Chapter 18
Modeling and Verification of Cooperation Incentive Mechanisms in User–Centric Wireless Communications

Alessandro Aldini
University of Urbino "Carlo Bo", Italy

Alessandro Bogliolo
University of Urbino "Carlo Bo", Italy

ABSTRACT

User-centric wireless networks are characterized by a community-scale objective aiming at the shared provision of user-generated services and contents. This may be contrasted by the reticence of individuals to share the limited resources of mobile devices. Hence, cooperation incentives play a key role to promote prosocial decisions and to isolate selfish nodes and cheating behaviors. In particular, trust-based incentives and remuneration are used to induce collaborative behaviors in Wi-Fi communities. Typically, these mechanisms are based on reputation infrastructures and virtual currency systems, the application of which should not hinder the normal operation of the network. In this chapter, the authors present an approach to the combined use of indirect rewards deriving from trust-based incentives and direct rewards deriving from remuneration. The effectiveness and efficiency of such an approach in the setting of user-centric wireless networks is verified by conducting a formal study of the benefits of the joint application of these rewards and of the related impact upon performance.

INTRODUCTION

The recent trends in autonomic wireless architectures are giving rise to community-scale initiatives with the purpose to guarantee broader connectivity and to share user-provided contents, applications, and services. For this kind of architectures, called *user-centric networks* (UCNs, for short), cooperation incentives play an essential role to stimulate users to share services (including access to public networks) and resources (including bandwidth, computational power, and storage space) in spite of possibly selfish and cheating participants hindering the functioning of the entire system. In particular, reputation (either inherent in the social dimension or based on trust-management infrastructures) and remuneration (based either on fiat money or on virtual currency) emerged as two complementary incentive mechanisms to increase motivation and to discourage and isolate selfishness, cheats, and mistrust.

On one hand, reputation not only represents an intrinsic incentive to cooperate deriving spontaneously from social interactions, but it is also adopted as an extrinsic enabling condition for taking part in the community, refer to Jøsang et al. (2007) for a survey. Reputation is the result of prosocial behaviors and gives a perception of the public trustworthiness of a community member. Reputation-based decisions are supported by trust management systems, which give explicit quantitative estimations to the subjective reliance on the character, integrity, ability, and honesty of each community member.

On the other hand, reputation may not be perceived as a sufficient incentive to take prosocial decisions, especially in the setting of wireless communities, which very often are highly dynamic because of the short-term membership of a significant part of the community. As a consequence, users may not be adequately motivated to maintain and support a reliable and stable trust system. Moreover, in a situation such as this, reputation fails to guarantee reciprocity, which is

a property describing the evolution of cooperative behaviors influenced by the probability of future mutual interactions. In other words, the lack of conditions favoring mutual exchanges of resources and services does not stimulate the willingness to cooperate. For these reasons, monetization represents an alternative way of estimating the value of prosocial decisions that does not rely on reciprocity and overcomes the limitations of barter. Monetization is supported in online communities by virtual currency, see, e.g., Greengard (2011). Virtual currency represents a form of credit-based remuneration replacing the role of real money, thus bypassing all the issues related to strong security requirements, taxation, and mistrust, which may impair the functioning and applicability of payment mechanisms in wireless networks.

Combining trust-based and credit-based rewards is an appealing approach that has received attention in the last years, as it gives the opportunity of taking advantage of the complementary strengths of the two incentive mechanisms while overcoming their weaknesses. Based on these observations, the general cooperation framework for wireless UCNs we present combines the application of trust management and virtual currency mechanisms. According to this general model, the main driving principles adopted to join the cooperation incentives establish that:

- Trust is used to affect individual decisions and opportunities;
- Trust cannot be traded for virtual currency or money;
- Virtual currency is a commodity money mainly used to facilitate cooperation among community members;
- Virtual currency can be traded for fiat money at the only purpose of allowing the community to benefit from external services and to provide services to non-member end-users.

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