13 AUTOMATING DECISIONS FOR INTER-ENTERPRISE COLLABORATION MANAGEMENT

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The current trend towards networked business forces enterprises to enter federated, loosely-coupled business networks, since much of the competition takes place between networks and value nets. The Pilarcos B2B interoperability middleware supports trend by providing services such as business service discovery and selection, interoperability management, eContracting, and reputation-based trust management. Although these services automate the interoperability knowledge management and interoperability testing, and may help in routine decisions, an essential element of the architecture involves an expert system that automates or supports decisions on joining collaborations, acting in them, or leaving them. The expert system focuses on a single enterprise needs. This paper focuses on the ways of governing the automation level in the expert system in a way suitable for autonomous enterprises to control their participation in agile collaborations.

1. INTRODUCTION

The collaborative use of software-supported business services has become increasingly important for enterprises, as competition between enterprises is increasingly being replaced by competition between business networks and value nets. Entering the networked business encourages even SMEs (small and medium enterprises) to enter fields that are traditionally dominated by larger companies. The collaborative way of working allows focused fields of expertise to be utilized as elements of large, value-added services.

Enterprises have a strategic need to participate multiple network simultaneously, and for managing changes in these networks. This is reflected as new requirements for the supporting computing facilities [3-5, 10, 12, 13]. The type of joint work and the associated value proposition varies between integration (coordination, communication, channeling) and federated solutions (cooperation, collaboration) [11]. The forms of collaboration vary from loosely-coupled federations of autonomous actors providing services to each [9], to distributed workflow management approaches [1], and the level of automation provided by support facilities varies.

In this area, the Pilarcos architecture provides B2B middleware support for forming and managing loosely-coupled business networks of autonomous actors [7, 9, 19]. Its tasks include partner selection and negotiation, interoperability tests for technical and business aspects of services (such as technical communication interoperability and sufficient match in meeting business processes), collaboration lifecycle management with partner changes, and breach management.

The Pilarcos architecture views the open service market as a breeding environment for different types of value nets; the market is guided by published business network models addressing different motivations for collaboration, coordination, cooperation and communication. The service providers are autonomous: they publish a service offer as an indication of a willingness to provide a given service at given terms and they make independent decisions on whether to join, continue in or leave an eContracted community [7, 9].

In this kind of environment, the nature of decision-making is profoundly different from centrally coordinated collaboration: the trustworthiness of a potential partner cannot be judged based on its service offers alone, a partner may decide to leave the collaboration abruptly or a partner may choose to contradict the contract.

This paper proposes an expert system to support decision-making for participation in inter-enterprise collaborations. The expert system addresses needs for controlling interoperability aspects, for meeting the pressure to balance risks and benefits of collaborating, and for reputation-based trust decisions. Section 2 discusses the information needs of the expert system and negotiation protocols involved. Section 3 discusses the automation potential for the negotiations and decisions, as well as ways of governing the process and making escalation decisions. Section 4 discusses the impact of the system, related work, and future work items.

2. NEGOTIATION SUPPORT FOR JOINING INTER-ENTERPRISE COLLABORATIONS

The expert system role is either a) to make an automated collaboration decision in a routine case or b) to escalate the decision to a human administrator in a new type of situation, together with appropriate information about the proposed collaboration to support the decision.

In the Pilarcos architecture [9], the collaboration establishment process is as follows. First, the initiating partner selects from a public repository a business network model that suits the purposes of the collaboration. The business network model comprises of a set of external business processes between roles, assignment policies determining on what conditions roles in the business processes need to collocate (or are forbidden to collocate) with a partner, and coherence rules for the joint behaviour. The published models are designed by domain experts and can be harmonized to serve the business area. The models are rather abstract to allow technical realizations vary, and model checked to remove deadlocks and other unwanted features; indeed, in future, we even consider privacy-aware analysis for the models. A simplistic business network model may have roles of client, seller, and notary; the interactions denoting offers, counteroffers, contracts, and signatures and archiving actions by the notary.

Second, the populator [7] acts as a secretary for the initiator and seeks suggestions for the missing role players in the business network model through service offer repositories. The populator only acts on the public information and is expected to ensure that the selected offers form an interoperable collaboration community according to the rules of the business network model.

We understand interoperability, or the capability to collaborate, as the effective capability to mutually communicate information in order to exchange proposals, requests, results, and commitments. The term covers technical, semantic and pragmatic interoperability. Technical interoperability is concerned with connectivity between the computational services, allowing messages to be transported from one application to another. Semantic interoperability means that the message content becomes understood in the same way by the senders and the receivers. This concerns both information representation and messaging sequences. Pragmatic interoperability captures the willingness of partners to perform the actions needed for the collaboration. This willingness to participate refers both to the capability of performing a requested action, and to policies dictating whether it is preferable for the enterprise to allow that action to take place.

If no interoperable communities can be found, the initiated activity fails; the involved parties can participate the definition of a new business network model, or push new service offers to be published in order to improve the situation. For minor mismatches, the interoperability criteria can be relaxed, with the condition that there are sufficient translators/interceptors to make the necessary bridges in the technical level, and that the participants trust on those brides suggested.

As the populator returns information of suitable partner sets, the initiator can start the negotiation phase [9]. It informs each of the proposed collaboration partners about the proposed eContract. When all partners have agreed, the eContract is distributed to all, and the committed services are prepared for collaboration activities. The eContract is an active, distributed agent that is used for following the state changes in the collaboration (i.e., progress of work), source of breach detection rule generation, and source of information about identities and properties like location of the partners' service interfaces.

In each enterprise, there is an agent that uses the expert system to provide decisions for accepting the proposal, rejecting it or refining the proposal further. In this phase, information and reasoning used for the decision are private and not exposed to other enterprises, but is embedded in the suggested expert system.

The decisions on joining collaborations are multifaceted. The partners need to determine whether the collaboration is a) interesting, b) acceptable and c) worth taking the risks involved.

Interest in a collaboration depends on business strategic issues, concentrating on whether the collaboration objectives suit the enterprises' own objectives and views on what strategies are plausible to good return of investment or will create a competitive edge on the market. The interest to collaboration may depend on the availability of necessary supporting partners in the business network model, or wish to avoid working for the competitors. In the enterprise, some of the clear strategic decisions can be coded for the expert system to follow. Especially, the interest can be narrowed only to certain kind of business networks, or new partners are less interesting than existing, strategic partners, since these concepts are computationally manageable in the proposed architecture.

Acceptability of a collaboration is here understood as ability to participate the collaboration with the existing facilities within the range of publicly announced policy limits. Technically, this decision can be supported by the selection and interoperability checking process of the populator. An enterprise can limit the amount of suggestions directed to it by advising the populator through the details in the published service offers. For example, an enterprise can publish offers using certain communication technology only. However, acceptability rules like not working with company X are more prone to be left for the negotiation phase for not creating a negative publicity.

Finally, evaluating whether a collaboration is worth taking the risk is a trust decision on two levels: a) is the collaboration as a whole to be trusted with the information feeds, resources, and activity involved, and b) is each of the other partners to be trusted to perform its part sufficiently for the collaboration not to cause major losses.

The Pilarcos architecture relies on reputation-based trust decisions. In the network of autonomous enterprises, a flow of reputation information about the business services is organized: each time a collaboration ends successfully or to a breach situation, positive or negative recommendation can be sent to others. The reputation information can then be used for selecting service offers to new collaborations, and effectively implementing a social regulation system to the overall architecture [7]. The trustworthiness of the reputation information must be taken to account.

We define trust as the extent to which one party is willing to participate in a given action with a given partner in a given situation, considering the risks and incentives involved [16]. Risk we express as the potential benefits and costs of a positive trust decision to a set of assets – namely: money, control of autonomy, and customer satisfaction representing different domains of reasoning – each separately on a scale of expected major or minor loss or gain. Risk tolerance describes a set of thresholds for risk itself and the quality of the reputation information that was used to produce the risk estimate. Multiple threshold sets can be defined; the central two thresholds to set determine obvious positive (allow) and obvious negative (do not allow) decisions: the gray area between the two is left for an actor with higher authorization, a human user, to determine. A threshold set can for example specify that the probability of minor or considerable monetary gain combined be greater than the probability of minor or considerable monetary loss, and that the probability of a minor reputation loss is tolerable. The evaluations of risks and incentives are annotated to the business network models in the design phase, the corresponding thresholds are for business/system administrators to choose/adjust.

To expert system must consider the following information elements and sources:

- the business network model to describe the shared view of business processes involved; this information is made available in the eContract proposal;
- the partner's capability to fulfill a role in the collaboration;
- interceptors needed for communicating with that partner service;
- the partner's reputation, to base trust decisions on earlier experience;
- the value proposal of the activity for the enterprise itself;
- the expected gains in terms of assets such as money, reputation, as well as the possible losses, also in terms of effects to assets; and
- knowledge of the degree in which interoperability on non-functional aspects can be supported (for example, security and nonrepudiation of the communication between partners, QoS management, etc).

3. GOVERNING AUTOMATION IN DECISION-MAKING

The level of automation in eContracting has to be considered carefully. The risks involved in adopting the Pilarcos style of operation include taking wrong automated decisions, or reacting too quickly or slowly to changed reputation information. Risks may also be introduced by creating vulnerabilities in the middleware layer.

The techniques for avoiding these vulnerabilities include the use of metapolicies for grouping decision situations to routine cases and human-decidable, adjustable thresholds for different types of operational situations for positive and negative routine decisions, and finally building of systemic trust into population and negotiation processes as well as into Pilarcos middleware information repositories. The thresholds were already mentioned in Section 2; systemic trust on Pilarcos middleware level is left to be discussed elsewhere [7]. As the remaining element, we discuss metapolicies.

A metapolicy is a policy about when and how a decision can be made by an automated decision-making system according to its internal rules. We have identified four metapolicy categories:

1. Strategic orientation of the enterprise,
2. Systemic trust on automatically added services,
3. Credibility, correctness and quality of reputation metadata and
4. Privacy policy interfacing.

The strategic orientation metapolicies direct the expert system to use resources only to consider in detail proposals that are interesting in terms of acceptable business network models, acceptable partners, or other crosscutting property known in the expert system but that cannot be published in service offers. This kind of metapolicy effectively guides the expert system to favour collaborations of the already acceptable type; new lines of business need to be introduced to the system by reformulating the policy too. The policy represents the guideline to follow; the guideline itself can be derived from for example managerial or financial reasoning.

Systemic trust on automatically added system level services addresses a new problem created by Pilarcos-like architectures. The Pilarcos middleware allows relaxed matching of service interfaces, and thus, supports automatic configuration of communication channels. The type repository [20] in which interface descriptions and their relationships are stored, also provides references to modifier-interceptors to be placed in the communication channel to for example transform euros to dollars. However, the type repositories may be external to the enterprises, or use externally provided modifier-interceptors; therefore, the trustworthiness of the collaboration can be undermined by that small helping device. These metapolicies should be able to identify which type repositories or which interceptors can be freely used and which should be rejected.

The third category of metapolicies arise from the need of suspecting the quality of information in the Pilarcos middleware repositories and in the reputation information collection process. The reputation information is divided into two types: local reputation, which is gathered from events generated by local monitors and transformed into experiences, and external reputation, which is gathered through agents operating in global reputation networks. Local reputation is reliable and high quality, but expensive to gather, as it requires taking the risk of collaborating with the target actor. On the other hand, external reputation is less expensive to gather but more unreliable, and more likely to contain errors. The relative weights given to local and external reputation in a risk evaluation are determined by the amount, certainty and credibility of each type of reputation information [17]. The weight is increased as the amount of cases seen with a definite outcome increases (uncertain results are noted as a separate category of outcomes), and credibility of reputation information providers is followed as their reputation in their role as seen by their peers. For example, if the reputation system does not support rigorous source credibility evaluation or distorts information passed through it, its credibility is low.

Finally, privacy metapolicy governs privacy-affecting activities in collaborations. From a design point of view, it would be tempting to treat privacy-policies as normal policies governing each service or information element, but the nature of privacy-preservation is to veto otherwise acceptable actions. Therefore, we raise the privacy-policies to the level of metapolicies. For example, it may be the case that the suggested collaboration is interesting, acceptable, and considered at the general level to be trustworthy. However, in the processing it may happen that a service request triggers the need of passing classified documents as part of the service. In this case, it is essential that the privacy classification of information overrides any collaboration agreements, and the individual action of serving a single service request is escalated to human decision-makers. The privacy policies must be attached to all metainformation, in addition to the normal payload data.

4. DISCUSSION

We have outlined a semi-automated negotiation system for establishing inter-enterprise collaborations. The negotiation system takes advantage of multi-agent technology by modeling a single organization as an agent running the negotiations. The agent provides service interfaces towards other such agents in other organizations, and interfaces for local services for accessing collaboration management facilities. The Pilarcos architecture has been partially implemented: the populator general performance behaviour appears to be feasible for its task; a simple negotiation protocol has been implemented to let us try on different ways of decision-making. The reputation-based trust decision system is on its way towards implementation. Thus, the information sources will be there to support a range of negotiation protocols to be evaluated with the expert system.

In the domain of B2B collaboration support systems, the Pilarcos approach can be compared to for example ECOLEAD [14] and many projects with virtual enterprise focus. The main difference between ECOLEAD and Pilarcos approaches is that Pilarcos assumes a truly open service market, and builds a separate trust management system based on reputation information. Other approaches tend to trust on breeding environment of already trusted partners, between whom the business processes are formed around the existing capabilities. In contrast to this, Pilarcos uses the publication of business network models as a tool to direct the service markets. The same difference of approaches appear to some well-known trust management projects, like TrustCom [21], where the pre-existing strategic network of partners also appear. Further comparison between Pilarcos (Tube) concepts with other reputation and trust management systems can be found in our surveys [15,17].

The negotiation protocols supported should flex to different situations – sometimes an auction protocol is suitable, sometimes haggling style. Traditional multi-agent negotiation systems, like Magnet [2], focus on auctions in supply chain integration or marketplaces. Chiu et al. [6] have a meta-modeling based approach where they bring up the notion of log-rolling issues where two negotiators have conflicting interests in bilateral negotiations. In Pilarcos, the same situation may arise, especially where multiple policies need to be agreed on simultaneously. The choice is to be made between abandoning the suggested collaboration, and compromising on favourable policy values. The situation is an extension to the traditional distributed constraint satisfaction problem [8]. Zhang et al. [22] propose a graph-based solution to reason about ordering multi-linked variables. The same kind of model can be used in the Pilarcos negotiations for resolving conflicts.

In comparison to multiagent systems, like OMNI [8], the Pilarcos approach differs by using predefined contract templates, by running multi-party negotiations instead of bilateral, and by supporting privacy of decision-making.

Technical challenges include finding a simple but effective language for expressing various policies; there is no eContracting language, not even an ontology to provide orthogonal vocabulary for structuring the field. Languages such as BCA [18] provide for expressing permissions, obligations and prohibitions for the legal and business logics side of the contracts, but do not cover all the required interoperability levels.

The present pressure towards agile business networks can not be addressed by generative solutions in the long run. The first wave of solutions indeed will rely on jointly designed business processes, agreeing that as an unifying model, and wrapping local business services to meet the expected interfaces. This may work for large scale B2B networks, where the level of agility is reasonable – business strategies and investment directions do not change that often. However, it is clear by now that there is a fast growing market of C2C, and mixed communities that require not only agility support from the platform, but support for truly ad-hoc community management. On this field, only reflective, model-controlled solutions can meet the challenge.

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