PARTNER SELECTION FOR VIRTUAL ORGANIZATION
Supporting the Moderator in Business Networks

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Abstract: More and more companies improve their sustainability by belonging to company networks. When a specific inquiry is directed towards the company network required is a selection of companies that partner- up in a mixture of supplementing or even overlapping companies to form a virtual organization. The selection of partners is a challenging task for the network moderator and poor results - producing less value for the participating selected companies - as well as unintelligible results - that confuse the companies - can jeopardize the network. Therefore, we outline a web-based solution where the information technology supports the moderator by providing not only an optimized solution of the selected companies but also makes the management process transparent and traceable thus building a firmer future ground for the network.

1 INTRODUCTION

The concept of *the virtual corporation* evolved about 15 years ago (Davidow & Malone, 1992). The virtuality is launched from *company networks* in which companies come together to jointly act on the market in a well coordinated manner by (after a selection process) forming a suitable *virtual organization*. The concepts of networking and collaboration have been promoted as an (or the) approach to deal with the present business challenges especially for small and medium sized enterprises (SMEs). Parts of the hypothesis and theory behind this recommendation of collaboration are based on the theory and analysis of successful industrial clusters (Porter, 1998). Interestingly the vehicle for stronger global awareness goes hand in hand with regional collaboration. More recent research on virtual organizations includes the ECOLEAD Project (Camarinha-Matos & Afsarmanesh, 2006) which is targeted at new frameworks, methodologies, and tools for the present and also the future networking practice. Among others the preliminary results of ECOLEAD include the concept of *virtual organization breeding environment* as a sort of basic-level collaborative environment. This environment is being especially prepared to enable fast virtual organization creation processes so that companies may quickly get engaged in collaboration processes to meet business opportunities.

For the coordination of such collaborative business processes in company networks an authority has been suggested (Harbilas et al., 2002 and Pereira-Klen & Klen, 2005) which we refer to as *(network) moderator*. The special task for the moderator is to perform the *orchestration task* or the selection of companies for building a virtual organization. The moderator thus determines what particular subset of companies of the network is best suited for handling a received inquiry. This is a somewhat complicated

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task as there are several constraints involved that are directly expressed by the requestor in the inquiry such as a price limit or a delivery deadline for a certain product. Furthermore, less obvious extra constraints that require deep insights into the current economical situation as well as the collaboration history of the network are to be considered. Due to these constraints and also because of the fact that the product and service offerings of the network members may overlap, moderators are in need of reliable and documentable support for the orchestration task. The selection of companies can be further complicated as the central descriptive attributes of network members might not be limited to existing products and offerings but also have resources as competences and capabilities describing the potential of the company, and furthermore include an outspoken strategy of developing, adding, and exploiting these potentials.

The eBusCo.net (Electronic Business in Company Networks) research project includes investigations into comprehensive IT support for moderators of company networks with a focus on the partner selection. We intend to integrate this service into available and forthcoming collaboration platforms for company networks. Furthermore, the project also includes an empirical survey with focus on ICT readiness and networking maturity amongst SME companies in the production industry of the KERN region of Northern Germany and the region of Southern Denmark. Some more practical insights for company networks are gained by observations in two existing company networks and with the active involvement of two regional business development agencies.

This paper presents results of our work on the support service for the partner selection or orchestration task of moderators for given inquiries coming to the company network. The service gives the moderator the opportunity to apply dynamically individual optimization criteria from a list of predefined criteria. The service will use these criteria to compute the most suitable set ("best fit") of network members under a comprehensive evaluation of the resources in the companies as well as the current economical status and the collaboration history of the network. The service is expected to outperform even experienced moderators because handling many simultaneous constraints is a very complicated intellectual task. Furthermore, the service is designed to bring more consistency, transparency, and traceability regarding the decision making involved in the orchestration task. It may also serve as an analysis tool to support the supervision of a company network.

In this article this first introductory section is followed by a section presenting the context of the moderator for inquiry handling in an existing company network. The third section introduces the object model and the building blocks for the support service for network moderators. A system architecture and implementation details for a first prototype of this service are presented in section four. Section five discusses related work while some concluding remarks are given in section six.

2 THE CONTEXT OF MODERATION IN AN EXISTING COMPANY NETWORK

In the eBusCo.net project we have made some observations from existing company networks in the process of development of the support service. In the German region we have focused on the Produktionsnetzwerk Neumünster (Production network) where around 30 production companies have participated for more than six years. The rather long time period is an indication of the success of the network and part of the success of is believed to be caused by the fact that the network is moderated. Having a moderating person can be regarded as a structural fact but it cannot be disregarded that personal competences also bears evidence to the success of the business network. In this case the moderator function is filled by a well integrated and accepted person with a large background in production processes and technologies but also in business management. Among the moderator responsibilities to the production network we focus in this article exclusively on the decision process for selecting the most appropriate set of companies. Our observations and discussions with the moderator and members of the Produktionsnetzwerk Neumünster and also other companies concerning the inquiry handling process are summarized in the graphical illustration of the process steps given in Figure 1.

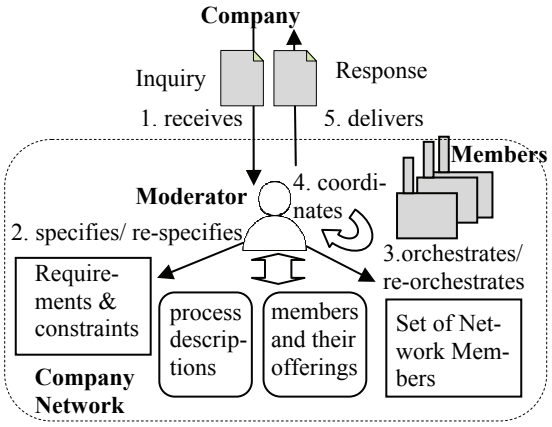

Figure 1: Moderator-based inquiry handling.

An external inquiry is received (1) by the moderator in the network. The inquiry has the form of a potential customer order. If the inquiry refers to a product of the company network's standard product offering, then a description is already available for the moderator of the required collaborative production process in the form of a historically stored and retrievable description of the process. If the request has more innovative elements the moderator must create a corresponding new process description. The process description then acts as the object for the moderator's decomposition of the request corresponding order components.

As a concrete illustrating example we assume a company network that has specialized on passenger seats for planes, ships, trains, and busses. In our example the company network has received a request for quotation from a shipyard asking for an offer for 400 passenger seats with an integrated infotainment system. Assume that a corresponding process description for the production of the requested seats within the network will be used to specify the following six order components:

provision of metal seat frames,
provision of seat upholsteries
provision of circuit systems
provision of monitors
provision of harnesses
final assembly of seats.

These order components constitutes a specification of the requirements (2). As the example shows, these requirements refer to needed product parts and production steps. Further requirements can specify constraints concerning the network companies in the form of preferences from the inquiring company as to participating companies. In our example, the inquiring shipyard might have explicitly asked that the seat frames should be produced by a specific company of the network. There can also be constrains in the form of collaboration preferences among the network companies.

Given the requirements and constraints for the needed set of companies, the moderator orchestrates a corresponding set of network members (3). This orchestration activity consists of the selection of a set of network members based on their company products, and services and their company profile in general. Steps two and three may be repeated several times until the moderator is satisfied with the set being orchestrated. Next, the selected members are contacted by the moderator in order to coordinate (4) their particular assignment and further details of the collaborative fulfilment process and also the response of the company network to the inquiring company. This may require for the moderator to again repeat steps two to four until all open issues are solved and a consensus exists regarding the response to the inquiring company. The moderator then generates a corresponding response (e.g. offer to a Request for Quotation) which is next delivered (5) to the inquiring company.

The above description is based upon our observations from the Produktionsnetzwerk Neumünster. However, we find that an IT-based support services may be very useful in general for the inquiry management process in networks. In particular, we see a strong need to support the orchestration task for a number of reasons. First of all, finding the most-suited set may easily over-challenge a human moderator due to a large number of different set alternatives based upon the big number of participating companies in the network. Secondly, often the members of a company network offer not only complementing but often also overlapping offerings. Thirdly, there is an aspect of fairness as it is expected that business is to be somewhat evenly distributed over all network members. Furthermore, proper IT support may reduce the influence of human factors on the orchestration outcome and is expected to bring better consistency of orchestration decisions over time, better traceability of these decisions, and also provide analytical possibilities for the general management of the company network.

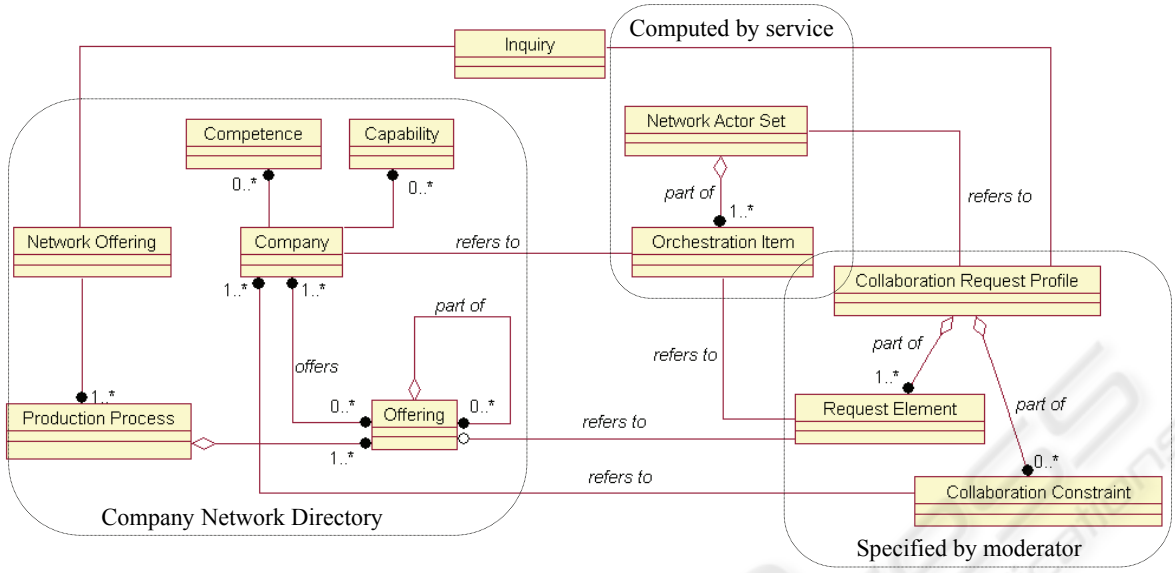

Figure 2: Support service for network moderators - Object model.

3 CLASSES AND CONSTRAINS IN THE ORCHESTRATION SERVICE

The previous section motivated the support service for moderators of company networks with focus on the task of orchestration. Now we present some major considerations for the design of the support service for orchestration. The central classes and relations of such a service are described through an object model (Figure 2) based upon the diagrammatic notation of the Object Modelling Technique (Rumbaugh, 1998).

The class Network Offering represents the offering of the company network to the Inquiry arising from the market. The Network Offering is established through collaboration of network members in the production. The class Production Process models these collaborative processes where the different parts are modelled by the class Offering representing both, physical products (or product parts) and production services.

The "part-of" association reflects that the offered products and services themselves may be composed of Offerings. The class Company has attributes describing the general data about the companies, whereas the competencies, technical abilities (capability), and offering of the companies are modelled by separate classes. These classes are together framed as Company Network Directory (CND) in Figure 2.

The classes of CND capture relative static data. However, the remaining classes of Figure 2 refer to dynamic data that relates directly to the inquiry handling activities of the network moderator. The classes at the right border of Figure 2 capture data that the moderator will have to prepare for each inquiry. The class Collaboration Request Profile holds administrative data about an orchestration problem to be solved for a given inquiry. The class Request Element represents and relates to the products and production services (Offering). The class Collaboration Constraint represents the set constraints shown in Table 1.

Table 1: Collaboration Constraints (CC) for the set orchestration task.

CC	Explanation
INCLUDE	Specifies a member of the network that has to be included in the set.
EXCLUDE	Specifies a member of the network that has to be ignored for the set.
MUTUAL EXCLUDE	Specifies a pair of members of the company network that must not be considered together for the set.

The "part-of" association between class Collaboration Request Profile and class Request Element reflects that a Collaboration Request Profile may be composed of many Request Elements. Likewise, the "part-of" association between

Collaboration Request Profile and Collaboration Constraint reflects that a Collaboration Request Profile may involve many constraints.

The Network Actor Set and Orchestration Item (two classes in the middle of Figure 2) represent the orchestration result generated by a support service for a given Collaboration Request Profile. The class Network Actor Set captures administrative data about the total orchestration result. The class Orchestration Item describes an assignment of a single company from the network to a Request Element. As a Collaboration Request Profile may consist of many Request Elements, a Network Actor Set may consist of many Orchestration Items. This is expressed by the "part-of" association between class Network Actor Set and class Orchestration Item.

The example scenario of a company network specialized on passenger seats introduced in Section 2, the assumed Request for Quotation for 400 passenger seats may be mapped into a Collaboration Request Profile as given in Figure 3 below (here presented as a sketched XML document).

```
<CRP CRP-ID="ID of the CRP">
  <Inquiry-ID>ID of inquiry from shipyard asking for an offer for 400 seats</Inquiry-ID>
  <!--description of the request elements -->
  <Request-Element RE-ID="1">ID of seat frame as an offering</Request-Element>
  <Request-Element RE-ID="2">ID of seat upholstery as an offering</Request-Element>
  <Request-Element RE-ID="3">ID of circuit system as an offering </Request-Element>
  <Request-Element RE-ID="4">ID of monitor as an offering </Request-Element>
  <Request-Element RE-ID="5">ID of harness as an offering </Request-Element>
  <Request-Element RE-ID="6">ID of seat assembly as an offering</Request-Element>
  <!--description of the collaboration constraints -->
  <Include-CC ICC-ID="1">ID of member being the preferred seat frame supplier</Include-CC>
</CRP>
```

Figure 3: Request Elements.

Similarly the Figure 4 shows a Network Actor Set that might have been orchestrated for this sample Collaboration Request Profile.

The orchestration task service will take as input a Collaboration Request Profile and as output compute the several possible Network Actors Sets under consideration of the information in the Company Network Directory. However, as the number of alternatives will tend to be high it can easily lead to a situation of information overload. Furthermore, the computation of these alternatives will in itself be a problem of magnitude due to a combinatorial explosion. Therefore our research is also geared towards a smarter orchestration service that will be capable of considering optimization criteria for the orchestration task and use these criteria to compute a short ranked list of Network Actor Sets. This ranking will reflect the "goodness of fit" of a Network Actor Set with respect to given optimization criteria. Through this approach, we believe that the natural way moderators deal with the orchestration task is imitated to a large degree.

```
<NAS NAS-ID="ID of the NAS">
  <CRP-ID>ID of corresponding CRP</CRP-ID>
  <!--description of the orchestration items -->
  <Orchestration-Item OI-ID="1">
    <Request-Element>ID of corresponding RE in CRP </Request-Element>
    <Actor>ID of assigned member company</Actor>
  </Orchestration-Item>
  <Orchestration-Item OI-ID="2">
    <Request-Element>ID of corresponding RE in CRP </Request-Element>
    <Actor>ID of assigned member company</Actor>
  </Orchestration-Item>
  <Orchestration-Item OI-ID="3">
    <Request-Element>ID of corresponding RE in CRP </Request-Element>
    <Actor>ID of assigned member company</Actor>
  </Orchestration-Item>
  <Orchestration-Item OI-ID="4">
    <Request-Element>ID of corresponding RE in CRP </Request-Element>
    <Actor>ID of assigned member company</Actor>
  </Orchestration-Item>
  <Orchestration-Item OI-ID="5">
    <Request-Element>ID of corresponding RE in CRP </Request-Element>
    <Actor>ID of assigned member company</Actor>
  </Orchestration-Item>
  <Orchestration-Item OI-ID="6">
    <Request-Element>ID of corresponding RE in CRP </Request-Element>
    <Actor>ID of assigned member company</Actor>
  </Orchestration-Item>
</NAS>
```

Figure 4: Sample Network Actor Set.

There are several examples of optimization criteria for the orchestration task specified in Table 2 and many more could be given. The *General Criteria* refer to key properties of single network members that typically drive collaboration decisions in company networks while the *Collaboration-oriented Criteria* address aspects of the company network as a whole that drive the collaboration decisions.

It should be noted, that the two examples for collaboration-oriented criteria given above can work in opposite directions as the company that has had only a small profit share normally also will not have a large amount of collaboration experience. This exemplifies that the moderator has to be careful in choosing from the list of optimization criteria for a given inquiry. Through standard optimization techniques one may compute the targeted short ranked list of Network Actor Sets under consideration of the chosen optimization criteria. At the current stage of our research, we are experimenting with a heuristic optimization scheme (Thimm, 2007).

Table 2: Optimization criteria for orchestration.

Optimization Criterion	Explanation
General Criteria	
Distance	Preference is given to network members that are closest to a given location.
Price	Preference is given to companies that offer the lowest price for the product and service, respectively.
Experience	Preference is given to companies with largest amount of experience in supplying the specified Request Elements.
Product Quality	Preference is given to companies that are assessed as high-quality product suppliers.
Service Quality	Preference is given to network members that are assessed as high-quality service suppliers.
Resource Availability	Preference is given to companies with largest amounts of unused production resources.
Economic Power	Preference is given to companies with strongest economic power
Collaboration-Oriented Criteria	
Collaboration Experience	Preference is given to companies with largest amounts of collaboration experience.
Network-Related Business Benefit	Preference is given to companies to which the network delivered the smallest total amounts of profit shares so far.

4 PROTOTYPE OF THE SUPPORT SERVICE

A first standalone prototype of our proposed support service for network moderators are currently being implementing. Figure 5 shows the general layout for the prototype for which we apply the typical technologies for web-based multi-tier software architectures. That is, the prototype offers a web browser-based front end that communicates over the HTTP protocol with the application that runs on a web application server.

The *Collaboration Proposal Generator* presents the central component that computes Network Actor Sets (NAS). We use the XML approach as presented in Section 3 for a standardized data exchange between the front-end and the application server. The prototype is implemented based on the Java programming language and further Java technologies such as JSP, JSF, and JPA.

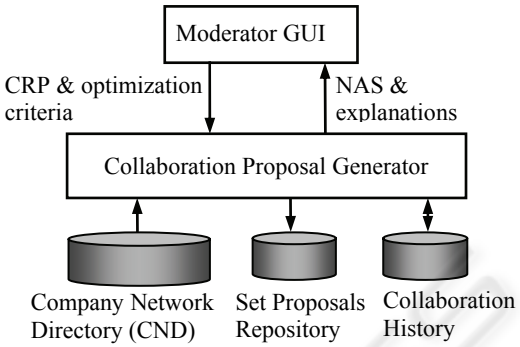

Figure 5: System architecture of prototype.

The database is logically divided into the three main repositories shown in Figure 5. The *Company Network Directory* (CND) corresponds to the CND of our object model described in Section 3. In this repository the companies are described in terms of their product and service offerings and also their competencies and technical abilities. The *Set Proposals Repository* contains recorded Collaboration Request Proposals and Network Actor Sets resulting from interactive sessions of the moderator. Data about performed collaborative processes and business transactions that has earlier occurred in the network are administered in the *Collaboration History*.

In Figure 6 we present the prototype GUI for the moderator. The choices (e.g. for products and services) in the selection boxes are dynamically populated from queries to the database. The upper window part contains GUI elements to describe a Collaboration Request Profile. The Request Elements may be specified by selecting corresponding products and production services from the given product list and production services list. Collaboration constraints may be edited through usual GUI elements for condition editing known from other software packages. In the middle part of the user interface the optimization criteria may be selected from a given set of check boxes. Given this input the generated Network Actor Sets are presented in the lower part of the main window. The two lists contain the proposed component products and production services with correspondingly assigned companies. The list box with title “Products Assigned” contains the component products with corresponding suppliers. The list box with title “Production Services Assigned” contains

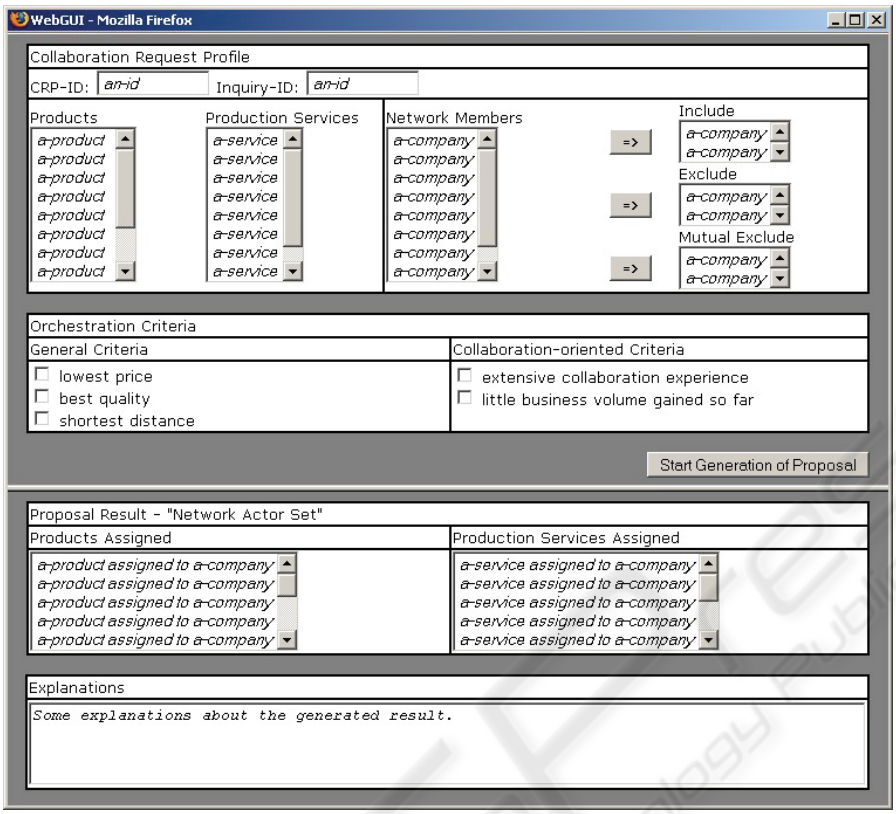

Figure 6: Moderator GUI of prototype.

the proposed production services also with associated supplier names.

5 DISCUSSION OF RELATED WORK

The work here draws from other research and concepts that have been developed for collaborative order management in business networks (e.g. Gizanis, 2006 and Fleisch & Österle, 2000). The difference between these proposals and our work is that we especially consider that complex products may be jointly produced by several companies together in possibly many collaboration alternatives. We particular strive at a means that will enable moderators to find the best alternative among all possible choices based on explicit knowledge about the companies and products. Such explicit knowledge is not available in typical cooperative order management environments. With respect to the research area that is especially dedicated to IT support for virtual organizations our proposed support service is especially related to the virtual organization creation framework developed in the ECOLEAD project (Camarinha-Matos et al., 2005). According to this framework the virtual creation process consists of seven main steps. It appears that the considerations for the first four steps (i.e. 1. identification and characterization of collaboration opportunity, 2. rough VO planning, 3. partners search and selection, 4. Negotiation) are reflected in our approach as well, whereas the remaining steps (5. detailed VO planning, 6. contracting, 7. VO launching) are outside of our current scope. The idea to assess potential partners with respect to different types of selection criteria can also be found in the ECOLEAD project. However, to our knowledge still so far missing is a description of how these ideas may be combined to a corresponding support service for VO planners. Such a corresponding solution for a support service targeting the orchestration task in company networks for example is presented in (Jarimo & Salo, 2007). Often mathematical methods are employed in these solutions (Schweinberger, 2002 and Bittencourt & Rabelo, 2005).

6 FUTURE WORK AND CONCLUSIONS

A great deal of work still lies ahead in determining correct and fruitful concepts for the description of both offerings as well as the potentials of companies. We will draw upon other researchers working with ontologies and ontology construction especially within eBusiness (Missikoff & Taglino, 2003). Furthermore, the transformation of an incoming inquiry by deconstruction or modularization (Baldwin & Clark, 2000) into a production process has not been the focus of our current version but further support of the moderator will be welcome in that area too.

The responsibilities of moderators of company networks may include the inquiry management process and, therefore, also the determination of the best possible set of network actors to handle a given inquiry. These actors are to be selected from the set of all members of the company network. This task may impose a complex orchestration problem on the moderator for which we seek to develop a flexible and powerful IT based support service. We address this objective by an adaptable optimization approach where moderators may choose optimization criteria from a given list of predefined choices. The optimization criteria given in this article only present an initial proposal. We expect that many more useful criteria can be found and integrated in our solution which will be part of our future work. Integrating additional optimization criteria may require to extent our system architecture by further data repositories. For example, an optimization that takes the availability of production resources within the network into account will require a further data repository. In this repository the utilization profiles of the companies' production resources and production scheduling information, respectively, need to be available.

Before we will extend the set of available optimization criteria, we will verify our service by simulation experiments and through further tests with real moderators of company networks.

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