Towards Regulating Electronic Communities with Contracts

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Abstract

We present work-in-progress towards a high-level e-commerce architecture for the electronic marketplace. We separate out the main components responsible for trading based on contractual relationships and trusted service delivery. In this setting, we view an enterprise as an autonomous entity that interacts with others according to their private utility function and a set of shared goals expressed as normative statements contained within contracts. The Governance component provides a regulated environment where the citizen's behaviour can be monitored and compared against agreed contracts. Regulatory mechanisms can be deployed by the Governance to maintain contractual integrity of transactions.

1   Introduction

In recent years we have witnessed an explosion of business applications exploiting the Internet as a communication medium. Initially, on-line catalogues and shop fronts were deployed, followed by auction sites and finally by electronic marketplaces. [Sculley 1999]. Electronic marketplaces are e-commerce infrastructures that aggregate potentially large number of buyers and sellers. This allows them to interact according to a variety of market mechanisms such as requests for quotes, reverse auctions or exchanges; these often result in significant cost savings.

As each enterprise tries to maximize its goals (including market-makers), conflicts of interests are certain to appear. Possible concerns [Favier 2000] range from the security of transactions, the fairness of the market mechanism, anonymity, and so on to the identity of business partners and service performance.

MARKET MAKER   MARKET GOVERNOR
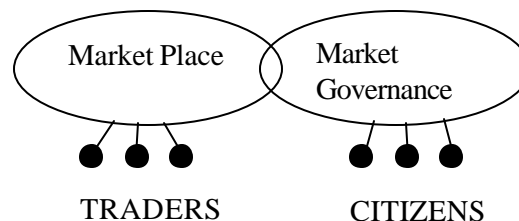

TRADERS   CITIZENS

Figure 1 Conceptual Model of Trusted Electronic Marketplace. The market-maker manages a community of traders that negotiate according to the market mechanism; the market governor manages a community of citizens that deliver services according to the contract.

Because of the increasing value of virtual transactions, we expect the trust issues to become more important and lead to the evolution of trusted electronic marketplaces according to the conceptual model indicated in Figure 1. The market-maker role is responsible for the marketplace that implements one or more market mechanisms with corresponding protocols. Traders (agent programs acting on behalf of enterprise roles) are admitted by the market-maker to the market place where they can negotiate goods or services. When agreement is reached, the traders return with a contract that specifies the details of the trade.

The market governor is responsible for the fulfilment of contracts and conflict resolution. The management by the market governance consists of a set of conflict handling and behaviour regulation mechanisms together with corresponding protocols. These are offered to citizens (agent programs or human enterprise roles) to facilitate fulfilment of their contractual promises.

Note, that in the above conceptual model trader and citizen roles can be fulfilled by different entities. Traders represent citizens that have signature power for potential contracts.

Both the marketplace and the market governance are can be viewed as communities where agents participate in order to accomplish goals: trading and fulfilment of contractual obligations. The market-maker and market-governor define and enforce the rules that impact behaviour of agents and influence the dynamics of the populations that they are responsible for.

The rules are structured in a way that allows communities as a whole to achieve their goals. The market-maker strives to achieve high transaction liquidity and is therefore likely to have lenient admission rules to the market-place. It will enforce market-mechanism related protocols (e.g.: preventing trader to place a bid with a lower price than last offer for English auction). On the other hand, the market-governor will have strict admission rules to the governance and specifies rules related to non-performance of obligations. The market governor and market place may exchange information related to their respective members to help them manage the communities that they are responsible for.

The fundamental problem motivating market governances concerns the non-performance of contractual commitments, plus a need for some practical mechanisms to resolve conflicts resulting from different views whether or not performance has actually occurred or not. Because enterprises are autonomous, it is not possible to directly enforce promises made in the contract. Therefore, the market governance is best viewed as a regulated community with mechanisms that give incentives to parties to perform and penalties for the lack of performance.

In the following sections, we explore how the concept of electronic contract and market governance can contribute to the solution of conflict resulting from non-performance.

2   The Role of Contract in Community Regulation

A contract is a statement of intent that regulates behaviour among organizations and individuals. The electronic contract is its reification in software that can be instantiated as a set of obligations between parties that are fulfilled, refused or waived as future events occur. Because the contract parties are assumed to act in their own interest, conflicts are likely to arise from time to time and an appropriate conflict handling mechanism is required.

We propose that market governor constructs a market governance contract from which any contract for participants of the market-governance will be created. The community contract $T(r, s, g)$ lists a set of roles r and a set of statements s that constrains behaviour of the roles and will be monitored by the role g. The contract $C(r', s', g')$ between a set of roles r' is negotiated as a set of statements s' over the roles and will be accepted in the community managed by the role g subject to constraints:

- Any statement in *s* from T applies to any entity fulfilling role *r'* if the relationship between *r* and *r'* exists;

- For any role statements *s'* are consistent with any statements *s* if they are applicable (e.g.: something that is forbidden by one statement can not be permitted by another one);

- The enforcing roles *g'* and *g* are fulfilled by the same entity.

The community contract *T* can be viewed as a *template* from which contracts *C* are constructed ensuring propagation of relevant community constraints. By joining the market governance and accepting the community contract *T*, the enterprise also agrees to follow certain behaviour and agrees to its behaviour being monitored by role *g*. By doing so, an authority relationship is formed between *g* and the enterprise. The enterprise can then assume a citizen role *r* that allows it to communicate with other community members in the context established by *T*. Citizens can negotiate contracts *C(r', s', g')* to play more specialized roles *r'* (e.g.: service provider or consumer) When the contract is lodged with *g'*, a check is made for the above mentioned constraints.

At a high level of abstraction, the contract statement $s_i(e, p, \sigma)\hat{I}\,s$ can be seen as a promise *p* to bring about the state of affairs σ, subject to condition *e*. Furthermore, the statement may specify what the evidence $E(s)$ is required to sufficiently demonstrate that σ has taken place.

The promise types $p=\{O, P, F\}$ are obligation, prohibition and permission. The statements involving former two types of promise imply a disincentive in case of non-performance and performance respectively whereas the latter allows for a free choice. The disincentive s_j for a statement s_i can be expressed as an obligation or prohibition statement s_j that is conditioned on non-performance of s_i. The promises are directed [Tan 1999] so that in each statement we can identify a promising role that bears responsibility to deliver the commitment.

Seen in the context of the regulation, contracts provide means of declaring expected behaviour and the behaviour that will constitute non-performance.

3   Market Governance

Market governance is a realization of a community of citizens and regulated by the market governor role and a collection of incentives and disincentives mechanisms that regulate behaviour of the community. The goal of the community is to minimize possibility of conflict and provide means of resolving it.

In principle, market governances *g* and *g'* can be federated (they form communities themselves) and enter into contracts that govern the exchange of information about their respective citizens between domains. This is a complex issue, however, as it would require assessment of the information relative to community contracts *T* and *T'* and is outside the scope of this paper.

Related to this problem is an issue concerning the association of the marketplace community shown in Figure 1 with the market governance. For now we will assume that the market maker selects the market governance based on the community contract *T* that is offered.
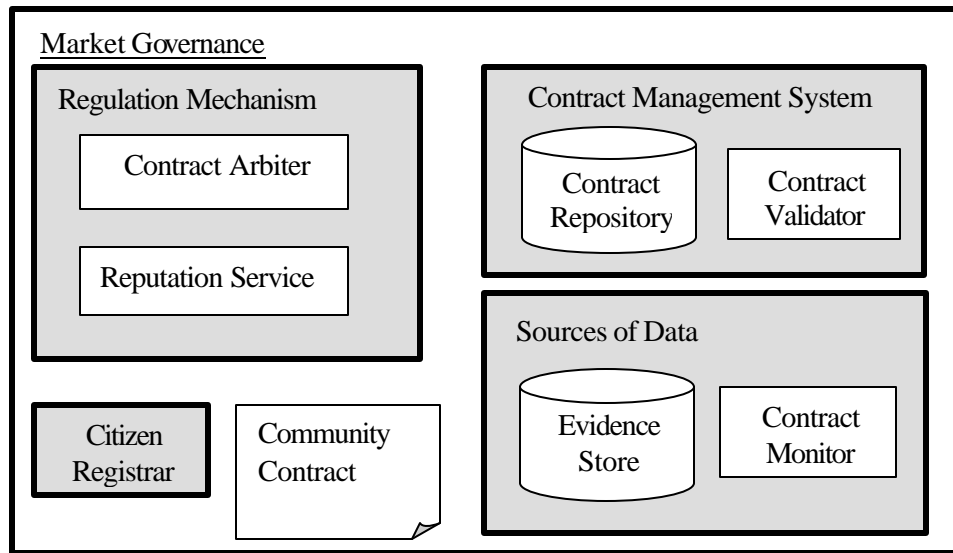
Figure 2 Market Governance main components.

The main components of market governance are shown in Figure 2 and are discussed below.

3.1 Citizen Registrar

The citizen registrar is in charge of the admission of individuals in the community. A set of admission rules is specified by the governor and enforced by the citizen registrar. If an individual matches the admission rules, they are invited to sign up to the community contract T. By doing so, they become a citizen of the governance.

3.2 Contract Management System

Contracts C signed by the citizens are validated by the contract validation component that checks that parties are citizens of the governance and that contracts are valid in that community. Contracts are stored in the contract repository.

3.3 Sources of Data

The regulatory mechanisms can function on the basis of data provided by the data sources. The contract monitor is used in the governance to monitor the progression of contractual relationships between citizens. The contract monitor is built around the Contract Fulfilment Protocol (CFP). The CFP is a collaborative protocol that allows individuals to talk about the lifecycle of their contractual commitments. The lifecycle can be conceptually represented as a set of commitment states and transitions between these states. An example of such a model is shown in Figure 3.
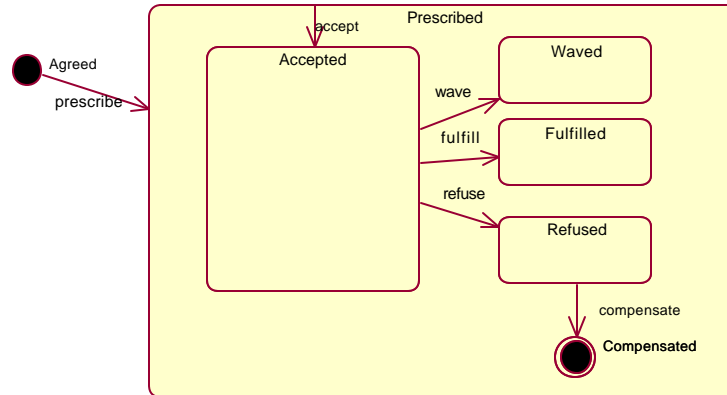
Figure 3 Promise lifecycle model. The states give correspond to main phases in promise lifecycle. Transitions represent interactions according to contract fulfilment protocol.

The transitions represent an exchange of messages between the contracting parties according to the CFP. The governor can specify an expected pattern of behaviour for the CFP and make it a part of the community contract *T*. This pattern of behaviour describes how the governor expects its citizens to behave as far as this collaborative process is concerned.

An additional source of data available in the market governance infrastructure is the evidence store where each contract party can store evidence $E(\sigma)$ concerning the delivery on contractual commitments by themselves and others.

The sources of data discussed above can then be used by the regulation mechanisms that are further discussed in the next section.

3.4 Regulation Mechanisms

The main objective of behaviour enforcement and the provision of a controlled environment like the market governance is to accomplish delivery of contractual promises even though the risk of non-performance is non-zero.

So far, we have considered the following elements:

- A declarative statement of sanctions in the contract for obligation and prohibition statement types;

- A declarative statement of the expected behaviour making explicit the expected pattern of interaction in terms of contract fulfilment protocol;

- Mediation of all or part of the interactions, given the declarative statements contained in the contract;

- Use of an evidence management service to store the evidence $E(\sigma)$ with the governor for certain mediated interactions so that it can be inspected by another party.

This data can be used by the contract arbiter and reputation service. When conflict occurs, the contract arbiter can be requested to decide on the state of the commitment given by the commitment lifecycle model. In case of obligation and prohibition, state *refused* implies activation of the penalty as a part of the *compensate* transition.

Based on the agreed expected behaviour patterns b_i and the historical knowledge of the actual mediated interactions h it is possible to build up a probability model that

would indicate the probability $p(t/b_i,a,h)$ of an entity a performing a transition $t \in b_i$ for a given promissory behaviour pattern. Components like the reputation service can use probability information in conjunction with the reputation matrix assigning score to each transition to derive total reputation score as a sum of scores from the reputation matrix weighted by respective probability estimate. Given that the score drops below certain threshold, the given entity would be excluded from the market governance by the market-governor. Entity can of course apply to be readmitted – this readmission is not automatic.

4   Related work and conclusions

Numerous approaches have been proposed for contract representation. First order-predicate logic [Lee 1998] coupled with documentary Petri nets, object-oriented models [Griffel 1998] and dynamic deontic logic coupled with speech act communication [Dignum 1995] have been explored. In the industry contracts [Grefen 2000] that can be used for cross-organizational workflow configuration and management have been investigated. However, the above work either does not allow for non-performance assuming complete and conflict free specifications or admits possibility of conflict without providing a mechanism to resolve it.

In this paper we have presented the conceptual model based on the notion of regulated community in which behaviour can be declared through contracts and influenced by regulation mechanisms implemented as contract arbiter and reputation service.

The reputation service has been previously suggested [Linington, Milosevic, Raymond 1998] as possible means of obtaining desired behavior and resolution of conflict [Dellarocas 2000b]. A conceptual model similar to the one presented here was outlined in [Dellarocas 2000a] where state machine descriptions have been proposed for contract objects as means to facilitate monitoring. We have extended the notion of introducing the state space to promises and linked it to contract fulfilment protocol. This allows us later to build a promissory interaction model against which the actual contractual interactions can be measured. We also introduced the idea of evidence for promise fulfilment that can facilitate the decision making process of contract arbiter.

The reusable realization of the conceptual model requires an ability to describe behaviour in a declarative way and to provide flexible regulation mechanisms that can compare the actual behaviour to the declared one. On-going research on policies for enterprise communities [Linnington 1999] aims to address specification of rules for community behavior. However, generally applicable notations are open to different interpretations, underlining the need to support conflict handling.

Application of regulation mechanisms includes decision-making based on the observed symbolic data streams. In environments with self-interested entities and limited trust, such data may not represent a complete and truthful statement of the actual situation, thus requiring dispute management support mechanisms such as the evidence service.

5   Future Work

Our future work will focus on the refinement of the conceptual model into a concrete implementation. We plan to refine the contract structure and provide a concrete electronic contract embodiment. We foresee that such electronic contract embodiment would consist of a declarative model expressed in XML document and corresponding

document transformations as well as the instantiation object model that would be more suitable during the contract monitoring and execution phase.

We also will be refining the details of the collaborative contract fulfilment protocol that will allow parties to communicate changes in contractual commitments as well as resolution of potential conflicts between them. Given this enabling infrastructure we will then study the dynamics of a community subject to a number of regulation mechanisms.

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