Transaction Trust in Normative Multiagent Systems

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Abstract. In this paper we apply Boella and van der Torre's normative multiagent systems to analyze a model of transaction trust introduced by Tan and colleagues. We discuss the role of constitutive and regulative norms in party trust and control trust. Moreover, we use so called contract negotiation games to indicate when controls are needed. Though sometimes regulators focus exclusively on adding controls, a scenario analysis can be used to show when this is not needed. We illustrate these issues of transaction trust by a case study from international trade, namely the Letter of Credit procedure.

1 Introduction

Trust is an important concept in open applications of multiagent systems. In an open system, the designer of an agent has no control over the expected behavior of the other agents the agent can interact with. In this paper we are interested in a kind of trust that has been studied extensively in the context of international trade: *transaction trust*. When a transaction must be arranged by individuals that do not know each other personally, and do not share a social or cultural background, lack of trust is likely. For transactions conducted over the internet, similar conditions apply. Mayer et al. [19] give the following definition of trust: "The willingness of a party to be vulnerable to the actions of another party based on the expectation that the other party will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party". A similar sentiment is found in the definition by Gambetta [10] "Trust is the subjective probability by which an individual a expects that another individual b performs a given action on which its welfare depends". Summarizing we might say that transaction trust is the willingness of individual a, the trustor, to be vulnerable to opportunistic action of individual b, the trustee.

TRUST IN THE OTHER PARTY   TRUST IN CONTROL MECHANISMS

TRUSTOR'S TRANSACTION TRUST
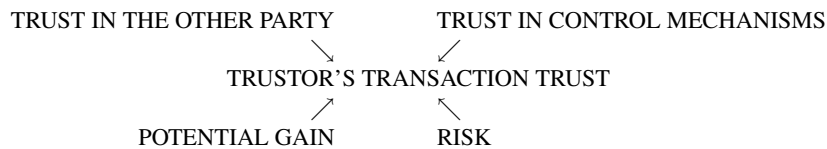
POTENTIAL GAIN   RISK

Fig. 1. Transaction trust according to Tan and Thoen [21, p. 850]

In the context of electronic commerce, transaction trust has been analyzed by Tan and Thoen [21, 22]. In their account transaction trust depends on four constituents: trust in the other party (party trust), trust in control mechanisms (control trust), potential gain and risk, as illustrated by Figure 1. Often trust is based on a personal relationship, on the social role that the other party is playing in some institution, on personal past experiences, or on reputation, which is in turn based on past experiences of other trusted parties. Such reasons for trusting the other party may lead to *party trust*. In the absence of direct reasons for trusting the other party, a trustor may turn to institutions that enforce control mechanisms. Think of an escrow service, or a quality standard maintained by an international standards body. The mere presence of a control mechanism is not enough. The trustor must understand how the mechanism works, and must have trust in the institution that enforces it. This is called *control trust*. In addition to these external determinants of trust, there are two internal factors that influence the trustor's reasoning: *potential gain* and *risk*. Using a kind of decision theoretic framework, these factors can be treated as a threshold: they set a minimal level of trust for the trustor to engage in a particular transaction. Only when the trustor can accumulate enough evidence to base his trust on, the transaction will go through.

Tan and Thoen [21, 22] implicitly distinguish among the following three steps in contract negotiation in electronic commerce, which is further developed by Kartseva et al [15]. First obligations are created. By engaging in a transaction, the buyer takes on the obligation to pay and the seller takes on the obligation to deliver the goods. Then in a second step sanctions are associated with the obligations, for example to pay a sum of money in case of late delivery or late payment. Thirdly controls are added to enforce the sanctions. In case there is enough party trust, the first step is sufficient. But in the absence of enough evidence to trust the other party, we also need control trust, based on sanctions and control mechanisms to enforce them. In particular, when analyzing new business models for electronic commerce, control mechanisms must regulate the exchange of value [11]. By analyzing Petri nets or UML diagrams on the basis of scenarios one can identify so called *sub-ideal paths*: deviations from a balanced exchange of value (principle of reciprocity). Sub-ideal paths are assigned a penalty to deter agents from following it [15]. However, agents must not only calculate the most profitable decision given some control mechanism, but also understand the control mechanism, and trust the institution that enforces it.

In this paper we study the following two research questions.

1. How do party trust, control trust, potential gain and risk interact in their constitution of transaction trust?
2. When is there sufficient evidence to trust the other party, such that expensive control measures need not be introduced?

We analyze the interaction among the constituents of transaction trust using the qualitative game theory based on recursive modeling in Boella and van der Torre's account of normative multiagent systems [4]. Boella and van der Torre argue that their theory can be used in theories or applications of trust to understand when it is necessary to revise it. In particular, they considered the impact for the study of trust dynamics, classifying the different motivations for fulfilling norms and analyzing the role of recursive

modeling in the decisions of agents. Finally, they explain that the attribution of mental attitudes has been explained by philosophical ideas such as the social delegation cycle, and they also introduce other kinds of norms such as permissive norms and constitutive norms (x counts as y in context c) in order to define contracts. The theory can be used for applications of rational decision making in normative multiagent systems, such as for example theories of fraud and deception, reputation, and electronic commerce.

First, violation games [4] are based on an agent who attributes mental attitudes to the normative system, and uses recursive modeling to play strategic games with it. Obligations are defined in terms of mental attitudes of the normative system, and its logical properties are considered. In particular, Boella and van der Torre formalize an agent who attributes mental attitudes such as goals and desires to the normative system. The wishes (goals, desires) of the normative system are the commands (obligations) for the agent. Since an agent is able to reason about the normative system's behavior, the model accounts for many ways in which an agent can violate a norm believing that it will not be sanctioned.

Secondly, contract negotiation games [6] extend violation games. They are defined for an agent that wishes to create obligations together with associated sanctions and controls. In this game, an agent recursively models whether another agent would violate or fulfill the new obligation, which adds another level of recursion to violation games. The three step model of Tan and Thoen can be formalized as follows. First, the creation of obligations is formalized as a creation of goals of the normative system, and a constitutive norm that not fulfilling the obligation counts as a violation. Secondly, the creation of sanctions is formalized by constitutive norms that a violation of norms leads to a sanction. Thirdly, control is formalized by a set of constitutive norms together with a set of real agents that have been delegated the task of enforcing the control procedure of the normative system.

Boella and van der Torre argue that the distinction between constitutive and regulative norms plays a crucial role in normative multiagent systems. We use this distinction to model party and control trust. Controls typically consist of a set of definitions, i.e., constitutive norms. For an agent to understand the control procedure – a crucial element of control trust – it has to know the constitutive norms and is has to be able to play games with other agents and the normative system according to those norms.

In discussing the research questions, we do not focus on the technical details of the model; they have been explained elsewhere [4, 6]. Rather we use an example from international trade to illustrate our points. We do not consider party trust in detail, since a lot of research effort has already gone into topics like on-line reputation mechanisms, or methods for learning people's trustworthiness on the basis of past experiences, see e.g. [17, 9]. Much less attention has been paid to control trust.

As for our research method: we make a model of the relevant aspects of the individual's decision making process, and use a logic to represent the model. Such models can be used for simulation and analysis, or can be implemented directly. Our formalization is meant for analysis and simulation.

The remainder of this paper is structured as follows. We first introduce a running example, and then address the two research questions in two subsequent sections.

2 Running example: Letter of Credit

Consider the well known trade procedure of a Letter of Credit [7, 16, 15]. Suppose we have a potential transaction between a customer and a supplier located remote parts of the world. Hence there are no common conventions or trade procedures and lack of trust is warranted. The supplier does not want to ship the goods without first receiving payment, but the customer does not want to pay before the goods have been shipped. The Letter of Credit procedure (LC) can solve this deadlock situation. A Letter of Credit is an agreement that the bank of the customer, called the issuing bank, will arrange a credit to guarantee payment as soon as the supplier can prove that the goods have been shipped. The supplier can prove this by presenting the shipping documents, such as a Bill of Lading, to his own bank, the corresponding bank. The shipping documents are issued by the carrier of the goods, as soon as the goods have in fact been shipped. The corresponding bank transfers the shipping documents to the issuing bank, which only delivers the shipping documents to the customer after payment. With the shipping documents the customer can then reclaim the goods from the carrier. A possible way of modeling the procedure is depicted in Figure 2,adapted from [16].
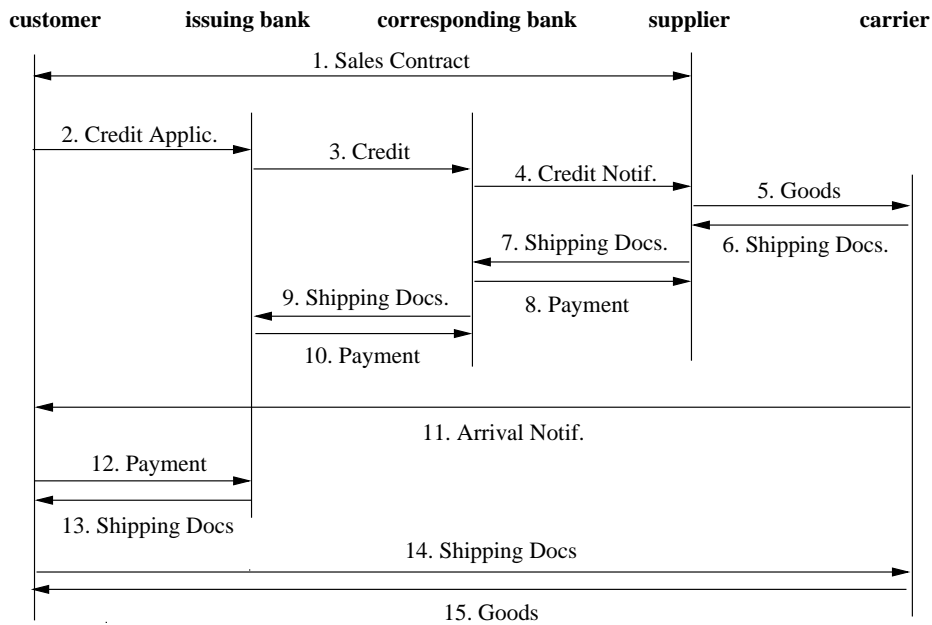

Fig. 2. Interaction Diagram of the Letter of Credit Procedure

By means of the Letter of Credit procedure the lack of trust between customer and supplier is replaced by a professional banking relationship between the issuing bank and the corresponding bank. The banks provide a service, a credit procedure, which

is paid for by a fee. The fee must cover the handling costs and insurance against the risk that the credit will not be redeemed. The professional banking relationship is more trustworthy than the original transaction relationship, for a number of reasons.

First, documentary credit procedures generally conform to the guidelines of the International Chamber of Commerce. Shipping documents have an *evidentiary effect*, guaranteed by the United Nations [23].

> "The multimodal transport document shall be prima facie evidence of the taking in charge by the multimodal transport operator of the goods as described therein; and proof to the contrary by the multimodal transport operator shall not be admissible if the multimodal transport document is issued in negotiable form and has been transferred to a third party, including a consignee, who has acted in good faith in reliance on the description of the goods therein." [23, article 10]

Second, trading banks tend to have a long term relationship. The success of the relationship depends on reputation. When a customer has a dispute with a bank over a Letter of Credit procedure, it might start a law suit, possibly damaging the reputation.

Third, banks are regulated by their respective Central Banks. That means that, at least locally, banks must adhere to the rules of the Letter of Credit procedure.

To illustrate a violation game, we consider a carrier that has the option of not shipping the goods, while still supplying the shipping documents (step 5,6). The normative system must deter the carrier from doing so. In normative multiagent systems, we model the decision problem of an agent in a given normative system, which can be used to decide whether to fulfill or violate an obligation, and which can be used to analyze fraud and deception.

To illustrate a contract negotiation game, we consider whether the customer and supplier would accept the contract with or without control mechanisms. Without controls, the customer would only accept the contract when the supplier can be trusted on the basis of additional information. With controls, the contract is accepted only when the carrier and the banks can be trusted. However, from the point of view of the customer, the banks and carrier are local participants. A contract negotiation game adds a level of recursion to the violation game of the carrier. We model the decision problem of whether to introduce norms, and which norms to introduce.

3 The constituents of transaction trust: violation games

In this section we analyze the interaction among party trust, control trust, gain and risk using a normative multiagent system (NMAS). Normative multiagent systems are "sets of agents (human or artificial) whose interactions can fruitfully be regarded as norm-governed; the norms prescribe how the agents ideally should and should not behave. [...] Importantly, the norms allow for the possibility that actual behavior may at times deviate from the ideal, i.e., that violations of obligations, or of agents' rights, may occur" [13].

3.1 Potential gain and risk: the mental attitudes of the agents, and agent profiles

To formalize the gain constituent of transaction trust, we have to define the motivational attitude of the agents. We could use payoff or utility, but Boella and van der Torre's normative multiagent system only represent the goals of an agent. Moreover, they also represent informational attitudes called beliefs. To reason about the risk of trusting another agent, each agent has a profile of the mental attitudes of other agents. A profile contains the beliefs (information) and goals (internal motivations), as well as a priority order over goals.

Mental attitudes are represented in a logical language, as sets of conditionals or production rules. This expresses the fact that mental attitudes are context dependent [12], and that their application is conditional on certain constraints. So each attitude Bel, $Goal$, is represented by a set of rules of the form $A \rightarrow B$, where both A and B are formulas, composed of facts by means of logical operators $\wedge$ (and), $\vee$ (or), and $\neg$ (not). Here A represents the conditions under which the facts represented by B may be inferred. Moreover, B may contain decision variables, also called actions, that will alter that state of the world. For simplicity, both facts and decision variables are represented by boolean variables, being either true or false.

Decisions are sets of literals built from decision variables, i.e., decision variables or their negations. Roughly, the effect of a decision is obtained by applying the belief rules to the decision, and a decision is evaluated by checking whether the effects of the decision imply the goals. Note that conditionals $A \rightarrow B$ do not behave as material implication. In our other work the semantics of the inference mechanism is expressed using input/output logic [18]. We refer to [4, 6] for the technical issues related to applying rules, and checking whether a decision fulfills a conditional goal.

In this section, we use a simplified version of the Letter of Credit procedure to illustrate the interaction among the constituents of transaction trust. In the next section, when we discuss contract negotiation games, a more detailed example will be given.

Example 1. Gain and Risk Construct a model M_{LC} as follows. Let Boolean variables 'LC', 'shipping_docs', 'transfer_goods', 'fraud', and 'law_suit' represent the facts of operating in the context of a Letter of Credit procedure, presenting the shipping documents, having transferred the goods from the custody of the supplier to the carrier, committing fraud, and starting a law suit, respectively. Let variable a range over the relevant agents: customer (c), issuing bank (ib), corresponding bank (cb), supplier (s) and carrier (ca).

Assume that it is profitable for the carrier to issue fake shipping documents. In other words: to hand over the shipping documents, without transferring the goods. The carrier might for example sell the goods on the black market. Moreover, the carrier believes it is operating in the context of a letter of Credit procedure.

> Belief of ca: LC
> Goal of ca: shipping docs $\wedge \neg$ transfer_goods

In the context of the example, the element of gain can be represented by the fact that a goal exists, and outranks other conflicting goals of the agent. The element of risk can be covered by the fact that another agent can represent goals in its profile (special kind

of beliefs), and realize they are contrary to its own interests. For example in the profile of the supplier, the violation behavior of the carrier constitutes a risk.

3.2 Party trust: obligations

Party trust involves all kinds of evidence to trust another agent. Such evidence may be based on personal experience, on a shared cultural background, on reputation or on the role the other agent is playing in some institution. In the context of this paper, party trust means that – according to its profile – the other agent will indeed fulfill the obligations associated with a transaction agreement or contract. We therefore now introduce obligations.

In Boella and van der Torre's normative multiagent systems, obligations are reduced to goals of the normative system, where the normative system itself is seen as a separate agent. This may be summarized by the slogan "Your wish is my command". The reduction makes use of a *violation predicate* [1]. Although the use of violation predicates to reduce obligations to modal or epistemic operators is well known, the crucial aspect here is that a reduction is made to goals of the normative system. Another important aspect of the model is that violation detection is separated from sanctioning. Sanctioning concerns the decision to sanction an agent in case a violation has been detected, and what sanction is most appropriate. To make sure that normative systems do not act arbitrarily, a number of conditions must be observed [5].

Definition 1 (Regulative Norm). Agent a is obliged to bring about x in circumstances c, under sanction s, with respect to a normative system n in a given model M, written as $M \models \mathsf{Obl}_{a,n}(x, s|c)$, if and only if the following conditions hold.

1. Goal of n: $c \to x$ If agent n believes that c, then it has as a goal that x should be brought about.
2. Goal of n: $c \wedge \neg x \to \mathsf{Viol}(\neg x, a)$ If agent n believes that c and $\neg x$ is the case, then it has the goal $\mathsf{Viol}(\neg x, a)$, i.e., to recognize $\neg x$ as a violation by agent a.
3. Goal of n: $\neg\mathsf{Viol}(\neg x, a)$ Agent n has as a goal that there are no violations. This is to prevent arbitrary violation detection.
4. Goal of n: $c \wedge \mathsf{Viol}(\neg x, a) \to s$ If agent n believes c and recognizes $\mathsf{Viol}(\neg x, a)$, then it has the goal to sanction agent a.
5. Goal of n: $\neg s$ By itself, agent n does not have a goal to sanction. This is to prevent arbitrary sanctioning.
6. Goal of a: $\neg s$ Agent a has the goal $\neg s$. Without this condition, sanction s would not deter agent a from violating the obligation.

The running example will be used again to illustrate the use of the definition.

Example 2. Obligations We use n to denote the normative agent that is able to enforce a norm. In the Letter of Credit procedure this role is usually taken by the issuing bank. Let us suppose that the sanction will be a lengthy law suit, with possible additional repercussions for reputation. Please note that sanctions in a strictly legal sense are more readily associated with criminal law; not civil law as in this example.

Model M_{LC} contains an obligation for every agent a to respect the meaning of the shipping documents, i.e. not to commit fraud, against a penalty of a lengthy law suit.

$M_{LC} \models \mathsf{Obl}_{a,n}(\neg\text{fraud}, \text{law\_suit}|\text{LC})$, if and only if:

1. Goal of n: LC$\rightarrow \neg$fraud
2. Goal of n: LC $\wedge$ fraud $\rightarrow \mathsf{Viol}(\text{fraud}, a)$
3. Goal of n: $\neg\mathsf{Viol}(\text{fraud}, a)$
4. Goal of n: LC $\wedge \mathsf{Viol}(\text{fraud}, a) \rightarrow$ law_suit
5. Goal of n: $\neg$law_suit
6. Goal of a: $\neg$law_suit

Without the obligation, committing fraud would be desirable, as we have seen for the carrier. However, we still have to relate (shipping docs$\wedge\neg$transfer_goods) to fraud. This is done by constitutive norms.

3.3 Control trust: Constitutive Norms

Controls typically involve specific agents, such as banks, as well as specific documents and definitions. These are described by constitutive norms. Constitutive norms constitute the institutional context, by establishing institutional facts [20]. For example, the rules of chess constitute the game by defining legal moves. Regulative norms, by contrast, restrict the behavior of agents through obligations and enforcement mechanisms. A constitutive norm applies only under certain circumstances and is intimately linked to an institution. The institution can be an abstract entity such as a community of users. Whether a rule applies depends on the jurisdiction of the institution. Thus constitutive rules are of the form "x counts as y under circumstances C in institution i".

Constitutive rules can create new institutional facts. The prototypical example is a declarative speech act [2]. For example, the utterance "I name this ship Johanna", uttered by a lady at an appropriate christening ceremony, will create the institutional fact of the ship bearing this name. Several logical representations of counts-as rules have been studied, see e.g. [14]. In this paper constitutive norms are modeled as belief rules of the institution. Moreover, having the rule is imperative for all agents under the jurisdiction of the institution.

Definition 2 (Constitutive Norm). Event or fact x counts as an institutional event or fact y under circumstances C, to all agents a that fall under the jurisdiction of i in a given model M, written $M \models \mathsf{Counts\_as}_{a,i}(x, y|C)$, if and only if:

Belief of a, i: $C \wedge x \rightarrow y$

In general, one can distinguish between the *institutional environment*, and the *institutional arrangement* that parties deploy to support an exchange [8]. In international trading, the legal and cultural framework of ownership and property rights forms the institutional environment. It applies widely and remains stable. By contrast, the institutional arrangements deployed by parties to support the closure and fulfillment of a contract, are relatively specific to each case, and can alter rapidly.

In our example, the institutional environment defines the general characteristics of a Letter of Credit procedure, laid down in the United Nations convention cited above. The Letter of Credit procedure that is arranged by a particular issuing bank for a particular transaction, is an example of an institutional arrangement.

Example 3. Evidentiary documents We use un to denote the United Nations: the institution that defines the meaning of shipping documents. Model M_{LC} is extended with a constitutive rule that defines the condition of fraud.

$M_{LC} \models \mathsf{Counts\_as}_{a,un}((\text{shipping docs} \land \neg \text{transfer\_goods}), \text{fraud} | \text{LC})$,
i.e., Belief of a, un: LC $\land$ shipping_docs $\land \neg$transfer_goods $\rightarrow$ fraud

3.4 Interaction among constituents of transaction trust: Recursive Modeling

Now we apply recursive modeling. Suppose agent a, for example the carrier, operates in the context of a Letter of Credit procedure, has a goal to cheat, and a goal to avoid law suits. Using the constitutive rules, we get an initial extension of the form {LC, fraud, ¬ law_suit}. Because the consequences of these potential goals are to a large part controlled by the other party, agent a will try and predict the decisions of agent n. A set of rules to predict another agent's decisions is called a profile. Crucially, profiles contain rules that are affected by the actions of the agent itself. That is why this process is called *recursive modeling*. However, for most applications no infinite recursion is needed; recursive models up to three levels of embedding are usually quite sufficient. Here we only need one level of embedding.

First, a compares rule 2 with rule 3. Which of these will get priority depends on a's profile of n. Lets assume that a believes that rule 2 outranks 3. That will produce an extension {LC, fraud, Viol(fraud, a) ¬ law_suit}. Second, a compares rule 4 and 5. If a expects n not to sanction, for example because of prohibitive costs of lawyers, a will form the goal to cheat. But if a expects n to act on detected fraud, we get { LC, fraud, Viol(fraud, a), law_suit, ¬ law_suit }, which contains a contradiction. This conflict must be resolved by a's own priority order. In case the penalty outweighs the expected profits, the agent will not form a goal to commit fraud: { LC, ¬ law_suit }.

The example shows that an obligation only works when two conditions are met. First, the sanction must outweigh the benefits of a violation.

(Goal of a: ¬ law_suit) > (Goal of a: fraud)

Second, the relative priorities of being detected and sanctioned, must be high enough.

Profile of a:
(Goal of n: LC $\land$ fraud $\rightarrow$ Viol(fraud, a)) > (Goal of n: ¬Viol(fraud, a))
(Goal of n: LC $\land$ Viol(fraud, a) $\rightarrow$ law_suit) > (Goal of n: ¬ law_suit)

Violation detection and sanctioning can be delegated to specific agents, such as a police force. In the Letter of Credit case, violation detection is to a large extend the responsibility of the victims. For example, when a carrier has not transferred the goods to the customer, the customer can take the shipping documents, and file a complaint, i.e., notify the normative system of the violation. Sanctioning is often delegated to the issuing bank, because it has a good overview of the procedure and, through its banking partners, can act effectively in distant locations and legal systems.

4 When to add controls: contract negotiation games

Under what circumstances do we need to introduce a control system? Regarding transaction trust, we can distinguish three scenarios:

– *direct transaction*: seller and buyer are in the same place, along with the merchandize. The prototypical example is a cattle market. In this case, there is no need for additional trust. Payment and goods can be exchanged simultaneously, and when in doubt, the buyer can look the animal in the mouth.

– *indirect transaction - trust*: there is a separation in either time or location between seller and buyer, or between seller, buyer and merchandize. The transaction depends on an evidentiary document, which 'counts as' the merchandize. For example, when you buy a ticket to the theater, you buy the right to view a performance that will be delivered later on. The buyer trusts the seller concerning the validity of the ticket.

– *indirect transaction - no trust*: there is a separation in either time or location between seller and buyer, or between seller, buyer and merchandize. The merchandize is represented by an evidentiary document, but buyer and seller have no initial reasons to trust one another. For example, in international trade we can not assume a personal relationship or shared cultural values. In this case, both parties will need additional control mechanisms, that will convince them that the other party will adhere to the obligations laid down in the transaction agreement.

In the second scenario party trust is sufficient. In the third scenario, we need an additional system to make sure that the seller is sanctioned in case of a fake ticket. In this section we consider the question when we need such an additional system for the Letter of Credit procedure. We model two sets of circumstances, one in which no control mechanism is in place, and one in which a Letter of Credit procedure has been established. Using these two models, we play a contract negotiation game.

4.1 Without Letter of Credit

We have the following scenario. Supplier s must decide to trust customer c in a transaction that consists of two actions: payment from c to s, and shipment from s to c, where price and details of delivery have been previously agreed. The sales contract would consist of two obligations:

$$\mathsf{Obl}_{c,n}(\text{payment} , - \mid \text{shipping})$$
$$\mathsf{Obl}_{s,n}(\text{shipping} , - \mid \text{payment})$$

However, initially there are no credible real agents that can be delegated the task of the normative system n to enforce sanctions for violations against this contract. This is shown here as '$-$'. Parties are left to enforce their own contract, i.e. use external motivations like threats. But although parties can easily detect violations, they do not have the power to make a credible threat, because of the distance and different legal systems. Still, it is conventionally believed that not paying after delivery, or not delivering after payment count as being 'in debt'.

$\mathsf{Counts\_as}_n(\neg\mathrm{payment},\mathrm{in\_debt}_c|\mathrm{shipping})$
$\mathsf{Counts\_as}_n(\neg\mathrm{shipping},\mathrm{in\_debt}_s|\mathrm{payment})$

Even without a control mechanism, there can still be reasons for an agent to honor the contract. First, an agent could have the internal motivation that being in debt is morally wrong, and therefore undesirable. If this disposition were known, for example through shared cultural values, the agent can be trusted. Second, when the trade relationship is supposed to last for a longer period, a credible threat would be to end the trade relationship and ruin possible future transactions. In both cases adding such information would beg the question. So, in the absence of further information, according to the profile of the supplier, the customer has no incentive to pay after delivery. Similarly, the customer will expect the supplier not to deliver the goods after payment.

Profile of s:
(Goal of c: $\neg$ payment) $>$ (Goal of c: $\neg$ in_debt$_c$)
Profile of c:
(Goal of s: $\neg$ shipping) $>$ (Goal of s: $\neg$ in_debt$_s$)

4.2 With Letter of Credit

What we need is a mutual obligation in which non-compliance of one, irrevocably leads to failure for the other. Such a direct exchange of goods for money is only possible, when parties are physically present, and in possession of the valuables.

$\mathsf{Obl}_{c,n}(\mathrm{payment}, \neg\mathrm{shipping}|\mathrm{shipping})$
$\mathsf{Obl}_{s,n}(\mathrm{shipping}, \neg\mathrm{payment}|\mathrm{payment})$.

Because a simultaneous exchange is not possible in international trade, the mutual obligation must depend on evidentiary documents.

$\mathsf{Obl}_{c,n}(\mathrm{payment}, \neg\mathrm{shipping}|\textit{evidence of shipping})$
$\mathsf{Obl}_{s,n}(\mathrm{shipping}, \neg\mathrm{payment}|\textit{evidence of credit})$.

Such documents can be created through a Letter of Credit procedure. The rules of the procedure (Figure 2) are constituted by the international trading conventions, encoded by the United Nations. So shipping documents count as evidence of shipping, and the letter of credit counts as evidence of credit.

$\mathsf{Counts\_as}_{un}(\mathrm{shipping\_docs},\mathrm{shipping}|,\mathrm{LC})$
$\mathsf{Counts\_as}_{un}(\mathrm{credit\_notification},\mathrm{credit}|,\mathrm{LC})$

The issuing bank acts as a normative system n to enforce adherence to these procedures. The issuing bank is a good candidate for enforcing the rules. First, its sanctions are credible. It is in a position to damage the other parties, for example by starting a law suit. Starting a lawsuit would not have been possible for the supplier for example, because it would involve a foreign legal system. Second, violation detection is relatively easy. Because of the evidentiary documents, typically the victim of fraud will be able to prove that a violation occurred.

We must show that because of the constitutive rules of the Letter of Credit procedure, and the regulative enforcement by the issuing bank, the link between 'evidence of shipping' and actual shipping, and the link between 'evidence of credit' and actual payment, is strong enough to let both parties engage in a transaction (Figure 2). The indirect transaction between buyer and seller without trust, must be replaced by a chain of direct transactions, and indirect transactions with trust.

So we must show that, in the profile of the supplier, the corresponding bank has an incentive to pay upon receiving the shipping documents (step 7-8), and consequently, the carrier will have an incentive to deliver the shipping documents in return for the goods (step 4-6). Similarly, we must show that, in the profile of the customer, the carrier has an incentive to transport the goods and deliver them in return for the shipping documents (step 14-15), and hence the corresponding bank and the issuing bank have incentives to transfer the shipping documents from the supplier to the customer, in return for their respective payments (steps 9-10,12-13) For lack of space, we can only sketch two of these requirements. The other steps are analogous.

Step 7-8 According to the supplier, why should the corresponding bank pay? First, not paying will not be in compliance with the constitutive rules of the Letter of Credit procedure. Second, the corresponding bank does not have much reason to withhold payment, since earlier it received credit from the issuing bank (step 3). Not passing on the credit may be detected by the Central Bank. Third, the corresponding bank needs the shipping documents to account for the credit (step 9-10). Because otherwise the supplier will not hand over the shipping documents, there is a direct motivation to pay. This is an instance of a direct transaction. As we analyzed, such an obligation requires three conditions. These conditions can be easily verified by the supplier.

Profile of s:
$\mathsf{Obl}_{cb,s}(\text{payment}, \neg\text{shipping\_docs}|\text{LC})$

Profile of s:
(Goal of cb: $\neg$payment) $<$ (Goal of cb: $\neg$shipping docs))
(Goal of s: LC $\wedge\neg$payment $\rightarrow$ $\mathsf{Viol}(\text{LC}, cb))$ $>$ (Goal of s: $\neg\mathsf{Viol}(\text{LC}, cb)$)
(Goal of s: LC $\wedge$ $\mathsf{Viol}(\text{LC}, cb)$ $\rightarrow$ $\neg$shipping_docs) $>$ (Goal of s: $\neg$shipping_docs)

Step 14-15 According to the customer, why should the carrier hand over the goods? First, the carrier needs the shipping documents to account for the payment it received from the supplier in step 5. Lacking shipping documents may be detected in an audit. However, the customer has no reason to trust that such audits will be effective. Second, the customer has a right to redress: he could notify the issuing bank (ib) that the carrier violated the procedure. Note that the carrier must be in possession of the goods, because of the arrival notification (step 11). That the shipping documents are still in possession of the customer counts as evidence that no delivery has taken place. This simplifies violation detection. So the carrier is risking a law suit, analogous to example 2. As before, this requires three conditions. Customer c is in a position to assess these conditions.

Profile of c:
$\mathsf{Obl}_{ca,ib}(\text{transfer\_goods},\text{law\_suit}|\text{LC} \wedge \text{shipping\_docs}\wedge\text{arrival\_notif})$

4.3 When to add controls: contract negotiation games

A contract negotiation game extends a norm creation gam. A contract consists of various rules. Since constitutive and regulative rules are themselves institutional facts, they can be created or abolished by special acts [6]. Roughly, the model is extended with decision variables that model acts to update the sets of beliefs and obligations of the agents. In particular, proposing or accepting contract offers can result in the addition of goals, according to the 'your wish is my command' principle.

Using this extension of normative multiagent systems, and using the formalization of a situation with and without a control system, we can play a recursive game to find out whether a control system should be introduced. Thus, the decision problem is whether to propose no contract at all, a contract without a control procedure, or a contract with a control procedure. Each agent considers the consequences of these scenarios. They decide for the second option, with a control system , only when they believe that the first option will lead to norm violation. In other words, they only create a control system when: there is not sufficient party trust to ensure that in the scenario without controls the obligations are fulfilled (section 3.1.), and there is sufficient control trust to ensure that in the scenario with controls the obligations are fulfilled (section 4.2)

5 Summary

Using a multiagent game theory, in this paper we further develop the analysis of transaction trust in electronic commerce. In particular, we use games in Boella and van der Torre's normative multiagent systems to represent and reason about the theory of transaction trust developed by Tan and colleagues. We focus on two kinds of games.

First, violation games clarify the interaction among the components of transaction trust: party trust, control trust, potential gain and risk. Potential gain is formalized by the goals of the agents, and risk is formalized by the possible strategies of other agents that may lead to a state in which the goals are not fulfilled. There is sufficient party trust when a game with the other agent ignoring the normative system already leads to a transaction. There is sufficient control trust when agents understand the control system in the sense that they can play games involving the controls (recursive modeling), and when these games have the effect that the sanctions are enforced.

Secondly, contract negotiation games explain when controls are needed, and which controls are created. Since control has a price, a rational agent does not create a control procedure when there is already sufficient trust. We distinguish among negotiation of the obligations, the sanctions, and the control system. Sources of complexity in the games, and therefore in control procedures, are the complexity of the constitutive norms that define the games and the number of agents involved as they increase the number of recursive models. We have to consider the agents that are involved in the transaction, as well as the agents involved in the control system. Such control agents, are either trusted or have to be controlled themselves too.

Future research will concern the relation between trust based reasoning in electronic commerce, and types of reasoning found in legal theories. Legal reasoning has several peculiarities such as hierarchical normative systems, in which one normative system

(e.g. EU) controls other normative systems (e.g. country), separation of powers as in the Trias Politica, argumentation in court, etc.

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