Empowered Situations of Autonomous Agents

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Abstract. Identifying situations in which power exists is an ability that agents can exploit when they must interact with one another. In particular, agents can take advantage of empowered situations to make other agents satisfy their goals. The aim of this paper is to identify situations in which power might exist through the roles agents play in a society as well as the powers that emerge from their own capabilities. However, unlike other models in which power is eternal and absolute, in our model power is always considered as being *dynamic*.

1 Introduction

Identifying situations in which power exists is an ability that agents can exploit when they need to interact with one another. In particular, agents can take advantage of empowered situations to make other agents satisfy their goals. That is, one of the advantages for agents in a society is that they can overcome their limited capabilities by using the capabilities of others and, in this way, satisfy goals that might otherwise not be achieved. However, given that agents are autonomous, the benevolent adoption of goals cannot be taken for granted since agents can choose not to adopt them [15], and therefore a mechanism to influence them must be used. One effective means of doing this is by using the power that some agents have not only due to their own capabilities [4], but also by being in particular situations in the society where they exist.

According to Ott [18], *power* can be defined as the latent ability to *influence* the actions, thoughts or emotions of others and, consequently, it is the potential to get people to do things the way you want them done. Translating these concepts to the context of agents, we can say that powers are expressed through an agent's capabilities to change the beliefs, the motivations, and the goals of others. However, power exists only if the other agents allow being influenced. That is, power involves a bilateral relationship between two agents, the one who exerts the power and the one on whom the power is exerted [9]. What is important to understand now is both where the power of agents comes from and why some agents become influenced.

Towards this end, the main objective of this paper is to analyse the situations in which power can be identified, whereas situations in which agents are influenced are left for future work. Unlike other models in which power is eternal and absolute, in our model power is always considered as being *dynamic*. That is, powers appearing in a particular situation might not exist in another, and they cannot be exerted over all agents, but a particular subset of agents. In addition, our model always considers powers of agents as being related to the goals of target agents (i.e. those to be influenced). We start our discussion by defining autonomous agents and norms in Section 2. After that, powers existing in a society are described in Section 3, whereas powers that are result of agents' capabilities are discussed in Section 4. Finally, both conclusions and future work are presented.

2 Agents and Norms

In this section, we describe the basic blocks from which to build up our theory of power relationships, and which underpin several aspects not included in this paper, but described elsewhere [14, 16]. In particular, we adopt the SMART *agent framework* described in [8] and, in what follows, we use the Z specification language to construct a formal model. Z is based on set-theory and first order logic, with details available in [21]. For brevity, however, we will not elaborate the use of Z further.

In the SMART *agent framework*, an *attribute* represents a perceivable feature of the agent's environment, which can be represented as a predicate or its negation. Then, a particular *state* in the environment is described by a set of attributes, *actions* are discrete events that change the state of the environment when performed, a *goal* represents situations that an agent wishes to bring about, and *motivations* are desires or preferences that affect the outcome of the reasoning intended to satisfy an agent's goals. For the purposes of this paper, we formally describe environmental states, actions and goals. Details of the remaining elements are not needed, so we consider them as given sets.

$$[Attribute, Motivation]$$

$$EnvState == \mathbb{P}_1\ Attribute; \qquad Action == EnvState \rightarrow EnvState$$
$$Goal == \mathbb{P}_1\ Attribute$$

In addition, an *entity* is described by a non-empty set of attributes representing its permanent features, a set of goals that it wants to bring about, a set of capabilities that it is able to perform, and a set of motivations representing its preferences. Moreover, *agents* are entities whose set of goals is not empty, and *autonomous agents* are agents with non-empty sets of motivations. By omitting irrelevant details, we formalise them as follows.

$$\begin{array}{|l} \textit{Agent} \\ \hline capabilities : \mathbb{P}\ Action;\ goals : \mathbb{P}\ Goal \\ motivations : \mathbb{P}\ Motivation;\ beliefs : \mathbb{P}_1\ Attribute \\ \hline goals \neq \varnothing \\ \hline \end{array}$$

$$AutonomousAgent \mathrel{\widehat=} [Agent \mid motivations \neq \varnothing]$$

An agent may have access to certain norms, which are represented as data structures relating to social rules. *Norms* are mechanisms within a society that influence the behaviour of agents within it; they can be characterised by observing several different aspects. First, norms must be complied with by a set of *addressee* agents in order to *benefit* another set of agents (possibly empty). They specify what ought to be done and, consequently, they include *normative goals* that must be satisfied by addressees. Sometimes, these normative goals must be directly intended, whereas other times their role is to inhibit specific goals (as in the case of prohibitions). Second, norms are not always applicable, and their activation depends on the *context*; there may be *exceptions* when agents are not obliged to comply with the norm. Finally, in some cases, norms suggest the existence of a set of *sanctions* or *punishments* to be imposed when addressees do not satisfy the normative goal, and a set of *rewards* to be received when they do. Thus, the general structure of a norm can be formalised as follows.

$$
\begin{array}{|l}
\textit{Norm} \\
\hline
addressees, beneficiaries : \mathbb{P}\, Agent \\
context, exceptions : EnvState \\
normativegoals, rewards, punishments : \mathbb{P}\, Goal \\
\hline
addressees \neq \varnothing \land context \neq \varnothing \\
\hline
\end{array}
$$

Now, in order to know if a norm has been fulfilled, the satisfaction of its associated normative goals must be verified. This is true if the normative goals are a *logical consequence* of the current environmental state. This is formalised as follows.

$$
\begin{array}{|l}
logicalconsequence\_ : \mathbb{P}(EnvState \times EnvState) \\
fulfilled\_ : \mathbb{P}(Norm \times EnvState) \\
\hline
\forall\, n : Norm;\ st : EnvState \bullet \\
\quad fulfilled\ (n, st) \Leftrightarrow (\forall\, g \in n.normativegoals \bullet logicalconsequence\ (st, g)) \\
\hline
\end{array}
$$

Moreover, a *normative agent* is an autonomous agent whose behaviour is shaped by the obligations it must comply with, prohibitions that limit the kind of goals that it can pursue, social commitments that have been created during its social life and social codes which may not carry punishments, but whose fulfillment could represent social satisfaction for the agent. All these responsibilities are represented by norms.

$$
\begin{array}{|l}
\textit{NormativeAgent} \\
\hline
AutonomousAgent \\
norms : \mathbb{P}\, Norm \\
\hline
\end{array}
$$

Sometimes, it is useful to observe norms not through the normative goals that ought to be achieved, but through the actions that can lead to the satisfaction of such goals. Then we can talk about actions that are either *permitted* or *forbidden* by a norm as follows. If there is a state that activates a norm, and the results of a particular action benefit the achievement of the associated normative goals, then such an action is *permitted* by the respective norm. Similarly, *forbidden* actions are those leading to a situation that contradicts or hinders normative goals. In general, it is not trivial to observe how the results of an action might benefit or hinder the achievement of normative goals, but to avoid drilling down into the intricate details of this, the associations between situation states that might either *benefit* or *hinder* goals are taken for granted. Moreover, we define two relations that hold among an action and a norm, which either permit or forbid it, as follows.

$$
\begin{array}{|l}
benefits\_, hinders\_ : \mathbb{P}(EnvState \times Goal) \\
permitted\_, forbidden\_ : \mathbb{P}(Action \times Norm) \\
\hline
\forall\, a : Action;\ n : Norm; \bullet \\
\quad permitted\ (a, n) \Leftrightarrow (\exists\, g : n.normativegoals \bullet benefits\ (a\ n.context, g)) \land \\
\quad forbidden\ (a, n) \Leftrightarrow (\exists\, g : n.normativegoals \bullet hinders\ (a\ n.context, g)) \\
\hline
\end{array}
$$

In other words, if an action is applied in the context of a norm, and the results of this action benefit the normative goals, then the action is permitted, otherwise the action is forbidden.

3 Institutional Powers

It is generally accepted that social structures define power relationships derived from the roles agents play in a norm-based system. In such systems there exist norms that entitle some agents to direct the behaviour of others. Therefore, as long as an agent wants to belong to such a system, it must recognise the power, and therefore the authority, of certain agents. We call these kinds of powers *institutional powers*, a term that we borrow from [11], and before analysing them we define a *normative multi agent system* as a set of normative agents controlled by a common set of norms (a better description can be found in [12]). In such systems four types of norms can be identified, namely, norms directed at controlling all agents($normsNMAS$), norms directed at enforcing compliance with norms by applying punishments($enforcenorms$), norms directed at encouraging compliance with norms by giving rewards ($rewardnorms$), and norms issued to allow the creation of new norms ($legislationnorms$). To effectively represent their function, the structure of the three last sets of norms is constrained as follows. First, enforcement norms are activated when a norm is not fulfilled in order to punish its offenders. By contrast, reward norms are activated when a norm is fulfilled, and their normative goals are aimed at rewarding compliant agents. Finally, legislation norms allow some agents to issue new norms. These constraints are represented in the relationships below.

$$
\begin{array}{|l}
enforce\_, reward\_ : \mathbb{P}(Norm \times Norm) \\
legislate\_ : \mathbb{P}\, Norm \\
\hline
\forall\, n_1, n_2 : Norm \bullet \\
\quad enforce\ (n_1, n_2) \Leftrightarrow (\neg\ fulfilled(n_2, n_1.context) \wedge \\
\qquad n_2.punishments \subseteq n_1.normativegoals) \wedge \\
\quad reward\ (n_1, n_2) \Leftrightarrow (fulfilled(n_2, n_1.context) \wedge \\
\qquad n_2.rewards \subseteq n_1.normativegoals) \wedge \\
\quad legislate\ (n_1) \Leftrightarrow (\exists\, issuingnorms : Action \bullet permitted\ (issuingnorms, n_1))
\end{array}
$$

Now, a normative multi-agent system is formally defined in the schema below. The first predicate states that all members must have adopted some of the norms of the system, the second makes explicit that addressees of norms must be members of the system, and the last predicates represent the constraints on each different set of norms.

$$
\begin{array}{|l}
\multicolumn{1}{l}{NormativeMAS} \\
\hline
members : \mathbb{P}\, NormativeAgent \\
normsNMAS, enforcenorms : \mathbb{P}\, Norm \\
rewardnorms, legislationnorms : \mathbb{P}\, Norm \\
\hline
\forall\, ag : members \bullet ag.norms \cap normsNMAS \neq \varnothing \\
\forall\, rg : normsNMAS \bullet rg.addressees \subseteq members \\
\forall\, en : enforcenorms \bullet (\exists\, n : normsNMAS \bullet enforce\ (en, n)) \\
\forall\, rn : rewardnorms \bullet (\exists\, n : normsNMAS \bullet reward\ (rn, n)) \\
\forall\, ln : legislationnorms \bullet legislate\ (ln) \\
\hline
\end{array}
$$

As we can observe, norms are in fact the way to *empower* agents by entitling them to punish, reward or legislate in a normative multi-agent system. In summary, it can be said that *institutional* powers are predetermined by norms that entitle agents to demand other agents to behave in a certain way. However we admit that those norms can change, and

therefore these powers might disappear. At least four types of institutional powers in a norm-based system can be found: power to issue new norms, power to punish offenders of norms, powers to claim a reward, and powers to claim benefits from a norm.

Legal Power This is the kind of power that legislators, as addressees of a legislation norm, have because they are entitled to issue new orders for the members of a normative multi-agent system. For instance, when the manager of a factory gives orders to workers under his control, we can observe that he is exerting the power acquired by the role he plays in the factory. Here, workers accept the manager's orders because they recognise his authority and therefore his power in the social structure. This kind of power is formally defined in the schema below, which states that an agent has *legal* power over another if the first is a legislator in the same normative system. Due to type compatibility, first a function to cast a normative agent as an agent is introduced.

$$
\begin{array}{|l}
theagent : NormativeAgent \rightarrow Agent \\
legalpower\_ : \mathbb{P}(NormativeAgent \times NormativeAgent \times NormativeMAS) \\
\hline
\forall\, ag_1, ag_2 : NormativeAgent;\ nmas : NormativeMAS \bullet \\
\quad legalpower\ (ag_1, ag_2, nmas) \Leftrightarrow ((ag_2 \in nmas.members) \wedge \\
\qquad (\exists\, ln : nmas.legislationnorms \bullet theagent\ ag_1 \in ln.addressees)) \\
\end{array}
$$

Legal Coercive Power It can be said that in a normative multi agent system, an agent has *legal coercive* power over another, if the first is legally allowed, through an *enforcement* norm, to punish the second when it fails to comply with a norm. Enforcement norms avoid the situation in which other agents coerce their peers. For instance, in a factory, only managers are entitled (by norms) to fire their workers, no worker can do so.

$$
\begin{array}{|l}
legalcoercivepower\_ : \mathbb{P}(NormativeAgent \times NormativeAgent \times Norm \\
\qquad \times NormativeMAS) \\
\hline
\forall\, ag_1, ag_2 : NormativeAgent;\ n : Norm;\ nmas : NormativeMAS \bullet \\
\quad legalcoercivepower\ (ag_1, ag_2, n, nmas) \Leftrightarrow ((n \in nmas.normsNMAS) \wedge \\
\qquad (ag_2 \in nmas.members) \wedge (theagent\ ag_2 \in n.addressees) \wedge \\
\qquad (\exists\, en : nmas.enforcenorms \bullet \\
\qquad\quad ((theagent\ ag_1 \in en.addressees) \wedge enforce(en, n)))) \\
\end{array}
$$

Legal Reward Power Once an agent complies with its responsibilities, it acquire the power to claim the reward offered. In fact, this is considered a right of the agent who satisfied a norm, and it becomes an obligation of the responsible agent for providing rewards.

$$
\begin{array}{|l}
legalrewardpower\_ : \mathbb{P}(NormativeAgent \times NormativeAgent \times Norm \\
\qquad \times NormativeMAS \times EnvState) \\
\hline
\forall\, ag_1, ag_2 : NormativeAgent;\ n : Norm; \\
\qquad nmas : NormativeMAS;\ st : EnvState \bullet \\
\quad legalrewardpower\ (ag_1, ag_2, n, nmas, st) \Leftrightarrow (n \in nmas.normsNMAS \wedge \\
\qquad (ag_1 \in nmas.members) \wedge (theagent\ ag_1 \in n.addressees) \wedge \\
\qquad fulfilled\ (n, st) \wedge (n.rewards \neq \varnothing) \wedge \\
\qquad (\exists\, rn : nmas.rewardnorms \bullet \\
\qquad\quad (theagent\ ag_2 \in rn.addressees \wedge reward\ (rn, n)))) \\
\end{array}
$$

Consequently, an agent has *reward* power over another, if the first has already fulfilled a norm for which the second agent is responsible (through a rewarded norm) for providing a reward.

Legal Benefit Power Agents who are expecting to receive the benefits of a norm for which non-compliance might be penalised are also empowered agents, because they can achieve something by using other agents' abilities. The benefits are guaranteed through legal enforcement of fulfillment. In other words, an agent has *benefit* power over another, if there is a satisfied norm for which the first is a beneficiary, the second an addressee, and there exists someone entitled to punish non-compliance with the norm.

$$legalbenefitpower\_ : \mathbb{P}(NormativeAgent \times NormativeAgent \times Norm \times NormativeMAS)$$

$$\begin{aligned}
&\forall\, ag_1, ag_2 : NormativeAgent;\ n : Norm;\ nmas : NormativeMAS \bullet \\
&\quad legalbenefitpower\ (ag_1, ag_2, n, nmas) \Leftrightarrow ((n \in nmas.normsNMAS) \land \\
&\qquad (ag_1 \in nmas.members) \land (theagent\ ag_1 \in n.beneficiaries) \land \\
&\qquad (ag_2 \in nmas.members) \land (theagent\ ag_2 \in n.addressees) \land \\
&\qquad (\exists\, rn : nmas.rewardnorms \bullet reward\ (rn, n)))
\end{aligned}$$

4 Personal Powers

There are also powers derived from an agent's capabilities on the one hand, and from the goals of target agents on the other. These powers have been studied extensively as part of *Social Power Theory*, and are known as *personal powers* [4, 3]. However, such powers have been limited to powers due to dependence among agents. Our work extends such theory by identifying other kinds of powers that are also a result of an agent's abilities. That is, some agents can either facilitate or impede the satisfaction of other agent goals. On the one hand we know that agents are entities with abilities to act. However, these capabilities are limited and, consequently, they may need other agents to succeed in the achievement of their goals. On the other hand, there are also situations in which, although possessing the needed abilities, agents cannot satisfy their goals because other agents hinder them. Both cases can lead to the creation of power. However, contrary to the cases presented in Section 3 where powers are given by the norms of the society, personal powers are given for their capabilities to satisfy goals.

Knowing if an agent can either facilitate or impede the achievement of some goals requires the evaluation of many aspects. For example, we can evaluate an agent's capabilities, its experience, its availability in the current state (which in turn depends on its goals), and even the relationships that such an agent has with other agents. However, this is a complex topic that we prefer to discuss in future work. At this moment, we define, and specify it without developing it further, a relationship that holds between an agent, a goal, and a specific state of the system when the agent is able to satisfy that goal in such an state. After that, two basic forms of power are defined by using it.

$$satisfy\_ : \mathbb{P}(Agent \times Goal \times EnvState)$$

Facilitation Power It can be said that an agent has the power to *facilitate* the achievement of another agent's goal, if the first has the means to satisfy a goal which, in turn, benefits the goal of the second.

$$facilitationpower\_ : \mathbb{P}(Agent \times Agent \times Goal \times EnvState)$$

$$\begin{aligned}
&\forall\, ag_1, ag_2 : Agent;\ g_2 : Goal;\ st : EnvState \bullet \\
&\quad facilitationpower\ (ag_1, ag_2, g_2, st) \Leftrightarrow ((g_2 \in ag_2.goals) \land \\
&\qquad (\exists\, g_1 : Goal \bullet (satisfy\ (ag_1, g_1, st) \land benefits(g_1, g_2))))
\end{aligned}$$

Being able to facilitate the satisfaction of goals creates dependence relations between agents with the relevant abilities and those without them. Therefore, a dependence relationship can also be defined in terms of powers and their absence, as follows.

$$depend\_ : \mathbb{P}(Agent \times Agent \times Goal \times EnvState)$$

$$\begin{aligned}
&\forall\, ag_1, ag_2 : Agent;\ g : Goal;\ st : EnvState \bullet \\
&\quad depend\ (ag_1, ag_2, g, st) \Leftrightarrow (g \in ag_1.goals \land \\
&\qquad \neg\ satisfy\ (ag_1, g, st) \land satisfy\ (ag_2, g, st))
\end{aligned}$$

These relations are, in general terms, equivalent to those given by Castelfranchi and colleagues [2, 4, 17], and a better and detailed definition of powers and dependence in terms of an agent's plans and capabilities can be found elsewhere [7, 13, 20]. However, for the purpose of this paper our definitions seem to be sufficient.

Illegal Coercive Power There are also agents whose abilities are not used to benefit the goals of some agents, but to impede or hinder them. In these cases, power is expressed by an agent's capabilities to directly threaten the goals of others agents in order to obtain what they want. We call this *illegal coercive* because there is no norm that entitled these agents to coerce the others. On the contrary, this kind of power is generally forbidden, which is why although some agents have this kind of power, they scarcely use it. Formally, we say that an agent has illegal coercive power over another if it can satisfy a goal that can hinder one of the goals of the second agent.

$$illegalcoercivepower\_ : \mathbb{P}(Agent \times Agent \times Goal \times EnvState)$$

$$\begin{aligned}
&\forall\, ag_1, ag_2 : Agent;\ g_2 : Goal;\ st : EnvState \bullet \\
&\quad illegalcoercivepower\ (ag_1, ag_2, g_2, st) \Leftrightarrow ((g_2 \in ag_2.goals) \land \\
&\qquad (\exists\, g_1 : Goal \bullet (satisfy\ (ag_1, g_1, st) \land hinders(g_1, g_2))))
\end{aligned}$$

Now, we describe situations in which these basic forms of powers are either overcome or related to other kinds of powers.

Comrade Power One of the things that makes small groups work is the friendship relations that are created among its members. In this case, agents have the power to require help from any of the *comrades* of the group. In general, members of this group, know that they can ask for help from the rest without objection. This represents benevolence towards a *specific group* of agents. For example, a group of friends helping each other as a way of being identified as members of what they consider a special group of agents. Note that the conditions to have this kind of power are that both agents belong to the same group of agents, and that the agent over whom the power is exerted is able to facilitate the required goal.

$$comradepower\_ : \mathbb{P}(Agent \times Agent \times Goal \times \mathbb{P}\, Agent \times EnvState)$$

$$\begin{aligned}
&\forall\, ag_1, ag_2 : Agent;\ g : Goal;\ ags : \mathbb{P}\, Agent;\ st : EnvState \bullet \\
&\quad comradepower\ (ag_1, ag_2, g, ags, st) \Leftrightarrow ((ag_1 \in ags) \land (ag_2 \in ags) \land \\
&\qquad (facilitationpower\ (ag_2, ag_1, g, st)))
\end{aligned}$$

Reciprocation Power Reciprocation with previous actions has been considered as one of the key aspects underlying society cohesion [10]. Agents who have worked in support of another's goals generally expect to receive some reciprocal benefits, even if not explicitly mentioned. This represents an ethical matter in which agents show their gratitude to others. Formally, we say that an agent has the power of being *reciprocated* by other agent, if it has already fulfilled a norm whose benefits were enjoyed by the second, and the second has the power to facilitate one of the goals of the first.

$$
\begin{array}{|l}
reciprocationpower\_ : \mathbb{P}(NormativeAgent \times NormativeAgent \\
\quad \times Norm \times EnvState) \\
\hline
\forall\, ag_1, ag_2 : NormativeAgent;\ n : Norm;\ st : EnvState \bullet \\
\quad reciprocationpower\ (ag_1, ag_2, n, st) \Leftrightarrow (fulfilled\ (n, st) \wedge \\
\qquad (theagent\ ag_1 \in n.addressees) \wedge (theagent\ ag_2 \in n.beneficiaries) \wedge \\
\qquad (\exists\, g : ag_1.goals \bullet facilitationpower\ (ag_2, ag_1, g, st)))
\end{array}
$$

Note that in contrast with *legal reward* power (described in Section 3), here the considered norms are not necessarily *system* norms, and the goal of the reciprocation is neither part of an offered reward nor the other agent's responsibility.

Exchange Power Castelfranchi et al. state that dependence makes a network of relationships that might be used by agents to influence each other [4, 5]. Among all possible forms of dependence relationships, one is of particular interest: *reciprocal dependence* occurs when an agent depends on another to satisfy a goal and vice versa. In this particular situation, both agents acquire what is called *exchange power* [6], because both of them have the power to offer something to benefit the goals of the other. In this way, any of the agents can start a negotiation process that finishes with the creation of a social commitment in which each part of the deal receives what it wants.

$$
\begin{array}{|l}
exchangepower\_ : \mathbb{P}(Agent \times Goal \times Agent \times Goal \times EnvState) \\
\hline
\forall\, ag_1, ag_2 : Agent;\ g_1, g_2 : Goal;\ st : EnvState \bullet \\
\quad exchangepower\ (ag_1, g_1, ag_2, g_2, st) \Leftrightarrow ((g_1 \in ag_1.goals) \wedge (g_2 \in ag_2.goals) \\
\qquad \wedge\ depend\ (ag_1, ag_2, g_1, st) \wedge depend\ (ag_2, ag_1, g_2, st))
\end{array}
$$

Before finishing, we emphasise that *no powers are eternal*. In the case of institutional powers, the authorities of a system are recognised as long as agents consider themselves members which, much of the time, is due to some of their goals being satisfied simply by being there. However, sometimes agents evaluate their society, or compare it with other societies, in order to know what might be more convenient for the satisfaction of their goals. As a result of this evaluation, agents might emigrate to other societies and, consequently, the norms that until now have influenced them can be abandoned, and authorities could lose their legal power. Personal powers are relativised to a particular situation in which some agent goals are either helped or hindered. Therefore, what is true in one situation may not remain true if an agent's interests, and therefore its goals, change. For example, *exchange power* disappears if one of an agent's goals is no longer considered important. In addition, it can also be said that *there are no absolute powers*, and therefore every kind of power has its own limitations.

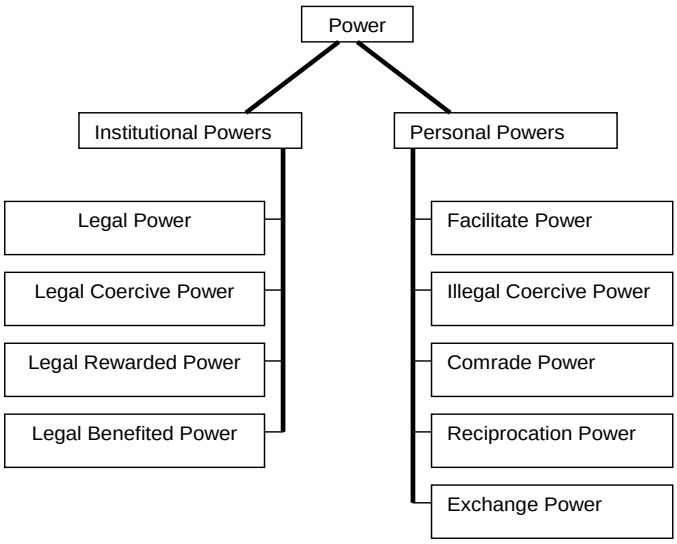

Fig. 1. Powers Taxonomy

5 Conclusion

The main contribution of this paper is a classification of dynamic power relationships that some agents can use to make other agents satisfy their goals. In our work, both powers acquired through the roles agents play in a society and powers that emerge from their own capabilities are analysed (see Figure 1). We argue that agents must be able to recognise either their power, or their susceptibility to be influenced because power is, in some sense, only "in the mind". Agents that do not recognise these situations may not be influenced, but will suffer in the long term through less optimal interactions. In addition, if agents know where a situation of power comes from, the limits of such power can be established and therefore abusive situations can be avoided. For example, when a secretary gets a job, he is informed who is the boss, who has the power to control him and, consequently, the boss's orders are fulfilled. However, if he is unable to understand both where the boss's powers come from and where the boss's authority finishes, his submissiveness could be exploited by making him to do things beyond his own responsibilities. Clearly, there remain many questions to be answered. For example, issues relating to how this model impacts on the development or implementation of multi-agent systems have not been our main focus, but are important nonetheless.

Although our analysis builds on important work on power, dependence and norms [1, 2, 11, 19], it goes beyond power due to dependence [4], or powers to legislate [11] in a society. In addition, in contrast to much work in which powers of agents are taken as absolute, our power situations have been relativised to both the society and the goals of agents. In the same way that power situations were identified in this paper, future work will be directed to analysing the conditions that enable agents to become influenced, and therefore willing to adopt both new norms and the goals of other agents.

Acknowledgments The first author is supported by the Faculty Enhancement Program (PROMEP) of the Mexican Ministry of Public Education(SEP) and the Benemérita Universidad Autónoma de Puebla (México).

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