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SUPPORTING MODERATORS OF COMPANY NETWORKS BY AN OPTIMIZATION SERVICE FOR ORCHESTRATION

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Abstract

The management process in company networks often imposes the challenging task to select or orchestrate members of the network into a particular set (network actor set) that delivers the "best fit" for an incoming inquiry to the network. The constraints are implied by the given inquiry, company offerings, and the current economical and collaboration status of the network. The companies forming the network are experiencing synergetic effects as their collaboration makes participation in larger and/or more complicated projects possible. The collaboration network is supported by information and communication technology and the task of orchestration is often entrusted to a person acting as network moderator. As many alternatives often exist, the task to obtain a proper set for a given inquiry can easily over-challenge a network moderator. This may lead to severe economic damage of the company network and the members. We introduce a supporting IT solution that will enable moderators to obtain optimized set proposals very flexibly and under comprehensive evaluation of the current economical status as well as from the collaboration history of the network. Our solution will also lead to better transparency, traceability, and analytical possibilities regarding collaborative inquiry and order management processes.

Keywords: Company Networks, Production Networks, Virtual Organizations, Collaborative Business, Cross-Company Business Process Orchestration, Collaboration Platforms, Company Selection, Moderator.

1 INTRODUCTION

Collaborative networks in which companies come together to jointly act on the market in a well coordinated form have been promoted as an approach to deal with today's business challenges such as the globalization of markets. Some parts of the hypothesis and theory behind this recommendation are based on the theory and analysis of industrial clusters (Porter 1998). More recent research defines collaborative networks and investigates it as a new scientific discipline (Camarinha-Matos and Afsarmanesh 2005) where the authors among other projects also introduce the ECOLEAD 6th framework project with a focus on virtual organization breeding environment forming the basis for the selection of a virtual organization. For the coordination of collaborative business processes in such networks an authority has been suggested (Harbilas et al. 2002, Kramler et al. 2005) which we refer to as (network) moderator. We learnt from an existing company network that the moderator's responsibilities may include the management process that we regard as the orchestration task. It is the goal of this task to determine that particular subset of companies of the network which is best suited for handling a received inquiry. This task involves on the one hand constraints that are directly expressed in the inquiry such as a price limit or a delivery deadline for a certain product the inquirer is interested in. On the other hand, further constraints are to be considered that may not be so obvious because they require deep insights into the current economical situation as well as the collaboration history of the network. 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 orchestration can be further complicated as network members not only have delivery of existing products and offering but also have resources as competences and capabilities and furthermore a strategy of developing and exploiting these.

The goal of our research is to provide comprehensive information technology (IT) support for moderators of company networks and in particular for the orchestration task. For the long run, we intend to integrate such a service into available and forthcoming collaboration platforms for company networks. The exploration of novel support services for moderators of company networks is one central goal of the eBusCo.net project which is the overall framework of the research described in this article (Thimm 2007). Other issues within eBusCo.net that stands for "Electronic Business in Company Networks" includes an empirical study of the information and communication technology (ICT) readiness and networking maturity with 1000 contacted companies (small and minor enterprises (SME[1])) in the production industry KERN region of Northern Germany and the region of Southern Denmark. Practical insights into company networks are contributed by the involvement of two existing company networks and two regional business development agencies.

In this paper we present results of our work on such a support service for the orchestration task of moderators. Using our service the moderator may choose dynamically for given inquiries individual optimization criteria from a list of predefined criteria. Our service will use these criteria to compute the most suitable set of network members under a comprehensive evaluation of the current economical status and the collaboration history of the network. We expect our service to outperform even the most experienced moderators that are completing the orchestration task in an intuitive pure intellectual fashion simply on the grounds of the limited capacity for handling many simultaneous constraints. The further benefits of our service are that it may lead to more consistency, transparency, and traceability regarding the orchestration task and that it enables analytical capabilities that are helpful for the supervision of a company network.

[1] The European definition of SME companies according to number of employees is for 10-49 (small) and 50-249 (medium). The complete SME definition also includes economic measures of the company (European Commission 2005).

The remainder of this article is organized as follows. Section two presents our observations with respect to inquiry handling from an existing company network. In Section three, we introduce an object model and building blocks for such a support service for network moderators. A system architecture and implementation details for a first prototype of this service are presented in Section four. Related work is discussed in Section five and concluding remarks are given in Section six.

2 OBSERVATIONS FROM AN EXISTING COMPANY NETWORK

Within the eBusCo.net project, we work together with two company networks. One of them is the German Produktionsnetzwerk (Production network) Neumünster which consists of about 30 production companies. This network has been working successfully already for more than six years. Part of the success of this network results from the fact that the network is moderated. This moderator is a well accepted person with a significant background in production processes and technologies but also in business management. The responsibilities of the moderator, among many others, include the orchestration of external inquiries with a need for choosing the most appropriate set of companies as the handlers of a specific inquiry.

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.

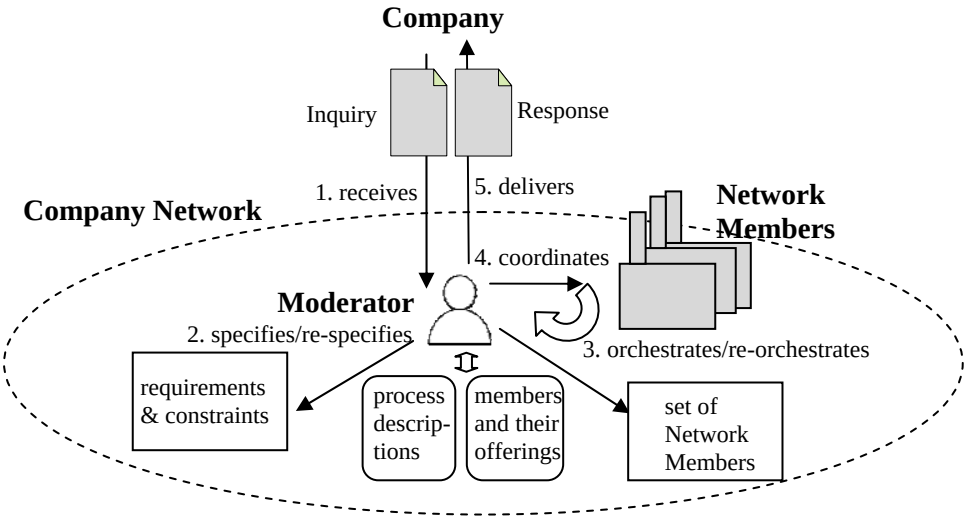

Figure 1. Scheme for moderator-based inquiry handling.

An inquiry is received by the network through the moderator (1). If the inquiry refers to a product of the company network's standard product offering, then a description is available for the moderator of the required collaborative production process. Otherwise, the moderator will create a corresponding new process description. Based on this process description, the moderator will then decompose the potential customer order into corresponding order components. As a concrete illustrating example we assume a company network that has specialized on passenger seats for planes, ships, trains, and buses. 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: 1. provision of metal seat frames, 2. provision of seat upholsteries, 3. provision of circuit systems, 4. provision of monitors, 5. provision of harnesses, 6. final assembly of seats.

By describing these order components a specification of the requirements is produced (2). As the example shows, these requirements refer to needed product parts and production steps. In addition to

these primary requirements, the moderator sometimes specifies constraints for the targeted network members. These constraints express preferences given by the inquiring company and/or collaboration preferences of the network members. In our example, the inquiring shipyard might have explicitly asked that the seat frames should be produced by a specific company of the network.

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 proper network members based on their company profiles and products and services offering. 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 with them (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 will then generate a corresponding response (e.g. offer to a Request for Quotation) which is next delivered (5) to the inquiring company.

Until now, our observations from the Produktionsnetzwerk Neumünster have been described. However, in general, IT-based support services may be very useful 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, the search space for finding the most-suited set may easily over-challenge a human moderator due to a large number of different set alternatives as often the members of a company network offer not only complementing but often also overlapping offerings. Secondly, it is often the case that the current economic situation of the network needs to be considered because operational rules given by the members of the network typically require that business should be somewhat evenly distributed over all network members. Furthermore, proper IT support may reduce the influence of human factors on the orchestration outcome and bring better consistency of orchestration decisions over time, better traceability of these decisions, and helpful analytical possibilities may arise from such a support service.

3 CONSIDERATIONS FOR AN ORCHESTRATION SERVICE

In the previous section we have motivated a support service for moderators of company networks that are targeted at the orchestration task. In this section, we present major considerations for the design of such a support service.

From a data modelling point of view the central entities of such a service may be described through an object model. We have devised such a model which is given in Figure 2 using the diagrammatic notation of the Object Modelling Technique (Rumbaugh 1997).

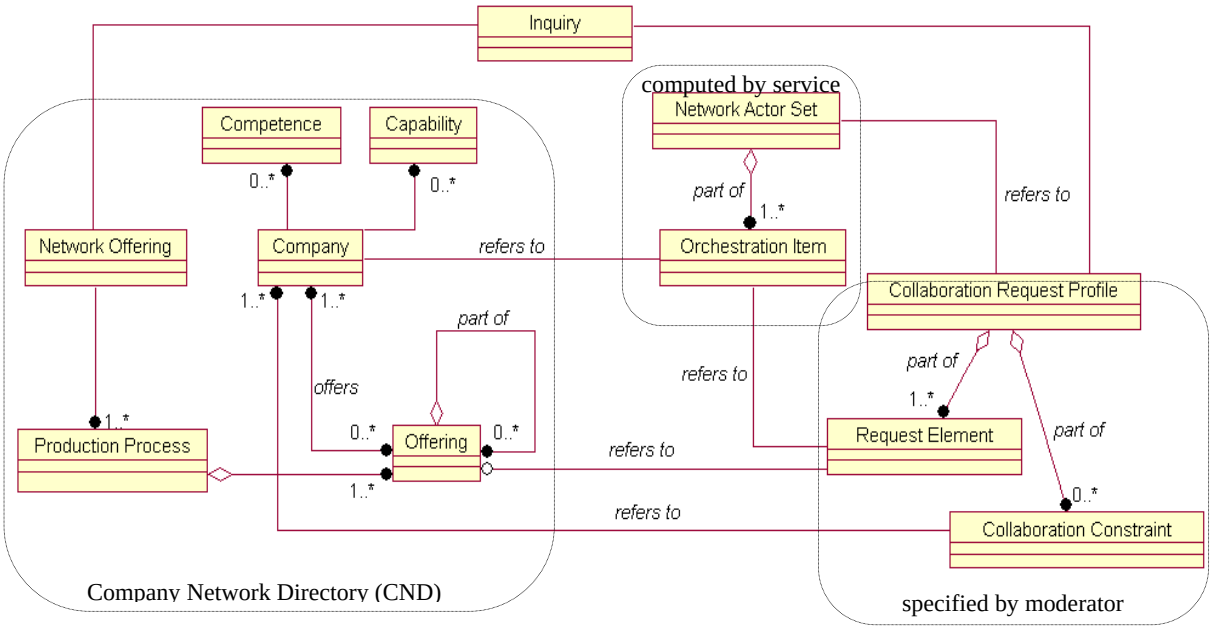

Figure 2. Object Model for a support service for network moderators.

The class Network Offering represents the offering of the company network to the market. If such an offering is ordered by someone then several network members collaborate together in the production of the product or the delivery of the service being ordered. The class Production Process models these collaborative processes that consist of a combination of a number of different parts. These parts are modelled by the class Offering which represents 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 several component products and component services, respectively.

The companies of the network are reflected by class Company. The properties of class Company reflect general data about companies, whereas the competencies, technical abilities (capability), and offering of the companies are modelled by separate classes. We refer to the classes that are framed together in Figure 2 as Company Network Directory (CND). These classes capture relative static data. As opposed to that 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 captures administrative data about an orchestration problem to be solved for a given inquiry. The class Request Element represents needed products and production services, respectively. The class Collaboration Constraint represents the set constraints shown in Table 1.

CC	Explanation
INCLUDE	Specifies a member of the company network that has to be included in the set.
EXCLUDE	Specifies a member of the company 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.

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

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 two classes in the middle of Figure 2 (i.e. Network Actor Set, Orchestration Item) 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 orchestration result. The class Orchestration Item describes an assignment of a single company from the network to a Request Element. Consequently, since 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.

For our sample 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. For the sake of clarity and readability this example is presented in the form of a sketched XML[2] 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 prefered seat frame supplier </Include-CC>
 </CRP>
```

Figure 3. A sample Collaboration Request Profile.

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

[2] XML stands for Extensible Markup Language which allows users to define their own type of documents as it is demonstrated in the figures.

```
<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. A sample Network Actor Set.

The concepts introduced so far may be used to implement a support service through which helpful information may be obtained for the orchestration task. As it is straightforward to see this service will take as input a given Collaboration Request Profile and as output compute the set of possible Network Actors under consideration of the information in the Company Network Directory. However, one may argue that only computing a list with all the possible orchestration alternatives is not sufficient. Often the number of different alternatives will be too high and, thus, lead to an information overload situation or already the computation of these alternatives will be a problem due to a combinatorial explosion. That is the reason why our research is geared towards a more intelligent orchestration service that will be capable to consider 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 intuitive and somewhat incomprehensible natural way moderators deal with the orchestration task is imitated to a large degree.

Table 2 presents an initial set of optimization criteria for the orchestration task. The *General Criteria* refer to obvious key properties of single network members that typically drive collaboration decisions in company networks while the *Collaboration-oriented Criteria* address collaboration specific aspects or aspects of the company network as a whole that drive collaboration decisions, too. Ideas that are especially related to these Collaboration-oriented Criteria can be found in (Camarinha-Matos and Abreu 2005).

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.

Table 2. Initial set of optimization criteria for orchestration.

We are aware that several tensions can be created when selecting preferences for the criteria. The two examples for collaboration-oriented criteria given in Table 2 will typically work in opposite directions. It is thus unlikely that these two criteria both will be chosen at the same time for a given inquiry. In the extreme case that a member has no experience in collaborating with the other members then the network will not yet have delivered any profit shares to this member. If the criterion "Network-Related Business Benefit" is chosen then this member will most likely be selected.

In general, through standard optimization techniques one may compute the targeted short ranked list of Network Actor Sets under consideration of the chosen optimization criteria. For example, at the current stage of our research, we are experimenting with a heuristic optimization scheme described in (Thimm 2007).

4 PROTOTYPICAL IMPLEMENTATION OF THE PROPOSED SERVICE

We are currently implementing a first standalone prototype of our proposed support service for network moderators. Figure 5 shows the "big picture" of this 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 general Internet HTTP protocol with the application that runs on a web application server. We use the XML approach as presented in Section 3 for a standardized data exchange between the front-end and the application server. The data are maintained in a common database. The prototype is implemented based on the Java programming language and further Java technologies.

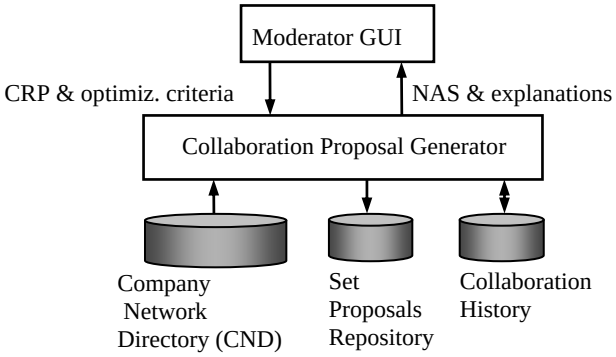

Figure 5. System architecture of prototype.

The so-called Collaboration Proposal Generator presents the central component that, among others, computes Network Actor Sets (NAS) through a heuristic optimization scheme presented in (Thimm 2007).

The content of the database may be 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. That is, 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 occurred in the network are administered in the Collaboration History.

Figure 6 shows the principle structure of the moderator GUI (Graphical User Interface). In general, the choices offered in the selection boxes are dynamically queried from 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. Obtained Network Actor Sets are presented together with some explanations in the lower part of the main window. In particular, they are presented in the form of two lists that 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 the proposed production services with associated supplier names.

5 RELATED WORK

There exist some similarities between our research and concepts that have been developed for collaborative order management in business networks (e.g. Gizanis 2006, 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 a lot of different 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 the typical environment of cooperative order management.

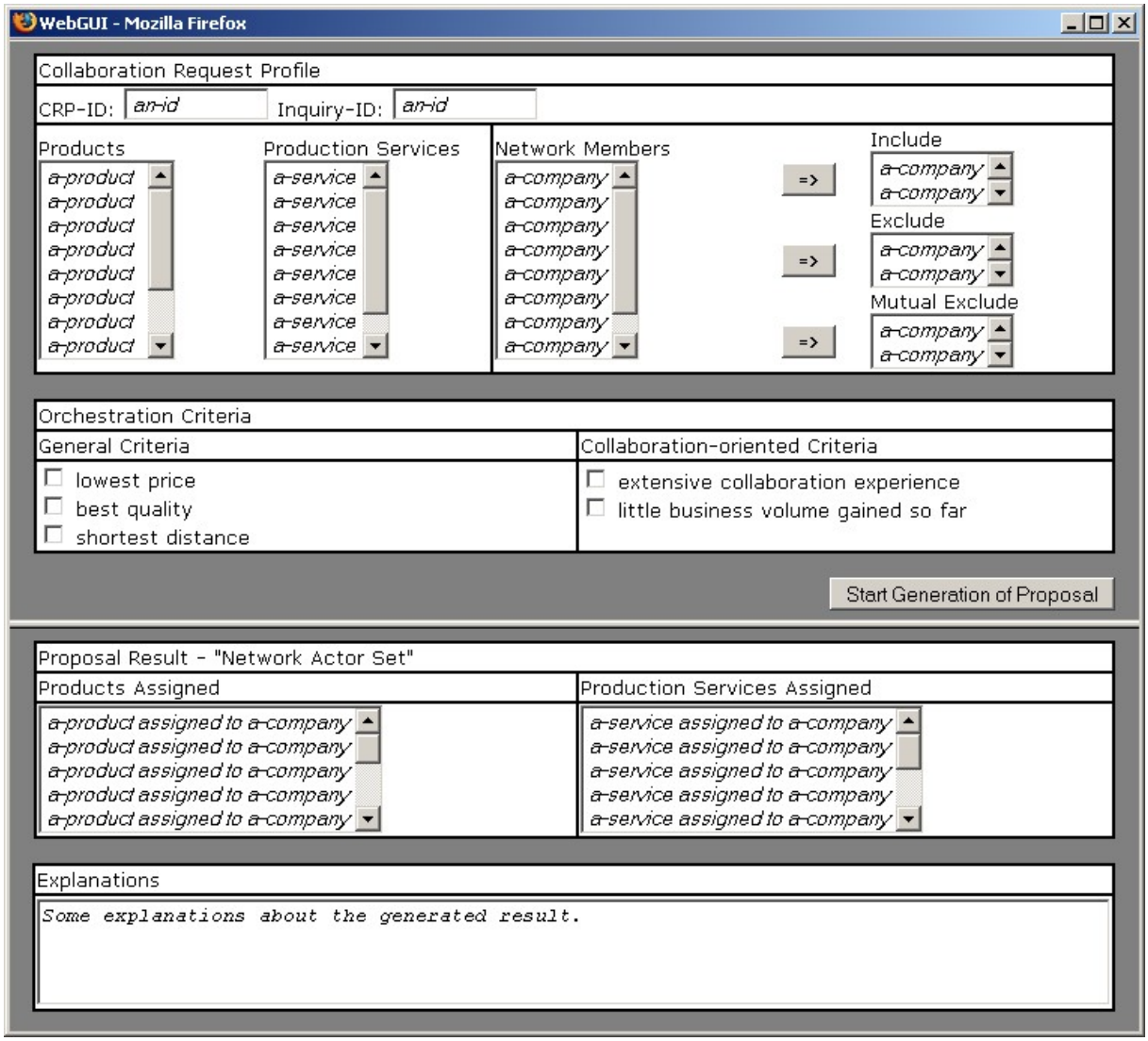

Figure 6. Moderator GUI of prototype.

The orchestration task in company networks has been addressed in other projects before (Jarimo & Salo 2007). Often mathematical methods are employed for this task (Schweinberger 2002), (Bittencourt & Rabelo 2005). Many of these approaches that have been proposed are geared at searching the best partners for the creation of a new company network. In contrast to that, we focus on the selection of partners from an already existing company network.

Some of the implementation issues for our proposed service that we have not explored so far have been addressed in other projects. We will adopt as much as possible from these projects. This will include proposals for representing products and services (Hepp 2006), profiles and competencies of companies (Tsakopoulos et al. 2003) in a machine processible and standardized form.

6 CONCLUSIONS AND FUTURE WORK

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 carefully selected by the moderator from the set of all members of the company network. This task may impose a complex orchestration problem 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 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. Furthermore, the static or retrospective descriptions of the companies can be extended to include strategic information on which new competences and capabilities the company would prefer to address.

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.

The issue of selecting criteria will be refined into the possibility of applying weights for the criteria as well as mechanisms for identifying and opposing possible tensions or logical locks arising in the selection.

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