A Normative Multiagent Trust Framework for Electronic Payment Analysis

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Abstract

Lack of collaboration among transacting agents is a major hurdle to e-payment trust. The belief, goals and desires of agents in a payment system need to be followed with a level of trust. During the process of interaction among agents, trust is required in other to execute the best goal without violating any norm. In order to bring cooperation among transaction agents in payment system, this paper presents a multiagent trust model which uses a combination of Tan and Theon model for contract negotiation to ensure trust among agents. The model adopts creation of obligations by agents which is based on the mental attitude of each agent comprising of beliefs, goals and desires; the association of sanctions to obligations to ensure the execution of the best goal without violating of any norm and finally, addition of controls to enforce sanctions. It was observed that, despite the rules set up in the normative multiagent system, there still exist agent's violators, which were not allowed to make transactions. For a successful payment transaction, the norms existing among the interactive system must be observed.

Keywords: *Electronic Payment System, Trust, Risk, Normative Multiagent System and E-Transaction.*

1. Introduction

Electronic payment system involves the provision of payment services and transfer through such devices as telephones, computers, the internet, ATMs, smart cards [1, 2]. In an electronic payment system, a number of agents with broadly similar interests within each set are needed namely: customers, merchants, and financial institutions like banks and probably a switching company called the regulators. The interaction of all payment agents can be regarded as a multiagent system. A Multiagent system is a system with more than one agent interacting together during transactions and serving as one collective intermediary [3, 4]. In a multiagent system, agents' act like law makers in a community, making laws, holding other agent violators accountable for their actions and enforcing sanctions when necessary. Each agent has mental attitudes represented in the form of conditional rules- beliefs, goals and desires that drive decisions to plan and execute actions [5]. Fellow agents within a multiagent system might share similar decision variables and mental attitudes which results in conflict of goals and desires [6, 7].

To resolve conflict in an e-payment system, the belief, goals and desires of agents in the system need to be followed with a level of trust. During the process of interaction among agents, trust is required in other to execute the best goal without violating any norm. Trust according to [8] is "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 the other party". In the context of e-payment, trust refers to the degree of customers' confidence that their money and personal information will be safe, and that all parties involved will not act against users' interests [9]. In other to ensure trust within a multiagent payment system, norms are needed. Norms are the rules of behaviour within a particular group to protect long term interests of the group against individual violators. A normative multiagent (NMA) system is referred to as the sets of agents that interact freely with organization, individuals, and organization- individuals governed by norms that describe how the agents ideally should and should not behave. The norms therefore regulate the behaviour of the agent [10].

Trust- based normative multiagent models are receiving dynamic attention in various aspect of electronic commerce, but only few have considered trust for electronic payment. [3] argued that transaction trust is composed of party trust and control trust. They studied control trust as trust in an institution that has set of control mechanisms. An account of control mechanisms using normative multiagent systems were discovered with the control mechanisms consisting of constitutive norms which defines documents, and regulative norms with violation conditions and sanctions. The research work suggested that transaction in electronic commerce should always be done with mutual obligations among transacting parties, in which the sanction for both parties is simply non-compliance of the other party [3]. However, the potential problem of the work to our study is that control trust was

extensively considered as a requirement for transaction. In an e-payment environment, party trust is not only essential but should be considered first before transaction [11.

In [12], a normative multiagent systems and trust dynamics by using recursive modeling to formalize sanction-based obligations in a qualitative game theory was discussed. Having formalized the agent attributed mental attitudes such as goals and desires to the normative system with the creation and enforcement of its obligations, the paramount wishes of the normative system were the obligations of the agent. They argued that if agents were able to reason about the behaviour of the system, it would account for reasons why agent violates a norm believing that it will not be sanctioned. A cognitive theory of normative reasoning which can be applied in theories requiring dynamic trust was therefore proposed [12]. Unfortunately, the focus of the work was on the motivations of agent when they violate norms and not the prohibitions. Prohibition serves as the optimum focus of research on norms in any e-payment activity.

Other literature include the one in [13], who focused on the prevention of malicious actions and ways to ensure agent trust by enhancing open multiagent system with normative mechanisms. Though, they admitted that, it is not reasonable to expect foreign agents to know in advance all the norms of the multiagents system in which they ought to execute, prohibition of violations are paramount. [13] presented a DynaCROM approach for addressing these issues. From the individual agents' perspective, the model gives more information in order to make agents become context norm-aware; while the perspective of the developers' reveals the model as a methodology for norm management in regulated MASs' [13].

In this framework, normative multiagents system is used to analyse trust in electronic payment environment. The procedure involves the use of Tan and Theon model for contract negotiation with further embedding of Smith and Rotolo's trust model to ensure trust among agents in the normative system.

2. Background to Normative Multiagent System

Normative multiagent system is based on mental attitudes of agent, like beliefs, goals and desires that drive decisions to plan and execute actions, and norms that serves as obligations accepted by the agents. These mental attitudes are represented by the set of conditions or production rules while the actions of the agent also called decision variables and facts (observed data) are represented by Boolean variables been either true or false. This section is divided into two, namely: contract negotiation which discusses and explains how contract is established among agents in e-payment environment and secondly the introduction of trust to ensure smooth and fair transactions among agents.

2.1 Contract Negotiation

To develop a contract negotiation within a normative multiagent system, Tan and Thoen model is employed for contract negotiations which are the creation of obligations, the creation of sanctions and assigning agents to enforce sanctions for payment activities [14].

2.1.1 Creation of Obligations by Agents

In this phase, obligations are created by each agent. In creating an obligation a customer takes on the obligation to acquire a product from a supplier by either paying for the product or not. Obligations of an agent are the beliefs, desires and goals which are collectively referred to as the mental attitude of an agent and are represented as a set of conditions or production rules. The mental attitude of all the agents in a normative multiagent system make up the norms of the normative system, they drive the decision of each agent to plan and execute action, enabling agents to choose which goals are legitimate to pursue based on a given system of norms, thereby resulting in an autonomous behaviour of agents. The action(s) of an agent also called decision variables are represented in Boolean variables, either True or False, while the decision making process is represented by a forward reasoning loop. The mental attitude of an agent is represented as rules in the form $\alpha \rightarrow \beta$. The antecedent α represents the condition under which the fact(s) represented by β the consequence may be inferred. β contains decision variables that will determine which action to take if α is true. Figure 1 shows a flow diagram that describes the process involved in the creation of obligations.

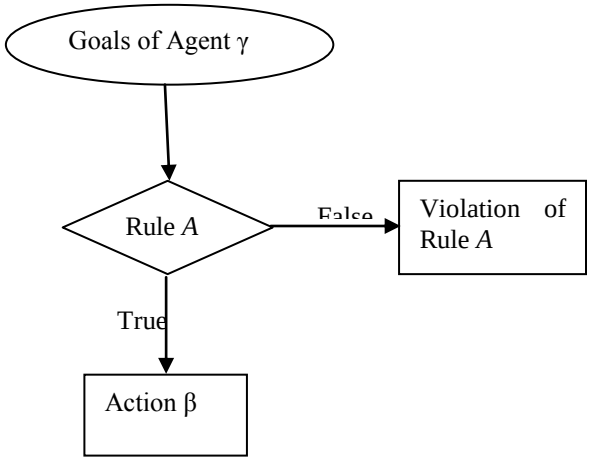

Fig. 1: The Creation of Obligations

In figure 1, an agent starts the creation of obligations with a set of initial goal(s) say *'γ'* represented by a set of decision variables, thereafter the agent tries to match each rule $\alpha \rightarrow \beta$ against the agent's goal(s) γ. If α is in γ and the facts of β do not contradict a fact γ then the rule is applicable. Moreover, during the process of matching each rule $\alpha \rightarrow \beta$ against γ there may exist several rules for which γ is applicable. To resolve this discrepancy, a technique called priority ordering is used, where by an agent select an action with the highest priority and applies it to γ. In other to enforce trust within a normative multiagent system sanctions are associated to violations of norms, which leads to the second step of the model been used in this project.

2.1.2 Association of Sanctions to Obligations and Enforcement of Sanctions

The goal of a normative system is not only to enforce agents to conform to the norms of the system but also to enforce sanctions. This phase involves the creation of sanctions formalized by constitutive norms where by the violation of a norm by any agent in the normative agent leads to a sanction. In a normative multiagent system constitutive norms is preferred over regulative norms because it not only regulate antecedent existing forms of behaviour, but creates obligations, prohibitions and permissions concerning specific agents [15, 16]. It also introduces new regulative norms, new categories and specifies by whom the changes can be done, thereby regulating the normative system. Where there is a violation of a norm and there exist enough party trust among participating agents then the creation of obligations is sufficient. But in the absence of sufficient party trust, we then rely on control trust which enforces violations on sanctions. Figure 2 declares the enforcement of the sanctions.

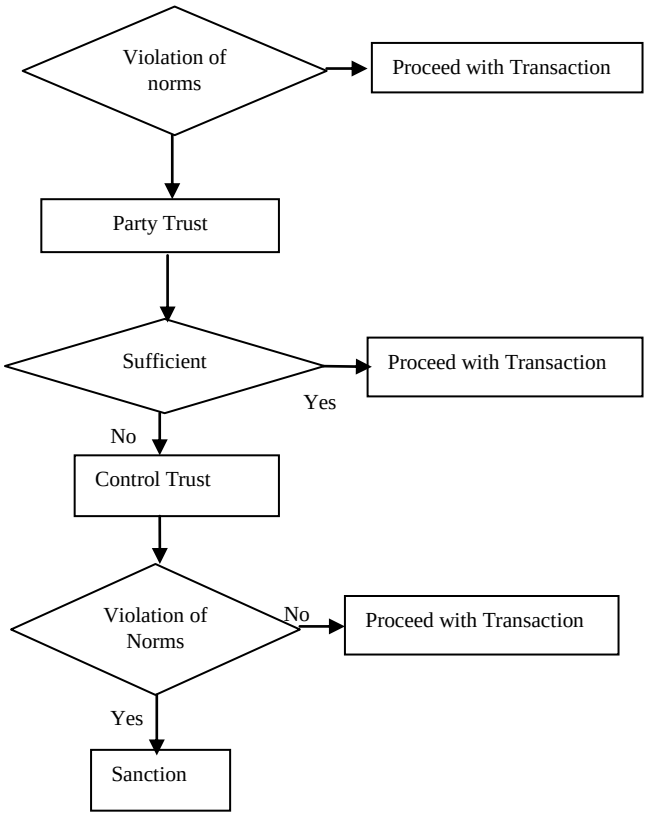

Figure 2: Enforcement of Sanctions

3. Trust Model Within a Normative System

Trust is an important part of transaction among agents with different mental attitudes- goal, desires and beliefs. Therefore, there is need to embed trust into a normative system. Trust can be in any of this forms; individual, joint and collective trust. Table 1 gives the interpretation of different trust equation.

(i) Joint Trust: This is a situation where every other agent taken as a group *G* believes that agent *B* will carry out its intended goals with this relation:

$$JTrust_B^G \gamma \equiv (\wedge_{i \varepsilon G} Trust_B^i \gamma) \quad (1)$$

(ii) Collective Trust: this situation occurs when a group *G* of agents believes that agent *A* will carry out their common goal

$$CTrust_B^G \gamma \equiv \mathrm{Re}l_B^G \gamma \wedge CBel^G(\mathrm{Re}l_B^G \gamma) \quad (2)$$

$$\mathrm{Re}l_B^G \gamma \equiv JTrust_B^G \gamma \wedge MDes^G(JTrust_B^G \gamma) \quad (3)$$

$$MDes^G \equiv (\bigwedge_{i \varepsilon G} Des^i(\gamma \wedge MDes^G \gamma) \quad (4)$$

(iii) Individual Trust: it involves an agent say *A* trusting another agent say *B* with respect to a goal *γ*. The association of the goal, desire and the belief is given in the following relation.

$$Trust_B^A\gamma \equiv Goal_A\gamma \wedge Bel_A Does_B\gamma \wedge Des_A(Does_B\gamma \wedge -Does_A\gamma) \wedge Goal_A Des_B\gamma \wedge Bel_A Des_B\gamma \quad (5)$$

Table 1: Trust Interpretation

Trust	**Interpretation**
Individual **Joint**	*Agent A has a goal γ* with the *believe that agent B will execute γ. Agent A does not execute γ itself* *Agent A_1 to A_n trust agent B to execute goal γ.*
Collective	*Group G relies on agent B to execute γ. G collectively believes that G relies on B to execute γ. G jointly trusts B to execute γ. G desires that G trust B to execute γ. Every member of G desires to execute γ. Every member of G desires that G desires γ.*

3.1 Contract Negotiation for trusted Multiagents System in an E-Payment Environment

In the negotiation of contract in an electronic payment multiagents system, five major interaction agents were used namely; the customer, supplier, customer's bank otherwise known as the Issuer, supplier's bank and a switching company known as the regulator of bank operations. Each agent represented as agent *A, B, C, D* and *E* respectively. Agent *A* serves as the customer; B is the supplier; *C is the* customer's bank; *D* is the supplier's bank and *E as the* switching company. In the payment procedure shown in figure 3, five main agents are involved: the consumer, the supplier, the consumer's bank, the supplier's bank and a switching company.

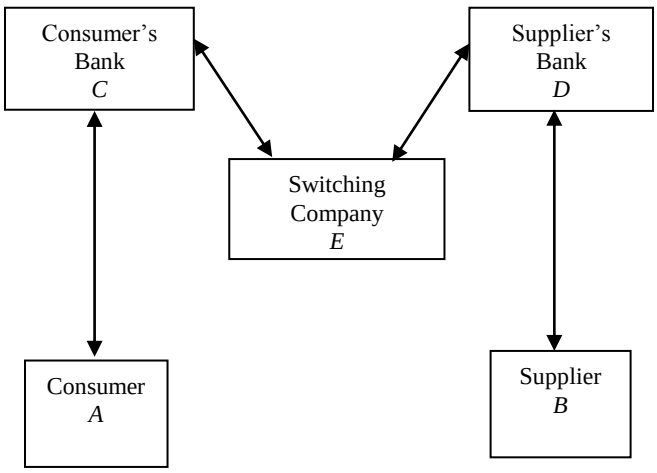

Fig. 3: Payment Procedure

Figure 4 shows the relationship between agents *A, B, C, D* and *E* and state the condition before they can be trusted for payment. The Figure shows agent *A's* desire to acquire a product from the supplier. To do this, agent *A* pays for a product which involves *A's* bank. If *A* fails to pay for the product, *E* checks if *A* has sufficient level of trust, if it has party and control trust then, transaction is allowed to proceed, otherwise it is terminated. If transaction proceeds to the buyer bank then, it would pay the amount into the supplier's bank else, *C* will be sanctioned.

Furthermore, *D* notifies *B* of the receipt of the amount of product so that *B* can supply the product. If *D* does not notify *B* then, *D* is sanctioned. Upon the receiver of this notification, if *B* failed to supply the product then, *B* is sanctioned. Otherwise transaction is terminated. This implies that if transaction successfully gets to the end of the phases then, it is a trusted transaction.

PHASE I

Agent *A's* goal is to purchase product from agent *B* through an e-payment site. In other for the transaction to be successful, *A* desires that *B* supplies the product before payment while *B* desires that *A* pays for product before supply. To ensure trust in the contract negotiation, *A* needs to trust *B* that after payment, product will be supplied (party/ individual trust). If *A's* trust on *B* is sufficient transaction will proceed, otherwise *A* trusts that another agent *E* will serve as a normative agent ensuring additional trust between agents *A* and *B*. If *A's* trust on *E* is sufficient then transaction will proceed to the next phase else *A* will be sanctioned for distrust resulting in a failed transaction.

PHASE II

In this phase agent *C* acts as the next intermediary between agents *A* and *B*. If *C* pays the amount for the product to agent *D* based on trust among the two agents - *C* and *D* then transaction will proceed, else additional trust based on agent *E* is needed to ensure that once the money is paid to *D* it will be remitted to *B* and product will be supplied. If control trust is still not sufficient for agent *C* to continue with transaction then *C* will be sanctioned.

PHASE III

If phase II is successful transactions enters into phase III. In this phase *D* serves as the major agent alerting *B* to either supply product upon receiving product or withhold supply. If *D* fails to notify *B* upon receiving payment for goods it is then sanctioned, if *B* is notified and does not supply product to *A* it is then sanctioned, but if it has sufficient trust (party trust) in agent *D* then product will be supplied to *A* resulting in a successful transaction.

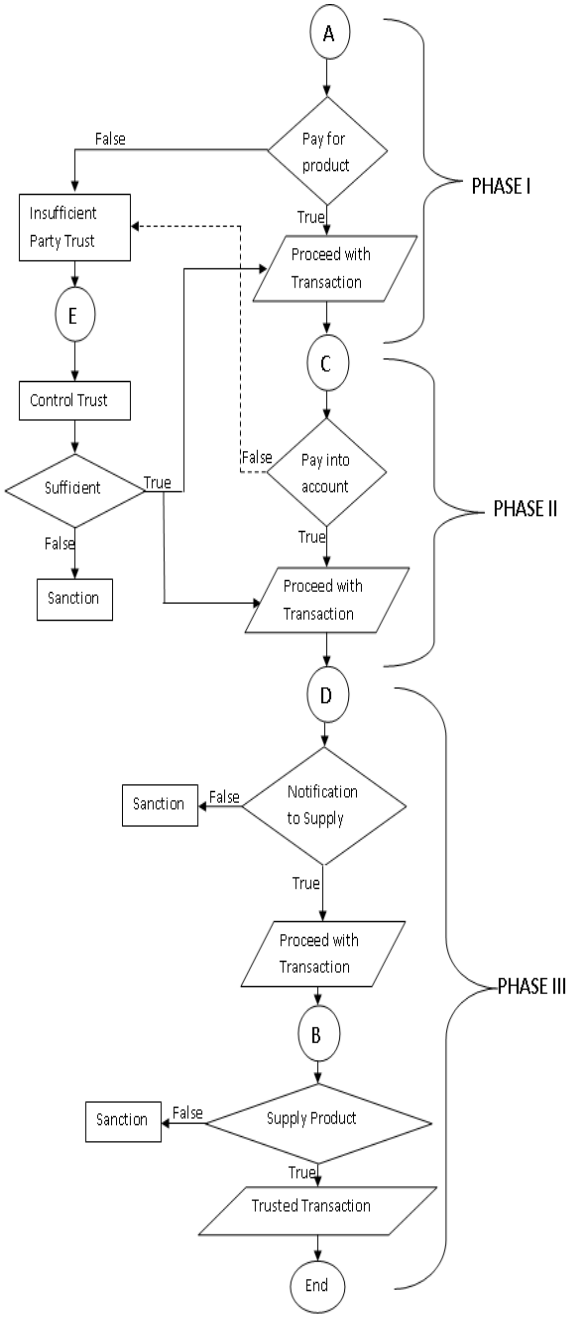

Figure 4**:** Phases for Trusted Transaction

3.2 Mental Attitude of the Agents with Trust Attributes

The attitudes of the payment agents are described using the five interacting agent in payment a payment system. Table 2 shows the goal, belief and the Desire of the interacting agents while figure 5 describes the negotiation between the agents. In table 3, the relationship among the interaction agents is described.

Table 2: Agents' Attitude

Agent	Belief	Goals	Desires
A	Render service before payment (Products may be paid for but not supplied)	Acquire product	Pay for product before supply. Get sanctioned if no payment after acquiring product. Acquire product before payment.
B	Pay before service (products may be supplied but not paid for)	Sell product	Supply product after payment. Get sanctioned in an attempt to maximize profit B might not supply product after payment. Supply product before payment.
C	Customer needs credit card for online transactions.	Issue credit card to customer	Satisfy customer by issuing a genuine credit card. Get sanctioned if it issues a fake credit card.
D	Buyer's credit details may be false	Validate buyer's credit detail	Satisfy supplier. Get sanctioned if it raises a false alarm
E	Banks might want to act fraudulently	Control bank operations	Sanction violators by either paying a fine or stop operations for a while.

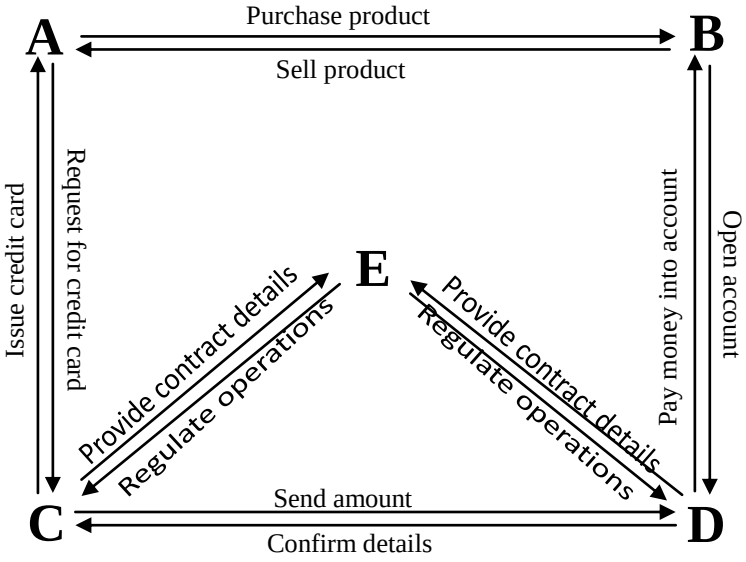

Figure 5: Negotiation Communication

The trusts between agents are explained with the following relation:

Trust between Agent *A AND B*

$$Trust_B^A\gamma \equiv Goal_A A_{g^1} \wedge Bel_A B_{g^1} \wedge Des_A(A_{d1} \vee A_{d2} \vee A_{d3}) \wedge Goal_A(B_{d1} \vee B_{d2} \vee B_{d3}) \wedge Bel_A(B_{d1} \vee B_{d2} \vee B_{d3}) \quad (6)$$

Trust between *Agent B AND A*

$$Trust_A^B\beta \equiv Goal_B B_{g1} \wedge Bel_B A_{g1} \wedge Des_B(B_{d1} \vee B_{d2} \vee B_{d3}) \wedge Goal_B(A_{d1} \vee A_{d2} \vee A_{d3}) \wedge Bel(A_{d1} \vee A_{d2} \vee A_{d3}) \quad (7)$$

Trust between *Agent A AND C*

$$Trust_C^A\alpha \equiv Goal_A A_{g1} \wedge Bel_A C_{g1} \wedge Des_A(A_{d1} \vee A_{d2} \vee A_{d3}) \wedge Goal_A(C_{d1} \vee C_{d2}) \wedge Bel_A(C_{d1} \vee C_{d2}) \quad (8)$$

Trust between *Agent B AND D*

$$Trust_D^B\delta \equiv Goal_B B_{g1} \wedge Bel_B D_{g1} \wedge Des_B(B_{d1} \vee B_{d2} \vee B_{d3}) \wedge Goal_B(D_{d1} \vee D_{d2}) \wedge Bel_B(D_{d1} \vee D_{d2}) \quad (9)$$

Trust between *Agent D AND C*

$$Trust_C^D\theta \equiv Goal_D D_{g1} \wedge Bel_D C_{g1} \wedge Des_D(D_{d1} \vee D_{d2}) \wedge Goal_D(C_{d1} \vee C_{d2}) \wedge Bel_D(C_{d1} \vee C_{d2}) \quad (10)$$

Trust among *Agent C, D AND E*

Let agent C and D be taken jointly as G such that their joint trust is;

$$JTrust_E^G\lambda \equiv (Trust_E^C\lambda \wedge Trust_E^D\lambda), \quad (11)$$

Then,

$$Trust_E^D\lambda \equiv Goal_D D_{g1} \wedge Bel_D E_{g1} \wedge Des_D(D_{d1} \vee D_{d2}) \wedge Goal_D(E_{d1}) \wedge Bel_D(E_{d1}) \quad (12)$$

$$Trust_E^C\lambda \equiv Goal_C C_{g1} \wedge Bel_C E_{g1} \wedge Des_C(C_{d1} \vee C_{d2}) \wedge Goal_C(E_{d1}) \wedge Bel_C(E_{d1}) \quad (13)$$

Legend

$\gamma \equiv release\ product$

$\beta \equiv purchase\ product$

$\alpha \equiv issue\ credit\ card$

A trust C to issue credit card

$\delta \equiv pay\ money\ into\ account$

$\theta \equiv pay\ money\ into\ account$

Table 3: The Relationship of the Interacting Agents

Agents	Interpretation
A and B	*A trust B to release product means . A's goal is to acquire product. A believes that B wants to sell product. A* desires to pay for product before supply, not pay for product and get sanctioned or pay for product after product has been supplied. *A's* goal takes into consideration the desires of *B* which is to supply goods paid for, not supply products paid for and get sanctioned or supply goods before payment. *A's* belief also takes into consideration the desires of *B.*
B and A	*B trust A to purchase product. B's goal is to sell product. B believes that A wants to acquire product. B* desires to supply goods after payment, not supply goods paid for and get sanctioned or supply goods before payment. *B's* goal takes into consideration the desires of *A* which is to pay for product before supply, not pay for product and get sanctioned but pay for product after supply. *B's* belief also considers the desires of *A.*
A and C	*A's goal is to acquire product. A believes that C will issue credit card*. *A* desires to pay for product before supply, not pay for product and get sanctioned or pay for product after product has been supplied. *A* considers as part of its goal the desires of *C* which is either to satisfy customer or issue a fake credit card and get sanctioned. A also believes that *C* could either satisfy customer by issue a genuine credit card or issue a fake credit card and get sanctioned.
B and D	*B trust D to pay money into account. B's goal is to sell product. B believes that D will validates credit card detail. B* desires to supply goods after payment, not supply goods paid for and get sanctioned or supply goods before payment. *B* considers as part of its goals the desires of *D* which is either to satisfy supplier or raise a false alarm and get sanctioned. B includes in its believes the desires of *D.*
D and C	*D trust C to pay money into account. D's goal is to validate credit card details. D believes that C issued credit card. D* desires to either satisfy supplier or raise false alarm and get sanctioned. *D* includes as part of its goals the desires of *C* which is either to satisfy customer by issuing a genuine credit card or issue a false credit card and get sanctioned. *D* also includes in its beliefs the desires of *C.*
C, D and E	*The group G jointly trust E to regulate operations. C trust E to regulate operations. D trust E to regulate operations. D's goal is to validate credit card details. D's goal considers the desire of E which is to sanction violators. C's goal is to issue credit card. D believes that E will control bank operations. D also believes that E will sanction any violator. C believes that E will control bank regulations.* *D desires to either satisfy supplier or raise false alarm and get sanctioned. C* desires to either satisfy customer by issuing a genuine credit card or issue a fake credit card and get sanctioned. *C* includes as part of its goal *E's* desire which is to sanction violators. *C* also includes in its beliefs the desires of *E*.

4. Theoretical Evaluation of Transacting Agents

Table 4 shows the result of possible transactions. Transaction 1 shows a buyer who has sufficient balance in the account to make payment, but has no party trust. Based on this sufficient balance, the buyers' bank (agent C) pays the equivalent amount of product into supplier's account. Thereafter, the supplier's bank (agent D) notifies the supplier (agent B) to supply the product requested based on individual trust. Transaction 2 depicts a buyer that not only has sufficient balance but also have a reasonable level of party trust. As a result of this, agent C pays the amount of the product into supplier's account, after which agent D alerts agent B to supply product. This is based on individual and party trust.

On the other hand, transaction 3 depicts a buyer that has insufficient balance in his account but has sufficient party

trust. Though, agent C and agent D were not involved in the transaction because of insufficient balance in agent A's account, the transaction still proceed based on party trust. However, transaction 4 depicts a transaction that terminates because not just because of insufficient balance but also as a result of lack of party trust.

Table 4: Agents' Transaction Table

Transaction	**Agent *A* (buyer)**	**Agent *C* (buyer's bank)**	**Agent *D* (supplier's bank)**	**Agent *B* (supplier)**	**Result**
1	Sufficient Balance, No Party Trust	Pay money into supplier's bank	Credit Supplier's account	Supply Product	Transaction proceeds based on Individual Trust.
2	Sufficient Balance and Party Trust	Pay money into supplier's bank	Credit Supplier's account	Supply Product	Transaction proceeds based on Individual and Party Trust
3	Insufficient Balance and Party Trust			Supply Product	Transaction proceeds based on Party Trust
4	Insufficient Balance and No Party Trust			Retain Product	Transaction terminates based on insufficient Trust

5. Conclusion

In this paper, a model that embeds trust in a normative multiagent system for e-payment analysis was introduced. The model uses a combination of Tan and Theon 3 steps model for contract negotiation and Castelfranchi and Falcone's trust model to ensure trust among agents in the normative system and when there is a violation of a norm as a result of distrust, sanction is melted out to the agent violator. The model for contract negotiation in e-payment system includes creation of obligations by agents which is based on the mental attitude of each agent comprising of beliefs, goals and desires, the association of sanctions to obligations to ensure the execution of the best goal without violating of any norm and finally, addition of controls to enforce sanctions.

In order to ensure further trust apart from the use of norms, Castelfranchi and Falcone's trust model were employed in order to ensure further party trust (individual trust) and control trust (collective trust). It was observed that, despite the rules to set up ensure further trust in the normative multiagent system, there still exist agent's violators, which were not allow to make transactions. For a successful payment transaction, the norms existing among the interactive system must be observed.

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