Towards fair P2P auctions over MANETs

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Abstract

The emergence of new mobile and wireless networks offers opportunities to expand traditional internet applications. At the same time peer-to-peer systems become widely deployed and allow users to obtain and provide resources in a stable, scalable and reliable manner. In this paper we consider the deployment of P2P auctions over ad hoc networks. We propose a communication architecture and a protocol to support this kind of auctions. We address fairness and define two time durations: Tregister (a fair registration duration) and Tfair (a fair round duration). We show by simulation that Tfair depends on the density of the network and on the number of nodes. We also show that the proposed protocol requires mulicast and is not affected by other applications' traffic.

1. Introduction

The emergence of new mobile and wireless networks offers opportunities to expand traditional internet-based applications. Among these networks, Mobile ad hoc networks (MANETs) do not need any infrastructure or any management entity. They are characterised by their completely autonomous, dynamic, auto-organised and ubiquitous nature [1]. Furthermore, they constitute an affordable communicating infrastructure with a major attractive economic benefit: the low cost of deployment and of management.
In the other side, peer-to-peer (P2P) systems constitute nowadays a major part of the online world. Ad hoc networks present resemblances with P2P systems in terms of decentralization, equality and autonomy [2]. This will help the apparition of new P2P applications over MANETs such as mobile commerce [3]. We propose here a novel model of m-commerce : P2P auctions over MANETs.
In this paper, we first present the motivation of this work. Then, we discuss the related work. Afterwards, we propose an architecture and a communication protocol for autonomous P2P auctions over mobile ad hoc networks. We discuss performance evaluation results and finally, present the concluding remarks and the ongoing work.

2. Motivation,Assumptions & Business Scenario

Envisaging auctions over MANETs would be advantageous in the context of spontaneous market created temporarily for the auction event. This scenario may suit business model where a market is set up for the sales of last minute plane or train tickets in an airport or a train stations, in a harbour for the sale of stocks of fish or within the framework of a farm. Nomadic exhibitions may also raise spontaneous auction events. This way of deploying auctions may also be considered as an extension of auction events occurring over an infrastructure network, permitting this way to MANET users to participate to such markets.
In this context an end user, being in a MANET, has just to open his laptop(or any other WIFI capable device) and expects to easily set up or access an auction event. Interested buyers or sellers can submit their bids; the process will advance round by round till the highest bidder wins the auction. This simple scenario implies multiple advantages and motivations such as ubiquity, convenience, availability, affordability and opportunity.
P2P auctions over MANETs have similarities with real time auctions. Hence, the following assumptions can be made about this type of markets:

- This kind of auctions would require the physical presence of bidders or their mobile devices. Most of bidders will be present at the beginning of the auction. Then, the probability of new arrival during the bidding process is low. Furthermore, the mobility of mobile nodes is low (about 1m/sec).
- The nodes moving zone depends on the place where the market is set up (port, farm, airport, train station, market).

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- Auctions are limited in duration. Because the items for sale are perishables.

The deployment of applications in an infrastructure-less ad-hoc environment is exceptionally hard due to low network bandwidth and the dynamic network topology. Particularily, the deployment of auction over MANETs raises various problems such as robustness, fairness, security and trust.

3 Related work

In [4] the authors envisage the deployment of auctions over the mobile networks. The auctioneer disseminates the bidding information over the network. Interested bidders submit their settings. Fairness is fulfilled by the setting of a "Waiting Timer" during which bids are saved within the network layer of the auctioneer. At expiration of this timer, the network layer of the auctioneer delivers all the information received to the auction application for evaluation. The best bid is then sent to all participants. The weaknesses of this scheme are mainly: 1) the periodic flooding of the current auction information on the network, 2) the trust in the auctioneer, 3) problems resulting from message relaying between peers are not treated and 4) introduction of processing within the network layer.
In [5], the authors present a self-organizing distributed auction system over MANETS. They consider a static geographic zone called the marketplace. This approach is based on the use of agents. However, this solution may cause problems at the marketplace when agents make different agreements.
The work [1] aims at deploying auctions over an ad hoc network and provides a fair bidding scheme. The auctioneer activity is distributed. This scheme considers a fixed number of participants and nodes' mobility. The fairness solution is based on the maximal hops number in the network. Since this information is provided by the network layer, this approach lacks flexibility with regard to this layer.

4 A proposal for communication protocol and architecture

4.1 Introduction

Most Internet based auctions model usually rely on a central auction server (the auctioneer). The server itself performs various functionalities and can be configured to implement multiple auction-related policies.
Because of the P2P and mobile ad hoc contexts, we propose a fully decentralized architecture without any central auctioneer entity. This latter's services are carried out by the different participating peers [6]. We avoid this way the auction inhibition in the case where the auctioneer becomes non-connected to the network. Several studies proposed to decentralize the auctioneer entity in auction models ([6], [7] and [8]). All these works proved that omitting the auctioneer is due to autonomy, security, reliability and scalability considerations.
We specify new communication architecture, called WAHS (Wireless Auction Handling System) (cf. Figure1), to support P2P auctions over MANETS. One peer component, named BSAP (Buyer/Seller Agent Peer) is defined. It is associated with an auction initiator as well as to each bidder participating to the auction. When associated with an initiator, the BSAP helps it setting up an auction event. When associated with a bidder, the BSAP helps it participating in an auction event and submitting bids. One protocol, i.e. BSA Peer (BSAP) protocol, is defined to support interactions between the functional components (the peers) of WAHS (see figure 1).

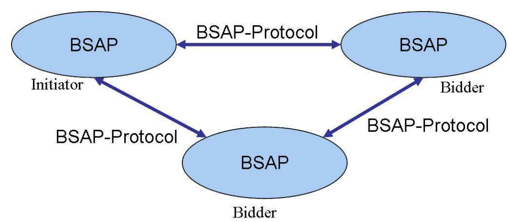


Figure 1. WAHS Architecture

4.2 The BSAP protocol specification

This consists first in defining the provided services and the vocabulary.
"BSAP-Protocol" describes the messages exchange between two BSAPs during a P2P auction process. For the sake of simplicity we consider English auctions as a case study in the rest of the paper. However, the proposed architecture and protocol can be used to model any kind of open cry auction protocol. This process defines a dynamic auctioning scheme without the intervention of any central entity. It is divided in to three phases:

a. Initialization

This phase is divided in three steps:
1- Auction advertisement: The BSAP initiator is a node (peer) connected to the ad hoc networks and has a good to sell. This peer announces the auction by broadcasting an "auction advertise" message in order to inform all nodes about the auction event to be set up.
2- Auction access: Each interested node sends an unicast "register bidder" message with its identifier and its personal information (such as its name, its address, etc.) to the initiator as soon as he receives the "auction advertise" message. It becomes registered participant to this auction.

3- Auction creation: The initiator sets its primary members list after having collected all "register_bidder" messages. Then, he sends an "auction_create" message to participants. This message contains the list of all registered peers.

b. Bidding

4- Submission: The first round begins for each bidder as soon as he receives the "auction_create" message. He sends to all the members of the ACL his bid in a "submit_bid" message and collects the other bids. Before accepting a bid, every bidder verifies if the sender is in the ACL; if not, he rejects the bid. During a round, each peer computes the best bid and decides to outbid in the next round or not.

5- Auction quit: A bidder leaves an auction by sending an "auction_exit" message to all ACL members.

6- New Auction access during the bidding phase: If a given peer J within the MANET wants to access an ongoing auction, he starts a neighbour discovery process using the expanded ring search (ERS) technique [9]. For this purpose, he sends an "Auction_REQ" message. When this message is received by an ACL member I, he replies with an "Auction_REP" message. Then, node J recovers the initiator's address and stops the neighbour discovery. Node J sends a "Join_REQ" message to join the auction. If the initiator replies with a "Join_Accept" message , then J sends a "Register_bidder" message for registration. The initiator sends an "auction_create" message to all the ACL members after doing all the necessary update.(see figure 2)

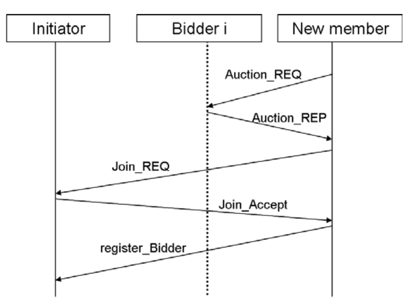


Figure 2. Joining an auction process

c. Closing

During the Bidding a possible inconsistency of the system may occur if one or more "submit bid" messages are lost due to wireless communication or congestion. At the very last round this may result in an inconsistency of the system where many peers consider themselves as winners although they have submitted different prices. To avoid such problem occurs, we propose that at the end of the auction life, each bidder who believes that he is the winner sends a "winner_notif" message to the initiator. The initiator collects all "winner_notif" messages and identifies the winner. The transaction settlement occurs between the initiator (seller) and the winner by exchanging unicast messages (we assume here that the winner is still connected). The settlement is not in the scope of this work.

In the Figure 3, we illustrate a basic bidding scenario of our auctions model.

5 Simulation and Performance Evaluation

In [1], the authors proposed an estimation of Tfair (noted Tfair/[1]) as function of the maximal hops number of the network, i.e the RTT between the two farthest bidders and the maximal time of the retransmission of all allowed unsuccessful packets before giving up a message transmission according to the IEEE 802.11 standard.

$$Tfair/[1] = 0.982656 * MaximalHopsNumber \quad (1)$$

The goals of simulations are to: 1) compare the obtained Tfair with one related work (eq. 1) 2) evaluate Tfair in different scenarios and identify the parameters affecting it.

5.1 The simulation environment

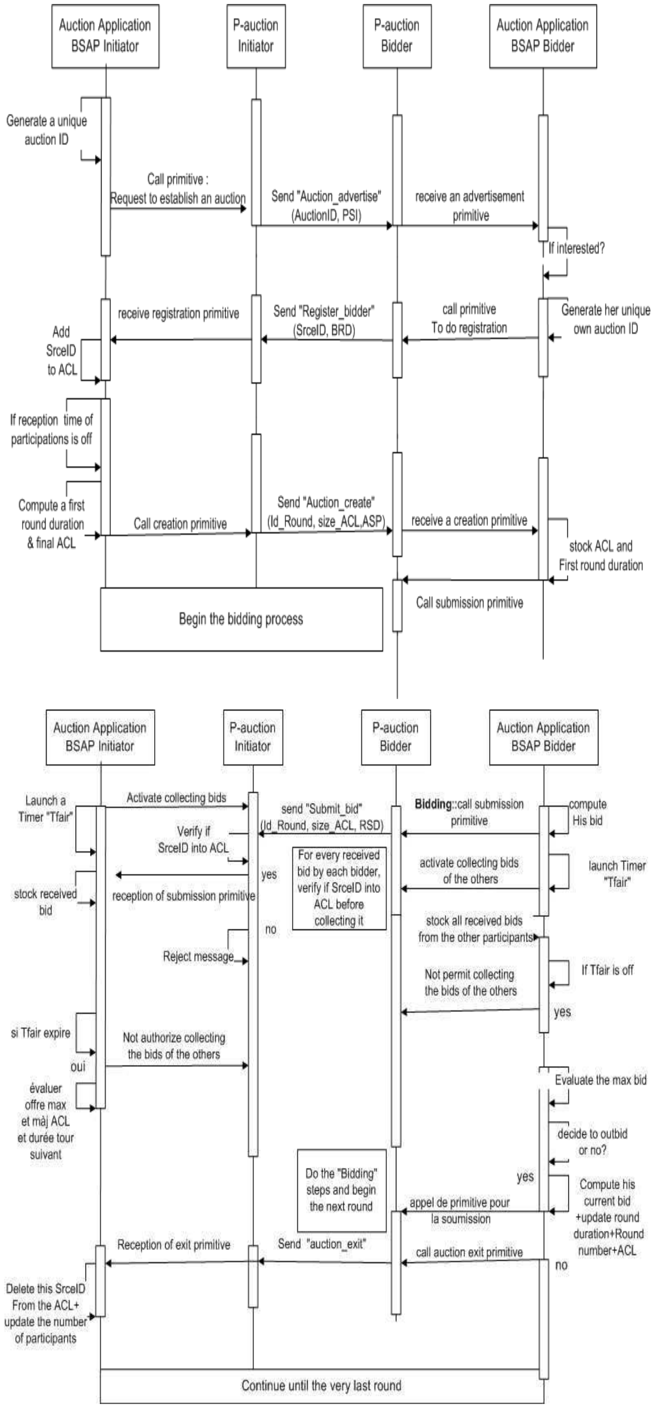
The simulation of the BSAP protocol was performed using the network simulator ns-2 with CMU extensions to support MANETs [10]. We used the random waypoint mobility model since it considered as the best model for MANETs [11]. The link layer is implemented using IEEE 802.11 Distributed Coordination Function (DCF) and Medium Access Control Protocol (MAC). The speed of the nodes in the network is 1 meters/second and the pause time is 5 seconds. The choice of this low mobility is justified by the deployment context of our application as we have already described in the section 2. We used AODV as a routing protocol since it is available over ns-2; although any other routing protocol can be used. We run 30 simulations with different mobility scenarios in order to have the 95 percent confidence interval for the mean of each gathered static.

5.2 The metrics

- To determine the optimal collect duration of registrations (Tregister) in order to give the chance to all mobile nodes to join the auction event. For this, we defined a metric named "Register_out" (eq. 2). This metric is calculated as follows:

$$Register\_out = \frac{register\_Nb\_out}{RegNb} \quad (2)$$

With:
$Register\_out$=Rate of registrations out register timeout.



(a)

(b)

Figure 3. The auction process:(a) the initialization phase and (b) the bidding phase

$Register\_Nb\_out$=number of register_bidder messages received out register timeout.
$RegNb$=total number of all registrations received by the initiator.
Tregister value is optimal when Register_out is equal to zero.

- To determine the Tfair in order to fulfil the fairness requirement [12] during the bidding process, we defined a metric named "Bids_out_rnd" (eq. 3). This metric value is computed in the following manner:

$$Bids\_out\_rnd = \frac{\sum_{j=1..Size\_ACL} bids\_out\_rnd/bidder_j}{Size\_ACL} \quad (3)$$

With:
$bids\_out\_rnd/bidder$= Rate of bids received per each bidder after the round timeout.
$Size\_ACL$ = the number of registered members.
Tfair corresponds to a bids_out_rnd equal to zero.

To determine the optimal timers' value of Tregister and Tfair, we varied two simulation timers: 1) Register timeout marking the end of the waiting time of the initiator during the initialization phase and 2) the round timeout marking the end of a round duration during the bidding phase.

5.3 Comparison with related work [1]

To compare the estimated fair round duration of our protocol (noted Tfair/BSAP)with Tfair/[1], we used the simulation scenarios shown in the table 1. We consider networks with static topologies, fixed nodes and a coverage zone of 50 meters as [1]. The last line in this table corresponds to the Tfair/[1] obtained for each scenario.

	Scenario 1	**Scenario 2**	**Scenario 3**
Network size	500m*500m	250m*250m	50m*50m
Maximal hops number	14	7	1
Tfair	12.6 s	6.3 s	0.9 s

Table 1. Simulation scenarios

Figure 4 shows that Tfair/[1] increases linearly by the rise of the number of hops and diverges with Tfair/BSAP. We observe that this latter increases by the rise of the number of hops but not linearly. Tfair/[1] is then too large. The goal of the following simulations is to determine the factors affecting Tregister and Tfair.

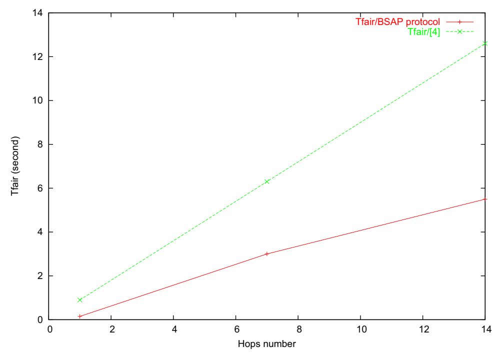


Figure 4. Tfair vs hops number

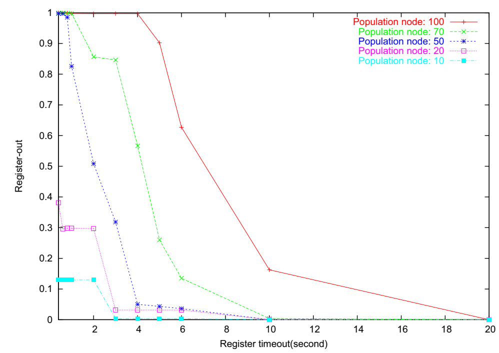


Figure 5. Initialization phase: Register timeout versus Register-out Rate

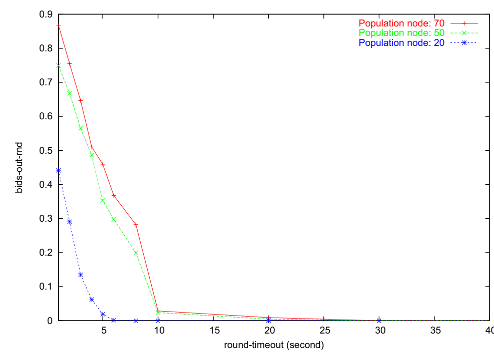


Figure 6. Bidding phase: Round timeout versus Bids-out-rnd Rate

5.4 Identification of the factors affecting Tfair & Tregister

We varied the following parameters and analyzed by simulation the behaviour of the BSAP:

- The node Population: This population is varied from 10 nodes to 100 nodes. The considered areas of the network were 183m x 183m, 258m x 258m, 408mx 408m, 483m x 483m and 578m x 578m for the 10, 20, 50, 70 and 100 node networks, respectively (ensuring the network density of around 300 nodes=km^2).

- The network density: 50 node networks with varying network density was simulated.

- The traffic in the network: We generated a CBR traffic over 10, 20 and 50 node networks. Each source injected 512 bytes packets with a rate ranging from 4 packets/second to 20 packets/second.

1. Impact of varying node population on Tregister and Tfair: Figure 5 shows the rise of Tregister with the rise of nodes population. The initiator has to wait for 3 seconds to allow up 10 bidders joining the auction and 20 seconds to have 100 bidders. In Figure 6, we see that all the curves are decreasing and the optimal round duration (Tfair) is varying with the number of nodes. In fact, the number of "submit_bid" messages out of round reaches zero as follows: for 20 population node the mean Tfair is 6sec; for 50 population node the mean Tfair is 25sec; and for 70 population node the mean Tfair is 30 sec. For simulations in Figure 6, we used Tregister values from the Figure 5 to have the maximum number of participants.

2. Impact of varying density on Tfair: Figure 7 shows that as the network density increases the mean Tfair increases. The behaviour of peers (many-to-many communications) in a high network density generates collisions and leads to more time spent for the transmission of bids.

3. Impact of Application Data on Tfair: Figure 8 shows that Tfair rises very slowly with the increase of CBR rate. However, it increases with the traffic rate for 50 node networks. In fact, each registered node is involved in the traffic of data. Thus, the more important is the traffic, the more important is the time required to transmit the "submit bid" messages.

6 Conclusion & Future Work

In this paper, we proposed a completely distributed and self-organized architecture and a protocol to support P2P auctions over MANETs. We focused on fairness and defined two time durations: Tregister and Tfair to provide a fair registration and a fair bidding. Simulation results show that Tfair depends on two network factors: the density of the network and the number of nodes. Besides, we show that the proposed protocol is not affected by the traffic generated by other applications on the network.
Compared to related works, our proposal has the advantage of being flexible with regards to both the MANETs' environment and the auction rules and technology.
Ongoing work is: 1) on assess the theoretical formula to estimate the fair round duration as a function of the identified network parameters and 2) on security of the BSAP

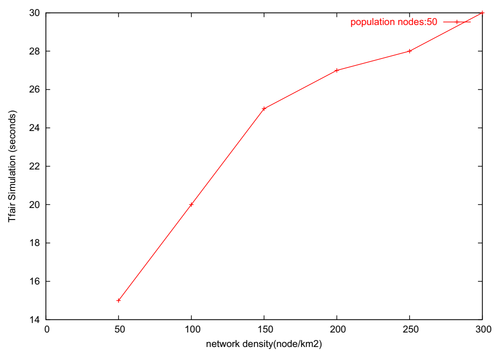


Figure 7. Bidding phase: Tfair versus network density for 50 nodes

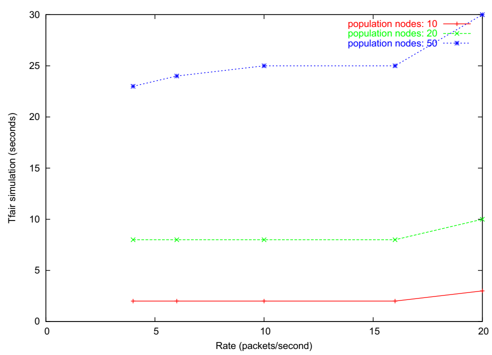


Figure 8. Bidding phase: Tfair versus CBR rate

protocol.

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