A market-based approach to managing the risk of peer-to-peer transactions

Stephanos Androutsellis-Theotokis *, Diomidis Spinellis, Panos Louridas, Kostas Stroggylos

Department of Management Science and Technology, Athens University of Economics and Business, 76 Patission Street, 10434 Athens, Attica, Greece

ABSTRACT

Market-based principles can be used to manage the risk of distributed peer-to-peer transactions. This is demonstrated by PTRIM, a system that builds a transaction default market on top of a main transaction processing system, within which peers offer to underwrite the transaction risk for a slight increase in the transaction cost. The insurance cost, determined through market-based mechanisms, is a way of identifying untrustworthy peers and perilous transactions. The risk of the transactions is contained, and at the same time members of the peer-to-peer network capitalise on their market knowledge by profiting as transaction insurers. We evaluated the approach through trials with the deployed PTRIM prototype, as well as composite experiments involving real online transaction data and real subjects participating in the transaction default market. We examine the efficacy of our approach both from a theoretical and an experimental perspective. Our findings suggest that the PTRIM market layer functions in an efficient manner, and is able to support the transaction processing system through the insurance offers it produces, thus acting as an effective means of reducing the risk of peer-to-peer transactions. In our conclusions we discuss how a system like PTRIM assimilates properties of real world markets, and its potential exposure and possible countermeasures to events such as those witnessed in the recent global financial turmoil.

1. Introduction

It is being progressively recognised that information systems and applications supporting collaborative tasks, including online transaction processing systems, that currently follow centralized client-server models can also be based on the maturing wave of peer-to-peer architectures [53,3]. In order to manage and reduce the risk inherent in peer-to-peer transactions and their decentralised and uncontrolled environment, a variety of approaches have been proposed, with reputation and trust management systems being the most prominent (see Section 2.2). These aim to provide peers with estimates of the risk involved in their transactions, based on the observed past behaviour of their counterparties.

Though reputation management systems (either centralized or distributed) offer a lot in this direction, the information they provide about past behaviour may not be enough to accurately assess the risk involved in a transaction. Open issues, to name but a few, include the fact that not all transactions receive feedback [49], shortcomings in the way reputation information is represented [14], perceived, and used by the transacting parties (especially for inexperienced users) [28], and dealing with participants lacking past transactions [23]. In a recent study, for instance, it was suggested that the way in which the positive and negative feedback is presented to users of the eBay system can make it difficult for buyers to evaluate past illegal behaviour of sellers [29]. As a result, there still is considerable concern over the amount of risk involved in online transactions, even with the support of reputation management systems [21,15,25].

In this work we propose a novel approach, based on the principles and instruments used in different (including

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* Corresponding author. Tel.: +30 2108203370.
E-mail address: stheotok@aueb.gr (S. Androutsellis-Theotokis).

commercial and financial) markets for managing, transferring or reducing credit and transaction risk. We demonstrate the practicality of this approach and evaluate its efficacy through the prototype PTRIM ("peer-to-peer transaction risk management") system. On top of a generic transaction processing system, PTRIM creates a peer-to-peer transaction insurance market-like layer that is used to manage the risk of transaction default. The transacting peers have the option to request offers from peers in this layer to underwrite the risk of their transaction, and therefore alleviate themselves from the need to collect, process and evaluate reputation information. A transaction default market is thus built on top of the main transaction processing system, within which the cost of "insuring" a transaction is determined through market-based mechanisms.

The main contribution of our approach is that it proposes a novel way of identifying untrustworthy peers and perilous transactions, based on the insurance offers the market will produce; the risk of peer-to-peer transactions is contained at a small additional cost; and at the same time, our system showcases a way for members of a peer-to-peer network to participate in a new profitable role, as transaction insurers.

It should be noted that although we implement and examine our proposed approach within a peer-to-peer environment, its underlying principles could also apply to different, not completely decentralised network architectures.

In this paper, we first present the key concepts of market-based transaction risk management that our approach is based on, briefly touching on the underlying economics principles, and we examine its relation to other work (see Section 2). We proceed to present the design, architecture and implementation of our proposed system in Section 3, and our methodology for testing and evaluating it both theoretically and practically (see Section 4), which includes studies with a deployed prototype, as well as experiments involving both real subjects and real transaction data crawled from the eBay online auction site. We discuss our evaluation results and outcomes in Section 5, and our system's current limitations and planned future work in Section 6.

2. Market-based transaction risk management

As was briefly described in our introduction, in our approach we form a market for transaction default insurance, and utilise it to determine and manage the risk involved in transactions. We propose this as an alternative to reputation management systems, although the two could supplement each other.

2.1. Risk management

We require a market-based transaction risk management system that would meet the following requirements:

1. Transactions should not need an intermediary; i.e. it should be possible to carry out a transaction involving only the transacting peers, and not a centralised clearing house.

2. Risk handling should be based on trading insurance; i.e. participants would offer and buy insurance against a transaction.

The first requirement is met by over the counter (OTC) financial instruments: instruments that are carried out by transacting entities negotiating and reaching agreement directly, without an intermediary. The second requirement means that, since insuring participants are trading not on the underlying asset but on an asset derived from it (insurance risk), we will be dealing with a model resembling financial derivatives [6,5,48]. In finance, derivatives are financial instruments whose performance depends on another variable, and are often used to transfer or reduce (hedge) risk involved in assets or transactions. These instruments are typically settled upon the occurence of a credit default event, and the characterisation of the risk involved dictates their cost.

The design of our proposed system and its market layer revolves around the above two concepts.

2.2. Relation to distributed reputation management

Our approach is proposed as a potential alternative to distributed reputation management systems supporting peer-to-peer transactions.

A considerable amount of groundbreaking work has been carried out in the distributed reputation management field in recent years, aiming at providing an expectation about a peer's behaviour in a transaction by monitoring, maintaining and distributing information about its behaviour in past transactions.

A variety of solutions have been proposed for addressing either or both of the data modelling problem (how to generate, interpret and process the reputation data), and the data management problem (how to store, retrieve, distribute and secure the reputation data in a scalable and efficient manner) [2]. Some notable systems in this area include the EigenTrust system [40], PeerTrust [60], Credence [59], a system proposed by Aberer et al. based on the P-grid structured routing algorithm [2,1], a Bayesian approach proposed by Buchegger et al. [7], TrustMe [52], XRep [11], a partially centralized mechanism presented in [30], to name but a few. Due to space constraints, we refer the reader to a comprehensive overview by Huaizhi and Singhal [34] and the references therein.

We want to stress that distributed reputation management systems and our proposed approach are by no means mutually exclusive, and could potentially complement each other within the same scope, supporting the same transaction management system.

2.3. The PTRIM market-based insurance layer

In our design, a peer-to-peer layer acts as a market offering transaction default insurance to a main, peer-to-peer transaction processing system (that is also part of our implemented system). Any peer can participate in this market: One could be regularly active as a buyer or seller, and sporadically choose to also offer insurance for specific transactions (e.g. involving peers that they know can be