Self-regulation of Social Exchange Processes: A Model Based in Drama Theory

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Abstract. This paper presents a dramatic model for self-regulation of social exchange processes in multiagent systems, based on the concepts of Drama Theory. The model has five phases of dramatic resolution, which involve feelings, emotions, trust and reputation. Agents with different social exchange strategies interact each other in order to maximize their strategy-based fitness functions. The objective is to obtain a more natural model than the ones existing in the literature, which are based on (partially observable) Markov decision processes or in game theory, so that it can be applied in real-world applications. We aim at promoting more balanced and fair multiagent interactions, increasing the number of successful social exchanges and, thus, promoting the continuity of social exchanges.

Keywords: Drama theory · Social exchange processes · Regulation of interactions

1 Introduction

The Piaget's Social Exchanges Theory [1] has been used as the basis for the analysis of interactions in Multiagent Systems (MAS). Such interactions are called services exchanges, which are evaluated by the agents when interacting, creating the concept of social exchange values, that are qualitative and subjective values [2–5]. A fundamental problem that has been discussed in the literature is the regulation of social exchanges [6–12], in order to allow, for example, the emergence of balanced exchanges along time, leading to social equilibrium and stability [1] and/or fairness behaviour [13,14]. In particular, this is a difficult problem when the agents, adopting different social exchange strategies, have incomplete information on the other agents' exchange strategies. This is a crucial problem in open agent societies (see [8,9]).

In previous works (e.g., [6,8,9]), Dimuro et al. and Pereira et al. have introduced different models (e.g., centralized/decentralized control, internal/external control, closed/open societies) for the social exchange regulation problem, developing different hybrid agent models. In particular, Macedo et al. [15] introduced the first step towards the self-regulation of the social exchanges processes. The

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problem was tackled in a game theory context, given a new interpretation, in terms of material[1] exchanges, to the special kind of interaction described by the evolutionary spatial ultimatum game discussed by Xianyu [14]. Considering an agent society organized in a complex network, the paper analyzed the evolution of the agents' exchange strategies along the time considering the influence of their social preferences on the emergence of the equilibrium/fairness behavior. However, long-term aspects of the interaction and other concerns that exchange processes may involve were not considered in this simplified model.

In [11], Dimuro et al. introduced the Game of Self-Regulation of Social Exchange Processes (GSREP), where the agents, possessing different social exchange strategies, considering both the short and long-term aspects of the interactions, evolve their exchange strategies along the time by themselves, in order to promote more equilibrated and fair interactions, guaranteing the continuation of the exchanges. In [12], Von Laer et al. analysed the problem of the self-regulation of social exchange processes in the context of a BDI-based[2] MAS, adapting the GSREP game to Jason [17] agents and introducing a cultural aspect, where the society culture, aggregating the agents' reputation as group beliefs, influences directly the evolution of the agents' exchange strategies, increasing the number of successful interactions and improving the agents' outcomes in interactions.

In Game Theory [18–20], usually, a game is defined by fixing the preferences and opportunities of the players. In 1991, Nigel Howard created the Drama Theory [21,22], a game theory extension, where the preferences and choices of the characters (players) may change under the pressure of the pre-game negotiations. Game theory tries to predict the outcome of a game with "rational" players. However, the theory of drama shows how aspiring players, communicating each other before a game, build not only the game that they will play, but also the result that they expect of it, without the need to predict an outcome. Furthermore, the drama theory challenges the theoretical concept of "rational" game. After analysing the pre-game communication, it is discarded the hypothesis that the players know what they want, what others want, and what they and others can do about it, and that all these things are fixed [22].

This objective of the present paper is to propose a dramatic model for the self-regulation of social exchange processes, applying the concepts of the drama theory to GSREP game, adding feelings and expressions of emotions based on the OCC model [23], in order to obtain a natural model that approximates the reality and sp that it can be applied on real world applications.

The paper is organized as follows. Section 2 summarizes the theoretical basis of this work: the main concepts of social exchanges and of drama theory. Section 3 presents the definition of dramatic model and Sect. 4 is the Conclusion.

[1] Material exchanges are concerned just with the short-term aspects of the interaction, involving only exchange values generated immediately after the interaction. [2].

[2] BDI stands for "Beliefs, Desires, Intentions", a particular cognitive agent model introduced in [16].

2 Theoretical Basis

2.1 Social Exchange

According to Piaget [1], a social exchange is any sequence of actions among two agents, such that one of them, to realize his/her actions, provides a service to another, with the immediate individual qualitative evaluation of the services provided. That is, the agent assigns a value to its investment in the realization of a service to another agent and the latter assigns a value of satisfaction for having received such a service. Such values are called material exchange values. In a social exchange process, debt and credit values are also generated, which allow the realization of future exchanges. Debt and credit are called virtual values.

A social exchange among agents involves at least two agents, X and Y, in two exchanges steps/stages, as shown in Fig. 1. In **Step I** the agent X performs a service to the agent Y and, in **Step II**, the agent X requests to the agent Y a payment for the service previously performed for it. In each step, the following exchange values are generated:

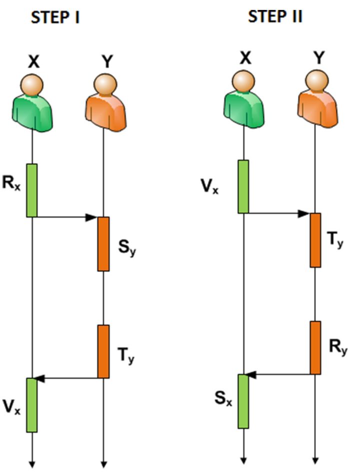

Fig. 1. Steps of a social exchange process among two agents [24].

- **Step I**:
  1. r_x: *Investment* value of agent X.
  2. s_y: *Satisfaction* value of agent Y.
  3. t_y: *Debit* value of agent Y.
  4. v_x: *Credit* value of agent X.

In this way, the agent X performs a service with some investment value (r_x) to the agent Y. The agent Y generates for the services received a satisfaction value

(s_y) and an acknowledgement value (t_y) or debt for the satisfaction to received service of X. At the end of this step, the agent X finished with a virtual value (v_x), that is, a credit related to the action performed to the agent Y.

– **Step II**:
  1. v_x: *Credit* value of agent X.
  2. t_y: *Debit* value of agent Y.
  3. r_y: *Investment* value of agent Y.
  4. s_x: *Satisfaction* value of agent X.

Similar to **Step I**, there is a possible charge debt from the agent X to agent Y, where the agent X collect of agent Y a service relative to its credit virtual value (v_x), acquired in **Step I**. The agent Y has on its conscience a debit value (t_y), and it will perform an offer with investment value (r_y) to the agent X, which will generate a satisfaction value (s_x) to Y offer.

So, in both steps (**Step I** and **Step II**), r_{agent} and s_{agent} are material values generated while performing/receiving a service, and t_{agent} and v_{agent} are virtual values that can be traded in the near future and will enable the choice of future agents' decisions. Importantly, there is no order in the occurrence of the steps **I** and **II** in repeated processes of social exchanges [6].

The social equilibrium is obtained when the balance of the values for each agent are around an acceptable value for the agent society, in general, around zero.

2.2 Drama Theory

Differently from Game Theory, which considers that a game is defined by previously fixed preferences and opportunities for the players, Drama Theory [21,22,25,26] is a theory of how the game itself may change: how a game G can be transformed into other game G', which, in its turn, may be transformed to a game G'', and so on. These transformations result from the fact that the players may put pressure on others during the pre-game negotiations, since they exchange threats, promises, emotional persuasion and rational arguments.

Drama theory helps to identify transformations caused by internal dynamics of pre-game negotiations. Such transformations describe rational and irrational processes of human development and self-realization, rather than just the rational choice of a given end.

While game theory exposes the rational behaviour, based on goals, drama theory shows how, in the course of an interaction, people change and evolve. Rationality is still important, but no longer dominates.

3 The Dramatic Model of Self-regulation Social Exchange Processes

The dramatic model of self-regulation of social exchange processes proposed is based in the five phases of dramatic resolution of Drama Theory, that are represented in Fig. 2.

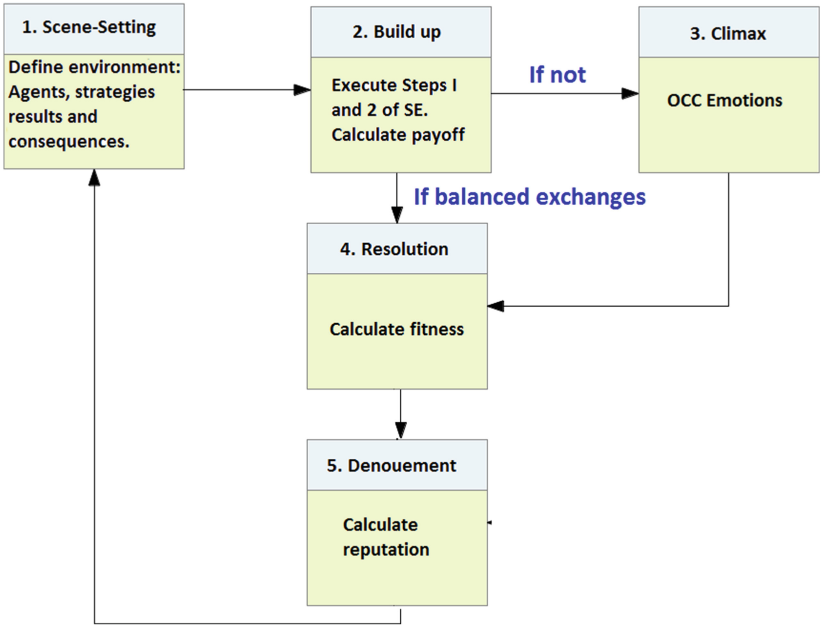

Fig. 2. Phases of dramatic resolution.

3.1 Phase 1: Scene-Setting

At this phase, the environment is defined with the actors (agents), agents' social exchange strategies, results and consequences.

The agents' social exchange strategies that are considered in this paper are altruism, weak altruism, selfishness, weak selfishness and rationality. For example, an agent with selfishness strategy is more likely to devalue the received service and overvalue an offered service, which impacts on debt and credit values; the rational agent plays just for the Nash Equilibrium[3]. The social exchange strategies are determined by various factors, as we explain in the following, but, in particular, by the maximal investment value r^{max} that the agents are willing to have for a service performed for another agent, and the minimal satisfaction value $s_{\min}$ they are willing to accept, with $r, s \in [0, 1]$.

The consequence is represented by a function $Q : X \to X$, where X is the set of the individual results of the characters or agents, i.e., their strategies. Individual results are a pair composed of aspiration (a particular future we would like to achieve) and a position (a future that it proposes to others).

In the dramatic model, the result of an agent is represented by the investment proposed (r^{prop}), i.e., the future it proposes to other agents; and the satisfaction expected (s^{esp}), i.e., the desire, a particular future that it would like to achieve.

[3] See [11] for a discussion on the Nash Equilibrium of the Game of Social Exchange Processes.

3.2 Phase 2: Build up

At this phase, a determinate frame $F = (Q, P)$ is selected, where, Q is the result set of each agent and $P = (P_i | i \in C)$ is a family of preference relations, one for each character or agent i at casting C, defined along of results set X. In this game, $(x, y) \in P_i$ means that "the agent i prefers the strategy x to strategy y".

After selecting the frame, the steps **I** and **II** of the social exchange are executed, as shown in Sect. 2.1. A social exchange strategy of an agent $\lambda = ij$, is defined by the tuple:

$$(r_\lambda^{prop}, s_\lambda^{esp}, k_\lambda^{\rho t}, k_\lambda^{\rho v}), \tag{1}$$

where $r_\lambda^{prop} \in [0, 1]$ and $s_\lambda^{esp} \in [0, 1]$ represent the proposed investment value that the agent λ will have for a service offered to another agent, and the satisfaction value that agent λ expects for received services, respectively; $k_\lambda^{\rho t}, k_\lambda^{\rho v} \in [0, 1]$ are, respectively, the factors of depreciation $(\rho = d)$ or overvaluation $(\rho = o)$ of debit and credit values that define each exchange strategy.

In this phase, they are calculated the Payoff Supposed (*payoffSup*) and the Payoff Effective (*payoffEfet*) of social exchange between the agents i e j, with the respective exchange strategies:

$$(r_i^{max}, r_{ij}^{prop}, r_{ij}^{efet}, s_i^{min}, s_i^{esp}, k_i^{\rho t}, k_i^{\rho v}) \text{ e } (r_j^{max}, r_{ji}^{prop}, r_{ji}^{efet}, s_j^{min}, s_j^{esp}, k_j^{\rho t}, k_j^{\rho v})$$

The *payoffSup* obtained by an agent i in this interaction is evaluated by function $p_{ij}^{sup} : [0, 1]^4 \rightarrow [0, 1]$, defined by.

$$p_{ij}^{sup} = \begin{cases} \frac{1 - r_{ij}^{prop} + s_{ij}^{esp}}{2}, & \text{se}(r_{ij}^{prop} \leq r_i^{max} \wedge s_{ji}^{esp} \geq s_j^{min}) \wedge (r_{ji}^{prop} \leq r_j^{max} \wedge s_{ij}^{esp} \geq s_i^{min}) \\ \frac{1 - r_{ij}^{prop}}{2}, & \text{se}(r_{ij}^{prop} \leq r_i^{max} \wedge s_{ji}^{esp} \geq s_j^{min}) \wedge (r_{ji}^{prop} > r_j^{max} \vee s_{ij}^{esp} < s_i^{min}) \\ 0, & \text{se}(r_{ij}^{prop} > r_i^{max} \vee s_{ji}^{esp} < s_j^{min}) \wedge (r_{ji}^{prop} > r_j^{max} \vee s_{ij}^{esp} < s_i^{min}) \end{cases} \tag{2}$$

The *payoffEfet* obtained by an agent i in this interaction is evaluated by function $p_{ij}^{efet} : [0, 1]^4 \rightarrow [0, 1]$, defined by:

$$p_{ij}^{efet} = \begin{cases} \frac{1 - r_{ij}^{efet} + s_{ij}^{esp}}{2}, & \text{se}(r_{ij}^{efet} \leq r_i^{max} \wedge s_{ji}^{esp} \geq s_j^{min}) \wedge (r_{ji}^{efet} \leq r_j^{max} \wedge s_{ij}^{esp} \geq s_i^{min}) \\ \frac{1 - r_{ij}^{efet}}{2}, & \text{se}(r_{ij}^{efet} \leq r_i^{max} \wedge s_{ji}^{esp} \geq s_j^{min}) \wedge (r_{ji}^{efet} > r_j^{max} \vee s_{ij}^{esp} < s_i^{min}) \\ 0, & \text{se}(r_{ij}^{efet} > r_i^{max} \vee s_{ji}^{esp} < s_j^{min}) \wedge (r_{ji}^{efet} > r_j^{max} \vee s_{ij}^{esp} < s_i^{min}) \end{cases} \tag{3}$$

The *payoffSup* and the *payoffEfet* of j agent are defined analogously.

Considering an environment composed of the cast $C = 1, ..., m$ of m agents, each agent $i \in C$ interacts with the others $m - 1$ neighbours agents $j \in C$, such that $j \neq i$. In every interaction cycle, each agent i evaluates its material results of local social exchange with each neighbour agent j, using the local *payoffSup* and *payoffEfet* functions, given in the Eqs. (2) and (3). Then, the full *payoffSup* and *payoffEfet* received by each agent are calculated after each agent has performed the two-step exchange with all its neighbours. For p_{ij}^{sup} and p_{ij}^{efet}

calculated by Eqs. (4) and (5), the allocation of total *payoffSup* and *payoffEfet* of a neighbourhood of m agents, is given by :

$$X^{sup} = x_1^{sup}, ..., x_m^{sup}, \text{where } x_i^{sup} = \sum_{j \in C, j \neq i} p_{ij}^{sup} \tag{4}$$

$$X^{efet} = x_1^{efet}, ..., x_m^{efet}, \text{where } x_i^{efet} = \sum_{j \in C, j \neq i} p_{ij}^{efet} \tag{5}$$

After calculating the payoff effective of exchanges, the balance of these exchanges is analysed. Ideally, a balanced exchange is when the difference between the payoffs of all exchanges is zero. However, in practice, this divergence occurs around zero. This divergence between the payoffs are calculated according to Eq. 6:

$$D_i = \frac{1}{(m-1)} \sum_{i \neq j}^{j=[1..m]} |x_i - x_j| \leq \alpha \tag{6}$$

where, m is the total number of agents and α is the divergence factor.

Therefore, it is considered balanced exchanges when $D_i \leq \alpha$ for all exchanges.

3.3 Phase 3: Climax

If, in phase 2, all the exchanges occur in a balanced way, the phase 3 is ignored and the game moves on to the phase 4, where the emotions will have null weight in the calculus of the *fitness* value, denoted by $\mathrm{F}_i(X^{efet})$ of an agent i.

If a of exchanges is not balanced, all agents migrate to the phase 3. We considered four types of emotions of the OCC model [23], namely, gratification, gratitude, regret and anger, represented by $a_\lambda, b_\lambda, c_\lambda$ and d_λ, respectively. Observe that in the OCC model there are three aspects that change the world reactions: events, agents and objects. The events are interesting because we may analyse its consequences, the agents because we may analyse their actions, and objects because the aspects and properties of those objects are analysed. The chosen emotions are part of a group that focuses on the action of an agent and the consequences of the events [27].

A *spatial social exchange strategy* of an agent $\lambda, \lambda = 1, ..., m$ is defined by the tuple:

$$(r_\lambda^{prop}, r_\lambda^{efet}, s_\lambda^{esp}, a_\lambda, b_\lambda, c_\lambda, d_\lambda, k_\lambda^{\rho t}, k_\lambda^{\rho v}), \tag{7}$$

where $a_\lambda, b_\lambda, c_\lambda, d_\lambda$ reflect the influence of the emotions in the fitness value $\mathrm{F}_i(X^{efet})$ of an agent i, in the following way:

- **Gratification** (a_i)

$$\mathrm{F}_i(X^{efet}) = x_i^{efet} + \frac{a_i}{(m-1)} \sum_{i \neq j} \max(x_j^{efet} - x_j^{sup}, o)$$

where X^{efet} is the total payoff effective allocation of agent i.

Gratification is a positive feeling generated in the agent itself who proposed the exchange when the *payoff effective (payoffEfet)* of the agent that received the service (x_j^{efet}), obtained by effective investment, is greater than the *payoff supposed (paypffSup)* it was supposed to receive (x_j^{sup}). This means that practising a value greater than the promised value, the agent feels more confident and also generates a reciprocal feeling of gratitude on the other agent.
- **Gratitude** (b_i)

$$\mathrm{F}_i(X^{efet}) = x_i^{efet} + b_i + \max(x_i^{efet} - x_i^{sup}, 0)$$

where X^{efet} is the total payoff effective allocation of agent i.
Gratitude is a positive feeling generated in the agent that received the service when the *payoff effective (payoffEfet)* of the agent that has practised the exchange (x_i^{efet}) is greater than the *payoff supposed (payoffSup)* it was supposed to receive the group (x_i^{sup}). When receiving a greater value than the one promised, the agent is grateful to the agent who performed the service, generating a good reputation of this agent, since it comply with what it promised.
- **Regret** (c_i)

$$\mathrm{F}_i(X^{efet}) = x_i^{efet} - \frac{c_i}{(m-1)} \sum_{i \neq j} \max(x_j^{sup} - x_j^{efet}, o)$$

where X^{efet} is the total payoff effective allocation of agent i.
Regret is a negative feeling generated in the agent itself who proposed the exchange when the *payoff effective (payoffEfet)* of the agent that received the service (x_j^{efet}) is less than the *payoff supposed (payoffSup)* that it was supposed to receive (x_j^{sup}). This feeling generated a reciprocal feeling of anger at another agent, and consequently it will get a bad reputation of this other agent, since it did not comply with what it promised.
- **Anger** (d_i)

$$\mathrm{F}_i(X^{efet}) = x_i^{efet} - d_i + max(x_i^{sup} - x_i^{efet}, o)$$

where X^{efet} is the total payoff effective allocation of agent i.
Anger is a negative feeling generated in the agent who received the service when the *payoff effective (payoffEfet)* of the agent who practised the exchange (x_i^{efet}) is less than the *payoff supposed (pauoffSup)* it was supposed to receive (x_i^{sup}).

Therefore, it is clear that an equilibrated balance is achieved when the antagonistic emotions are annulled.

3.4 Phase 4: Resolution

After execution of the steps **I** and **II** of the social exchange process in the build up phase, if there is an equilibrated balance, the game progresses to phase 4. At this phase, considering the payoff obtained in phase 2, the agent i calculates its adaptation degree through its *fitness* function $\mathrm{F}_i : [0,1]^m \rightarrow [0,1]$, defined by:

$$\mathrm{F}_i(X^{efet}) = x_i^{efet}$$

where X^{efet} is the total payoff effective allocation of agent i.

If the phase 3 has been executed, the emotions generated are added to the fitness function, representing the influence of these emotions on the results of the total agents' payoff effective.

Let X be the allocation of total *payoffEfet* of a neighbourhood of m agents. The general definition of the fitness function, based on exchange strategy of an agent i, is given by:

$$\begin{aligned} &F_i(X^{efet}) = \\ &x_i + \frac{a_i}{(m-1)} \sum_{i \neq j} \max(x_j^{efet} - x_j^{sup}, o) + b_i + \max(x_i^{efet} - x_i^{sup}, 0) \\ &- \frac{c_i}{(m-1)} \sum_{i \neq j} \max(x_j^{sup} - x_j^{efet}, o) - d_i + max(x_i^{sup} - x_i^{efet}, o) \end{aligned} \tag{8}$$

3.5 Phase 5: Denouement

After obtaining the value of *fitness* function, the phase 5 is executed. At this phase, the reputation of agents is calculated. For the social sciences, reputations are defined as a collective of beliefs and opinions that influence the actions of individuals in relation to their peers. The reputation can still be seen as a social tool in order to reduce uncertainty to interact with individuals of unknown attributes. To [28], reputation is generally defined as the amount of confidence inspired by a particular person in an environment or specific area of interest.

In computer science, reputation and trust it has gained growing evidence in last years, especially in the *Distributed Artificial Intelligence* (DAI) area, where Multiagent Systems are included. Trust and Reputation are used as a way of search for partners. The reputation has the power to propagate trust and can prevent unnecessarily agents interact. See [29–32]

Rodrigues and colleagues [33] developed a reputation model based on models such as REGRET [34] and Hübner [35]. The analysis of Reputation is divided into three dimensions: Social Dimension, Single Dimension and Ontological Dimension, as proposed in REGRET model. On the Social Dimension is analysed the effectiveness of the agent to its social group. In the Single Dimension is analysed the direct exchanges among agents. Finally, there is the Ontological Dimension, where social and individual dimensions are combined for a final analysis.

To our dramatic model, we used the reputation model proposed by [33], considering only the single dimension at the moment. At this phase 5, the $payoffs$ obtained in phase 3 through social exchanges will be stored in a list of size v.

The calculation of the reputation is given by:

$$Rep = \frac{\sum_{j \in C, j \neq i} p_{ij}}{size(v)} \tag{9}$$

With the obtained information in the denouement phase, the game return to phase 1, where it will redefine the environment from new strategies, i.e., from the calculated reputation, the agents will choose new partners to execute the social exchange, and start the second round of the game.

4 Conclusion

This introduced the model of a dramatic game of self-regulation of social exchange processes.

In the real world, the social exchanges not happen exclusively in a rational way, frequently involving feelings and emotions. In this way, the possibility of applying the drama theory to the game of self-regulation of social exchange processes has emerged.

Applying the concepts of drama theory and improving the trust and the reputation model to the developed dramatic model, we aim at the application in a simulation game of social exchanges in an environment that approximates the real world, that is, a world where the exchanges relations are based on emotions, feelings, trust and reputation.

The model will be implemented in NetLogo, an simulations with different compositions of the agent society and scenarios will be conducted to study the development of the strategies and social exchange processes through time.

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