

# Performance of a fixed reward incentive scheme for two-hop DTNs with competing relays

[Short talk]

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## 1. INTRODUCTION

Delay Tolerant Networks are based on the so-called *store-carry-and-forward* paradigm in which the source node transmits its message to each and every mobile node that it meets. The latter nodes play the role of relays. They store the message and carry it, in the hope that they will eventually reach the destination and be able to deliver the message. In practice, the delivery of a message incurs a certain number of costs for a relay, in particular in terms of energy – a scarce resource in mobile networks. It can therefore be expected that, even though some nodes will cooperate out of altruism, many mobile nodes will behave selfishly, acting as "free riders" that profit from the resources of others for transmitting their own messages without offering their own resources in exchange. Clearly, if there are too many selfish mobile nodes, the network collapses and it is no more possible to communicate between nodes. It is therefore crucial to design incentive mechanisms to persuade mobile nodes to serve as relays.

In [2], a simple reward-based mechanism was proposed to convince mobile nodes to cooperate. The idea is basically that the nodes which want to transmit a message pay the relays for resources they consume. In order to guarantee the full cooperation of relays, the source informs them that a reward will be paid only to the first one to deliver the message to the destination. In a two-hop DTN, this payment mechanism can be implemented as follows: to each relay it meets, the source gives an electronic cheque (or a promise of payment) worth the reward promised to this relay encrypted with the public-key of the destination. The relay that is the first to deliver the message also sends the e-cheque to the destination who then decrypts the e-cheque and sends it back to the relay. For the other relays, the destination does not decrypt the cheque.

### Contributions

In the present paper, we analyze a similar incentive mechanism for message delivery in two-hop DTNs, but assuming a *fixed reward* and in the more realistic scenario of *self-interested mobile nodes*. When the source wants to send a message, it proposes a fixed reward to each relay it meets. The relay can decide to accept or to reject the message de-

pending on the time at which it meets the source. This possibility to accept or reject a message and then drop it were not available in [2]. In that paper, a relay accepted a message when it met the source and always delivered it to the destination. This is because the reward proposed in that scheme depends upon the meeting time with the sources. In our model the reward is fixed, and if a relay accepts the message, it can decide to drop it at anytime thereafter. We model the competition between relays for message delivery as a game and explicitly characterize the equilibria of this game. In particular, we show that the equilibrium policy of a relay is of threshold type: it accepts a message until a first threshold and then keeps the message until it either meets the destination or reaches the second threshold. Formulas for computing the thresholds as well as probability of message delivery are derived for a backlogged source. Explicit expressions are obtained for this scenario in the limiting regime where the number of relays is large.

A model similar to one studied in this paper was first considered in [1] in which the competition was modeled a stochastic game. That model was in discrete-time, restricted to two players and a single message, and had partial results on the optimal policy. The model studied in this paper is in continuous time, for an arbitrary number of players, and a backlogged (with possibly infinite number of messages) source which sequentially proposes messages. Further, we study the mean-field limit for the single message case for which we give expressions for the probability of successful delivery of message as well as the probability distribution of the time to delivery.

The aim of our analysis is to determine how the reward should be computed by the source when multiple relays are competing for a message. This, in turn, will help the source providing an adequate reward in order to achieve a target delivery probability.

## 2. REFERENCES

- [1] T. Seregina. *Applications of Game Theory to Distributed Routing and Delay Tolerant Networking*. PhD thesis, INSA de Toulouse, Université de Toulouse, 2015.
- [2] T. Seregina, O. Brun, R. Elazouzi, and B. Prabhu. On the design of a reward-based incentive mechanism for delay tolerant networks. Technical report, Rapport LAAS n 14418 <hal-01061348v2>, 2014.