanations each member will get three different reports. In the following we describe the reports that will be prepared for the network member SUM Microelectronics Ltd. The report that presents the search profile as specified by the moderator is contained in Table 6. In general this report is divided into three parts. The first part contains the set of needed fulfilment steps. The second part shows the collaboration constraints and the third part presents the configuration criteria. The information items contained in these three parts correspond to the moderator's entries into the search profile template of the DSS.

1. VE Configuration Decision		
Fulfilment step	Member assigned	
production of metal seat frames	*The Heavy Group*	
painting of metal seat frames	*World-of-Colors*	
production of seat upholsteries	*The Cushioners*	
production of circuit systems	*SUM Microelectronics*	
production of monitors	*E-Wizards*	
production of seat belts	*The Cushioners*	
final assembly of seats	*Precision Experts*	
shipment of seats	*Delworld*	
installation of seats	*Instal-Ex*	
2. Total Scores		
Type of VE score	VE-score of chosen VE	VE-scores concerning all considered VE alternatives
Total VE score	*199*	*Min.: 78, Mean: 126, Max.: 199*
3. VE-Releated Scoring Data		
Scoring criterion	VE-score of chosen VE	VE-scores concerning all considered VE alternatives
Equally Balanced Revenue: 0.8	*89*	*Min.: 67, Mean: 72, Max.: 91*
Equally Balanced Workload: 1.0	*110*	*Min.: 56, Mean: 83, Max.: 110*
4. Company-Related Scoring Data for SUM Microelectronics		
Scoring criterion	Company-score	Company-scores concerning all considered alternatives
Collaboration Experience: 0.6	*73*	*Min.: 58, Mean: 62, Max.: 73*
Financial Power: 1.0	*120*	*Min.: 49, Mean: 72, Max.: 120*

Table 7: Report containing the search result and criteria evaluation view

Table 7 contains the search result and criteria evaluation view delivered to the network member SUM Microelectronics. It consists of four sets of clarification information. The first three sets provide shared network specific information whereas the fourth set is composed of private company specific information. The first set contains the moderator's final decision by showing the companies that participate within the chosen VE. The second set shows the total score of the chosen VE and also the minimum, mean, and maximum score of all considered VE alternatives. The third set consists of VE-related scoring data. For each considered network-related scoring criterion the score of the chosen VE alternative is given and contrasted with the corresponding minimum, mean, and maximum scores of the set of all considered VE alternatives. The fourth set of the report consists of company-related scoring data which is individualized for SUM Microelectronics. These scoring data concern the specific scoring result obtained by SUM Microelectronics for the company-related scoring criteria. In order to allow for a better interpretation of these company-specific scoring results the scoring values found among the set of all considered VE alternatives are given, too. In particular, the minimum, mean, and maximum scores obtained for all considered companies are given in this fourth part of the report.

1. Decision Impact on Entire Network		2. Decision Impact on SUM Microelectronics Ltd.	
Indicator		Indicator	
Current status	Future development	Current Status	Future development
Revenue		*Revenue*	
Network:10.500.200 Per member: *620.000*	Network:11.800.000 Per member: *710.000*	*840.000*	*1.251.000*
Revenue distribution			
unbalanced	*Slightly unbalanced*		
Utilization		*Utilization*	
low	Short term: *normal* Medium term: *normal* Long term: -	*low*	Short term: *high* Medium term: *high* Long term: -
Inventory		*Inventory*	
normal	Short term: *low* Medium term: *normal* Long term: -	*normal*	Short term: *low* Medium term: *low* Long term: -
VE Size		*VE Size*	
Minimum: *4* Mean: *12* Maximum: *24*	Minimum: *4* Mean: *10* Maximum: *24*	Minimum: *6* Mean: *8* Maximum: *15*	Minimum: *6* Mean: *8* Maximum: *15*
VE Value		*VE Value*	
Minimum: *80.000* Mean: 6.500.000 Maximum: 15.000.000	Minimum: *80.000* Mean: 5.665.000 Maximum: 15.000.000	Minimum: *80.000* Mean: 3.700.000 Maximum: 8.200.000	Minimum: *80.000* Mean: 2.400.000 Maximum: 8.200.000
Waiting Time		*Waiting Time*	
Minimum: *4* Mean: *8* Maximum: *15*	Minimum: *4* Mean: *6* Maximum: *15*	Minimum: *6* Mean: *8* Maximum: *15*	Minimum: *6* Mean: *8* Maximum: *15*

Table 8: Report containing the decision impact view

Table 8 presents the decision impact view as in our application scenario will be delivered to SUM Microelectronics. For a description of this view the economic and collaboration-specific indicators introduced in section four are used. The values in the column “Future development” describe future states of the indicators as they will result when the business request is handled by the chosen VE. In the first part of the report titled “Decision Impact on Entire Network” the data correspond to shared data that refer to the entire network. In contrast to that, the second part of the report titled “Decision Impact on SUM Microelectronics” is company specific and provides the individual indicators for SUM Microelectronics. These indicators correspond to private data.

The readability especially of the second and third report could be improved by showing the numbers in the form of boxplot diagrams including the standard deviation. This improvement will be part of our future work.

6 A Service Science Perspective on Results and Related Work

A number of specific topics addressed in this article belong to the core topics of service science [Chesbrough, 06]. So far, in our research we investigated these topics especially for collaborative networks with some emphasis on production networks. We discuss in the following these investigations and their relation to the research of other groups.

The issue of trust within networks is one subject of our investigations. We are especially addressing the question of how the network trust is influenced by a human network moderator. We are also studying the impact of service composition decisions on trust. The network will need trust between the members and in particular trust towards the moderator. The proposed services are regarded as means to supply and support that trust and, henceforth, to also promote system trust.

An empirical survey based on e-mail interviews identified three alternative approaches in collaborative use of interactive whiteboards [Kolfschoten, 09]. Although the persons were working in teams “many interviewees indicated that some participants at least took a more active role”. Even without process support some did experience the emergence of process structure and roles. The next alternative approach was “chauffeured” where one or two persons were operators which allowed for free-riding. The third approach was “facilitated” where a person was leading the process. The interview contained a question of “To what extent and how did you or someone else have a steering or guiding role in the process”. We stipulate that guidance occurrence is prominent in computer supported collaboration. This is one reason why intermediation in our research is considered as a set of intermediation tasks that are primarily performed by a skilled human moderator with support by corresponding IT based support services. Later research might make deeper investigation in the possibilities of a less centralized support solution. Another reason for the relatively strong emphasis of a human moderator in this article is to some extend implied by the fact that our organizational context consists of typical “brick and mortar” companies. We focus especially on networks where such companies contribute physical goods and services to the provisioning of larger, composed products which are of both high complexity and high value. As a result of these specific product properties the customers are provided with many configuration choices which can include many opportunities for negotiations. Furthermore, the product properties call for intense synchronization of all the actors of the network and also a close monitoring of especially the error prone processes during the fulfilment. Considering the current networking practice it seems that these requirements can especially be well satisfied by the use of a human moderator [PNW, 10], [Scholta, 05].

In other collaborative networks, for example of the digital entertainments business or the digital publishing business where the network members contribute fully digital services many of the intermediation tasks of the network can be fully automated through electronic intermediaries [Giaglis, 02].The concepts of such electronic intermediaries and corresponding intermediation architectures are for example investigated in [Clark, 99], [Fielt, 08].

Service composition has been studied by several research groups [Sycara, 03], [Küster, 07]. Often in these projects it is looked at service composition from a technical view assuming a Service Oriented Architecture (SOA) as a foundation. For example, a survey of different web service composition approaches can be found in [Osman, 08]. In our research we also address service composition through the consideration of the DSS. However, we aim on a composition of services that not necessarily correspond to digital services. The composition activity in our work is more broadly targeted at the composition of physical products and services and also digital (i.e. non-physical) products and services. This implies for our service composition approach several specific challenges that are not relevant if the composition is restricted to digital services. First of all if physical services such as production services are involved then for the forming of a VE it often is required to consider the service providers' resource utilization states. Moreover, unexpected events such as machine failures can require an adaptation of an already formed and working VE [Dangelmaier, 06]. Another specific challenge for the composition of both physical and digital products/services is that the resulting composed products can involve relatively large numbers of components. Moreover, different kinds of relations (e.g., predecessor/successor) can exist between these components. All this can quickly lead to a composition complexity that composed services/products of only digital components will only reach in rare cases. For example, compare the bill of materials for a car engine manufactured by a production network with a bill of material for a digital multimedia magazine.

Service composition often implies the task of service discovery [Sycara, 03], [Küster, 07] which strives on the discovery of appropriate composite services. Service discovery approaches are often focused on the ideal case where service repositories exist from which precise descriptions of the services can be retrieved in standardized formats. Today's more realistic conditions however impose the problem that the service description repositories are often based on local taxonomies which leads to interoperability problems. In these cases it is possible to overcome the heterogeniety problems for example by an alignment of the involved taxonomies [Jung, 08]. In our specific context service discovery in a service science sense is only required in rare cases. For example, if "arbitrary" products according to customer specific requirements are manufactured by the network then the possible contributions from network participants that fit to the demanded product need to be discovered. However, it is often predefined in networks how the partners' products and services can be composed to larger products and services [Scholta, 05], [PZW, 10].

Several researchers of the service science community are investigating the alignment of business-level functional and quality properties and also the alignment of IT-level functional and quality properties [Geihs, 09]. We are addressing in our research also the alignment of business-level functional and quality properties. However, in our context alignment does not mean dynamic adaptation of services. The company specific indicators of the decision explanations allow the network members to explore and evaluate potential alignments at the business level. For example, the indicators allow a network member to compare with the other members and to identify potential alignment measures. It can be the target of such measures to more often participate in future VEs by an extension of the company's competence and capabilities. Further business-level alignment measures can be the investment into new and better equipment in order to improve the company's production quality.

7 Future Work and Conclusions

A great deal of work still lies ahead in elaborating the proposed services. A refinement is planned for the information repositories that the services are based on. For the repository that contains status information about the network such as information about completed business transactions we will investigate into the issue of obtaining this information directly from the network participants' business transaction systems through a corresponding integration. For the transparency support service we will especially investigate information visualization techniques [Zhu, 08] [Tufte, 01] for effective visualization of decision explanations. This will also include solutions allowing the network members to customize the visual presentation of decision explanations to their individual needs.

We also consider an extension of our approach by additional components that will lead to active system capabilities. For example, alerts could automatically be delivered to the network if thresholds of indicators are violated.

A long term goal will be the study of the services' effectiveness with respect to the promotion of trust and a prospering collaboration climate. We intend to perform experiments with the services on the basis of simulation of the central model. Live tests and first experience with the implementation of the model will necessarily lead to further investigation into the different decision explanations and especially their set of indicators.

After introducing the concept of collaborative networks, we motivated the assignment of a human moderator to such networks as intermediation tasks cannot be left completely to electronic intermediaries. Instead a human moderator needs to be completed by specialized information support services. We exemplified this argument by a discussion of two corresponding intermediation tasks of collaborative networks and a proposal of two corresponding support services. By the description of a corresponding application scenario we demonstrated the collaborative network's use of these services.

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