Challenges for Social Control in Wireless Mobile Grids

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Abstract. The evolution of mobile phones has lead to new wireless mobile grids that lack a central controlling instance and require the cooperation of autonomous entities that can voluntarily commit resources, forming a common pool which can be used in order to achieve common and/or individual goals. The social dilemma in such systems is that it is advantageous for rational users to access the common pool resources without any own commitment, since every commitment has its price (see [9,13] for example). However, if a substantial number of users would follow this selfish strategy, the network itself would be at stake. Thus, the question arises on how cooperation can be fostered in wireless mobile grids. Whereas many papers have dealt with this question from a technical point of view, instead this paper will concentrate on a concept that has lately been discussed a lot with this regard: social control. Thereby social control concepts will be contrasted to technical approaches and resulting challenges (as well as possible solutions to these challenges) for social concepts will be discussed.

Keywords: Wireless Grids, Common Pool Dilemma, Social Control, Reputation.

1 The Common Pool Dilemma in Wireless Grids

Within the last years, the evolution of wireless and nano technology as well as computer networks have lead to a shift in ideas in the mobile phone world. Thus, not only are fourth generation mobile phones starting to place the user in the center of interest (user-centric view), but – associated with that – networks are evolving from centralized hierarchical systems with a centralized single management instance to decentralized distributed systems under the management of many [11].

Hence, Fitzek and Katz [8] for example, proposed to establish wireless mobile grids as shown in figure 1. In these wireless mobile networks, mobile devices with potentially different capabilities are envisioned to connect ad hoc and to cooperate and share their limited resources for the joint benefit. The cooperation between the mobile devices is enabled with the help of a short range

T. Doulamis et al.: (Eds.): GridNets 2009, LNICST 25, pp. 147–154, 2010.

communication link, such as WLAN or Bluetooth. The advantage of this kind of communication architecture is firstly on the side of the resources. Thus, for example the battery power and CPU capacity needed on the short link is significantly lower than it would be needed on the cellular link making the concept advantageous from a resource point of view [7].

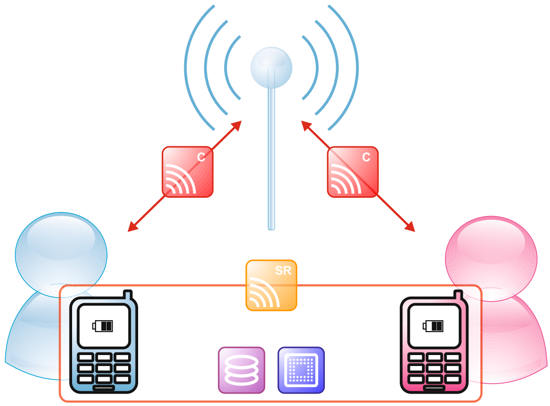

Fig. 1. Wireless Mobile Grid Communication Architecture [8]

However, despite the advantages, looking at the realization of the wireless mobile grid idea, from an economic point of view a problem appears that is very common to all open distributed systems in general: the network is depending on the cooperation of its users.

The cooperation idea in these networks is that, as shown in figure 2(a) the users voluntarily commit bandwidth, data storage, CPU cycles, battery power, etc., forming a common pool of resources which can be used either by all of them or in order to achieve a common goal [15]. The utility which users can obtain from the pooled resources is much higher than they can obtain on their own. For example, they can have access to a better variety of music, build a communication network, find solutions to complex computational problems in a shorter time, or achieve faster transfer of data to mobile terminals.

However, the problem in this constellation is that cooperation in these networks comes at a cost in the form of battery consumption, computation cycles, bandwidth or storage, etc. As a consequence, (bounded) rational users would prefer to access common pool resources without any own commitment, as shown in figure 2(b). Thus the yellow agent can enjoy the full benefits from the common pool without committing anything himself, i.e. by cheating on the three other agents. However, if a substantial number of users would follow this selfish strategy, the network itself would be at stake, depriving all users from the benefits [15].

The reason for this is straight forward: network users can have strategic behavior and are not necessarily obediently cooperating by making their resources

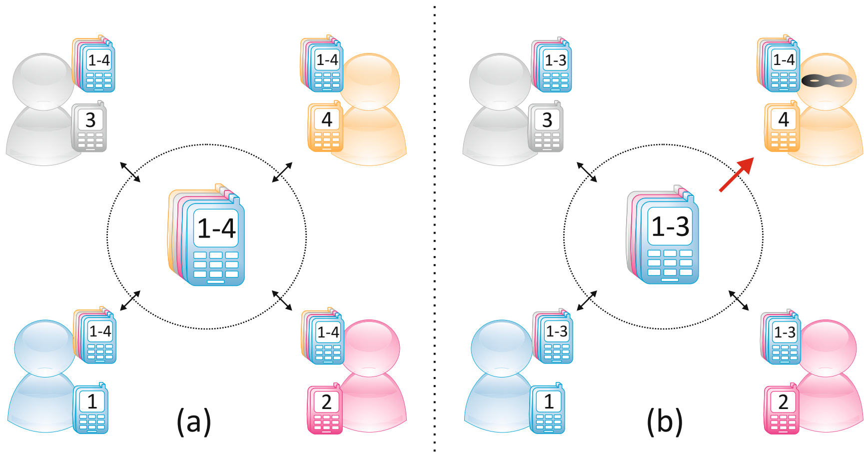

Fig. 2. The Common Pool Problem in Wireless Mobile Grids

available without the prospect of rewards for their good behavior. Unreciprocated, there is no inherent value of cooperation for a user. A lone cooperating user draws no benefit from its cooperation, even if the rest of the network does. Guaranteed cost paired with uncertainty or even lack of any resulting benefit does not induce cooperation in a (bounded) rational, utility-maximizing user. Rational users therefore would not cooperate in such an environment and all would be worse off than if they cooperated [1].

Consequently the question arises on how cooperation can emerge in such communication systems without any or with only rudimentary central authority where heterogeneous potentially selfish, bounded rational users with private utility functions act locally but their decision culminate in a global result?

2 Fostering the Compliance of Participants in Wireless Grids - Related Work

Scanning the scientific literature, there are four prototypical ways to foster cooperation in distributed networks, namely technical, legal, economical and social ones [11]. Of these four, the two most prominent ones, namely technical and social concepts shall now be briefly explained and compared, as especially due to the very different basic concepts potentially promising implications for wireless mobile grids may arise. Afterwards the paper will address social control mechanisms in more detail as these have recently been discussed at large as potential option to solve the cooperation challenge mentioned before. Thereby we will present a taxonomy of social control that is based on principal enforcement components and elaborate on challenges in each of the taxonomy elements.

2.1 Technical

Technical means are still the most widely researched approach to regulate behavior and foster cooperation. Thereby a methods is pursue which in social science is often referred to as regimentation: the appropriate behavior is “hard-wired” into either the network or if possible into the agents in the network through hard and software design. Typical examples of these technical means are communication protocols that are designed to limit the choice range of agents in order to cancel out non-system-conform behavior, or (especially in closed systems with non-human participants) the alteration of the mental state of the agents in the network to be in accordance with the normative system framework (this is done on the KAoS architecture [4] for example).

2.2 Social

The second common mean employed to foster cooperation in distributed and decentralized networks is based on social control mechanisms. As the name already implies, in these mechanisms the individuals of a society punish undesirable behavior and reward behavior that is in accordance with the goals of the system. Thereby two main approaches can be distinguished: the usage of cognitive components such as morality or conscience (i.e. the reflections of an agent about its own actions) or the use of social pressures (mostly in form of reputation) resulting from a group membership, in which others judge on the actions of an agent [11]. This group membership thereby can be as loosely as the common criteria of wireless mobile grid participation to a lot stronger ties like family membership. While both approaches help to increase cooperation, from a network designers point of view reputation seems more promising as the the cognitive impact on individuals can hardly be achieve. The basic idea behind reputation is that because people care about there reputation and because a higher reputation is supposed to yield higher long term income, they will not act in a way that may decrease their reputation and therefore they will cooperate in a system [14]. Contrasting reputation (and social mechanisms in general) to technical approaches, social mechanisms have the advantage to be independent of technological requirements. They do not need to be implemented beforehand, but can be applied and even changed and scaled at run-time making them more flexible and possibly less expensive from an implementation point of view. Furthermore social mechanisms are based on a number of information sources making attacks on the system less promising and the system itself more interesting for open distributed applications. However, as good as this may sound, there is a downside to social mechanisms as well. Thus, the distribution of information in the hands of many can lead to a distortion of information weakening the overall performance of social mechanisms if not implemented correctly.

Summing up, although social control mechanisms have some drawbacks that need to be discussed and solve in the future, they are one potential way (possibly together with technical mechanisms) to tackle the common good dilemma mentioned in the first chapter. That’s why, in the further course of this paper, social mechanisms and especially the challenges connected with them will be placed in the main focus. Thereby, first of all the basic components of social control as seen by us will be presented to then go into detail about challenges for these mechanisms.

3 Challenges for Social Control

3.1 Social Control

Now that the two most common approaches for fostering compliance have been briefly presented, the paper will have a closer look at social mechanisms and their components with regard to cooperation. Thus, in our view, the social processes can be divided into 3 main parts that are relevant for enforcing cooperative behavior: (1) the definition of expected / allowed behavior, (2) the observation of the system in order to detect cheating (i.e. non-cooperative) behavior and (3) the application of sanctions in case a violation has occurred [6]. Whereas the definition of allowed behavior is normally externally given or evolves through time within the system, with regard to cooperation especially (2) and (3) are of interest. Thus, for social mechanisms there are 3 different kinds of observers that can be used in a system: first-party observers who control that their actions are in accordance with the rules in a system (whether self-imposed or imposed by other sources) themselves (these observers would correspond to the cognitive approach of social control), second-party observers who observe the behavior of their transaction partners and third-party observers that control the behavior of other agents the system. Looking at the side of the actual sanctioning, based on the observations, the same kind of enforcers are imaginable: social groups (up to the society as whole), second-party enforcers (i.e. the transaction partners) and first party-enforcers [2]. As a result of these considerations about (2) and (3), the taxonomy consisting of 4 main methods for social control that can be seen in the final column of figure 3 can be developed.

These four methods are:

- Social control with either second or third party observers in which – based on observation of parts of the society – the whole society (or groups of it) react to the violation. The best known example of this method are reputation mechanisms the are based on the information of single agents but due to the distribution of information result in social sanctioning by more agents than the one(s) not cooperated with.
- Promisee-enforced rules, i.e. mechanisms in which the agents not cooperated with punish the “cheater” themselves, e.g. in form of a “an-eye-for-an-eye” way or by not interacting with the same agent again.
- Self-control mechanisms that are especially interesting from a cognitive point of view. In contrast to all other mechanisms presented so far, it does not included any additional party, but only the agent performing an action itself. This agent is assumed to have an own normative value system and constantly checks whether his actions are in accordance with that own value system and

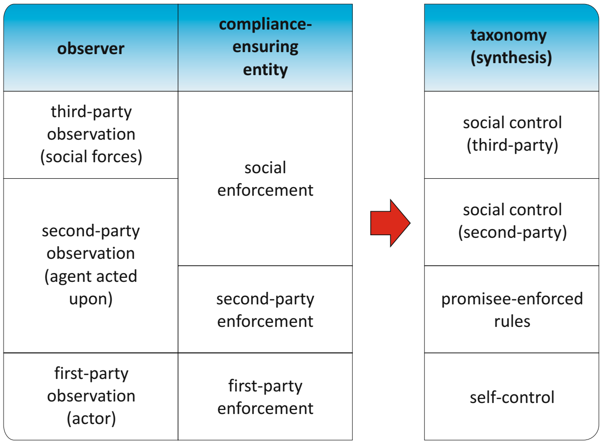

Fig. 3. Taxonomy for Social Control

the general normative wireless mobile grid framework (i.e. the agent is its own observer). Based on the normative value system the agent can then decide to sanction itself. An example of such a self-control scenario in wireless mobile grids could be that an agent that didn't contribute what he promised at a certain point of time is discontent with his performance (although the other agents might not have complained) and as a result offers the other agents something as compensation.

3.2 Challenges for Social Control Concepts

As the last step of this paper the specific challenges for social mechanisms will now be analyzed more closely. Thereby the four main methods derived at in the taxonomy will serve as a classification scene for the analysis. Hence, starting from the bottom of the taxonomy, challenges for each method as well as possible solutions will be presented.

Starting with the self-control method, the challenges this approach may have to face are very obvious. Thus, not only does this method leave the problem that it is dependent on the intrinsic motivation of the individual agents and thus it is not really to control from the outside, but furthermore it may pose an incentive problem. Assuming rational behavior, if no further changes are made to the system and the self-control method is the only way to foster cooperation, agents that act dishonestly will generate a higher profit than agents contributing to the system, crowding out cognitive cooperation effects. Some papers (see [3] for example) already address this problem by adding institutions that reverse the effect through adequate economic incentive mechanisms, however the model presented there only work for a limited parameter space and need to be further explored.

The second method, promisee-enforced rules, leaves the area of cognitive approaches and starts using weak social pressures instead. Thus, if being "cheated" second-party agents react themselves to the violation by storing their negative experience with the other agent (in social science this is often referred to as "image"-information [12]) and not interacting with the agent again. This reliance on own experiences has the advantage that information are always direct and correct, however due to the potential large number of other agents in a wireless mobile grid, the situation gets close to one-shot games in game theory, making the method very inefficient.

That is why in a last step, for the third and fourth method, the image information are circulated through the system either by the agent who was cheated or a third party who has witness the transaction. Although this might theoretical sound good, two major problems arise: the first one being the problem that false information might be generated by some agents and the second one being the problem that not enough information are contributed. This problem was dealt with by Conte and Paolucci [5] who distinguish 4 sets of agents (agents M transmitting an evaluation, evaluators E who evaluate the cooperation, targets T who are evaluated and the beneficiaries of the reputation information B, i.e. the agents who can use the information for their next cooperations. In their work Paolucci and Conte show that certain constellation of these sets of agents might either lead to wrong or to little evaluations. Looking at $E \approx T$ for example, i.e. a situation where the groups of evaluators and targets are highly overlapping (this is the case in the old eBay reputation mechanisms for example), "tit-for-tat" problems arise resulting in too good and too little reputation information. This idea was taken up by König et al [10] who could identified a certain constellation of the sets of agents for which enough correct reputation information is given and that consequently overcomes the problems just mentioned[1].

4 Conclusion

In this paper we looked at social control as one mean to overcome the common pool dilemma in wireless mobile grids. Thereby we first of all compared technical to social control mechanisms and pointed out the benefits of the latter. Afterwards, based on a taxonomy for social control, challenges were presented that need to be solved in order to establish social control in the long run. For these challenges, first approaches that try to address these challenges have furthermore been described. These approaches show that although still facing challenges, social control mechanisms are being worked on, nominating them as good complements for technical mechanisms in the future.

Acknowledgments. The work of Tina Balke was supported by the German Academic Exchange Service (DAAD).

[1] The constellation identified was $B \approx E, B \cap T = E \cap T = \emptyset$. For more information please refer to [10,5].

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