Electronic Commerce Research and Applications 13 (2014) 13–23

Contents lists available at ScienceDirect

Electronic Commerce Research and Applications

journal homepage: www.elsevier.com/locate/ecra

Multi-agent technology and ontologies to support personalization in B2C E-Commerce

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ARTICLE INFO

Article history:
Received 24 October 2012
Received in revised form 13 June 2013
Accepted 13 July 2013
Available online 23 July 2013

Keywords:
E-Commerce
Business-to-Customer
Electronic payment
CBB

ABSTRACT

In this paper we present an XML-based multi-agent system, called *Multi Agent System for Traders* (MAST), that supports several Business-to-Customer e-Commerce activities, including advertisements and payments. MAST helps both customers and merchants in performing their tasks by using a personalized approach. MAST's e-payment model avoids exchanging sensitive information, reinforcing trust between merchants and customers. A complete prototype of MAST has been implemented under the JADE framework, and it has been exploited for realizing some experiments, in order to evaluate its performances.

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1. Introduction

Nowadays, e-Commerce (EC) plays a pivotal role in the Web, involving different aspects (i.e., technological, economic, legal, etc.) depending on the characteristics of the EC transactions (Palopoli et al. 2006).

In particular, EC transactions between a merchant and a customer are commonly denoted as Business-to-Customer (B2C) processes, that can be compared to the retail trade of traditional commerce. More specifically, B2C market involves a large number of merchants interested in offering products by using a convenient media and customers that desire to purchase those products. In this context, customers and merchants can exploit different opportunities (Zwass 2003) as: (*i*) absence of time and space boundaries; (*ii*) simplicity, efficiency and comfortability of sales and purchases; (*i*) availability of low costs and several sale terms. However, a significant customer-merchant distrust (Iglesias-Pradas et al. 2013) still persists in EC, mostly due to the absence of personal contacts and to a low acceptance of the e-payment methods for security reasons.

A B2C transaction is a complex decision-making process consisting of different activities such as searching for a product, selecting a merchant, negotiating the best price and so on, that have to be carried out by both customers and merchants. In this context, a relevant attention has been devoted to identify the customer's behavior and the complementary merchant's behavior. Several studies have been proposed in the literature in order to model the different phases composing a B2C process. Some of them are derived by traditional retail commerce as the Nicosia (Nicosia 1966) or the Engel and Blackwell (Engel et al. 1995) models, while others have been specifically designed for the Web as the Nissen's Commerce model (Nissen 1997), the E-Commerce Value Chain model (Feldman 1999) or related to Simon's decision making process, usually used in Decision Support Systems (Miles and Howes 2000).

A widely adopted behavioral model is the Consumer Buying Behavior (CBB) (Guttman et al. 1998) that is also exploited in this paper. The CBB is structured into six different phases, each one relative to a well defined activity, as briefly described below; (*i*) *Need Identification*, where a user identifies his/her needs; (*ii*) *Product Brokering*, in which the user searches for products that satisfy his needs; (*iii*) *Merchant Brokering*, dealing with the identification of a merchant selling the chosen goods or services; (*iv*) *Negotiation*, to fix the transaction terms (i.e. price, quantity, etc.); (*v*) *Purchase and Delivery*, where the customer finalizes the purchase choosing both payment and delivery modality; (*vi*) *Service and Evaluation*, that consists of the customer's evaluation of his/her satisfaction level about the performed purchase.

In this context, the multi-agent technology (Costina et al. 2011, Hector 2005, Hubner et al. 2009, Maes 1994, Nwana 1996, Perini 2007) appears as a promising solution for designing tools capable of supporting virtual community of users. It allows users to interact with the environment and carry out delegated tasks in simple, intelligent and independent manner in order to realize some kind of collaborative space (Buccafurri et al. 2004, Nocera et al. 2011, Rosaci and Sarnè 2006, Rosaci and , Sarnè 2010, Rosaci et al. 2012,

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http://dx.doi.org/10.1016/j.elerap.2013.07.003

Tsvetovatyy and Gini 1996, Ye et al. 2001). Software agents have been fruitfully applied also in EC (He et al. 2003, Lax and Sarnè 2006Liu and Ye 2001, Rosaci and Sarnè 2012b, Ursino et al.2004) in order to design systems characterized by high levels of automation. Currently, only few agent systems cover more than one phase of a B2C process, while the most part of them provide only a rough and non-integrated support for a fixed typology of B2C activities. However, in developing such agent systems it is crucial that customers and merchants can be fully supported along all the tasks of a B2C process with a high automation level by attending them step by step, in a safe, reliable, and personalized way.

To this purpose, there is the need to obtain, maintain and update information about both customers' interests and preferences and merchant's trading data using suitable profiles (De Meo et al. 2007, Rosaci and Sarnè 2012b) and in such activity the results obtained by using software agents appears more effective than those obtained by other approaches. The customers' profiles can be realized either on the merchant or the customer side; each of the two possibility implies a different representation of the interests and preferences. Indeed, in the first case only the activities performed by the customer on that merchant's EC site are representable; differently, using the second alternative, it is possible to obtain a complete representation of the whole customer's B2C history. Furthermore, when a customer starts to use a system, his/her profile will be empty, and in order to provide him/her with a suitablypersonalized support it will be necessary to provide him/her with an initial profile to solve such a cold start problem. This initial profile can be obtained by exploiting rating data directly provided by users or automatically elicited by the system monitoring his/her activities.

Finally, the presence of a network in the payment phase introduces some critical issues, absent in traditional payment systems, that requires the development of specific e-payment schemas in order to offer a trusted environment.

1.1. Contribution

To provide a solution for the aforementioned issues, the most important contribution of our research is that of proposing a mechanism to weight the importance of the different B2C activities from the customer's perspective. To this purpose we adopt the well know CBB model above introduced to describe the different activities enacted in a B2C process. However, it is important to highlight that this contribution is not limited to only defining weights and coefficients of interests but, more important, we introduce a new method to allow a customer agent to assist its own user by using the aforementioned weights, obtaining a better effectiveness with respect to other approaches proposed in the past. Indeed, in our approach, the coefficients of interest of a customer for a product category, a product or a merchant are computed taking into account the weights above, and thus weighting the importance that the customer assigns to the different phases. The past approaches proposed in the literature computed similar coefficients of interest without discriminating the different CBB phases. In other words, if a customer shows an interest for a product in the "Need Identification phase", for those approaches this fact is considered equivalent to showing interest for that product in the "Merchant Brokering" phase. But for some customer, from the viewpoint of the personal interest, the act of showing interest for a marketing campaign about a product category could be considered less important than the decision, for instance, of searching for a suitable merchant in order to actually purchase that product. This observation leaded us to compute the coefficients of interests using different weights for the different CBB phases. The goal of our proposal is that of assisting the customers that use our approach in a more effective way than the classical approaches. In the next section, we will describe some widely used measures to evaluate the system effectiveness, and the results of some experiments that we present in Section 7 clearly show that our approach outperforms other approaches proposed in the literature in terms of user's satisfaction.

As a second contribution, we propose a B2C framework based on the above approach, called *Multi-Agent System for Traders* (MAST). MAST is, to the best of our knowledge, the first proposal of a multi-agent system capable of assisting both customers and sellers of a B2C community in all the phases involved in B2C activities. In other words, a customer using MAST will be assisted by this tool in (*i*) determining the most important needs; (*ii*) finding the most appropriate products to satisfy those needs; (*iii*) selecting the most suitable merchants for purchasing the desired products; (*iv*) defining the details of the transaction with the merchant; (*v*) operating the payment. Moreover, MAST assists also the human merchant in the activities above, automatically sending to customers appropriate offers, responding to customers' requests, etc. Any multi-agent system has been proposed in the past to assist customers and merchants in such a way.

MAST is composed of a set of personal XML-based agents, associated with customers and merchants, and an agency that manages the whole system. In particular, in MAST each merchant and each customer is provided by a software agent, managing a personal profile automatically built on the customer's or on the merchant's side, able to take into account the competencies of the involved parties accordingly to all the performed B2C activities. The underlying CBB model provides MAST with a useful starting point and guideline to identify and suitably weight the different events composing a B2C process. We point out that the choice of the CBB model among all the other possible models existing in the literature is due to the fact the CBB model is so general to be considered as a generalization of all the other models, and it is the most widely applied model for B2C in the recent related work.

The MAST framework presents the following important features: (*i*) software agents adopt the eXtensible Markup Language "XML" (www.w3.org) to manage agent profiles and messages in a light and easy manner, to represent categories of interests and their instances belonging to various cataloges and to realize agent communications in ACML language (Grosof and Labrou 2000) for guaranteeing portability and other benefits; (*ii*) an *Ontology* model (De Meo et al. 2012, Grosof and Labrou 2000, Kumar 2011), used as a common language for all the agents, allows to give a unique representation of products and categories belonging to various cataloges; (*iii*) an e-payment protocol, called AIPP (Agent Internet Payment Protocol) (Garruzzo et al. 2006), based on existing financial institutions, fully compliant with the standard FAST (Financial Agent Secure Transaction 2000) framework, it is used together with single-use account identifiers (Shamir 2002) in order to perform safe and trusted payments; (*iv*) a "yellow page" service is available for all the agents.

1.2. Plan of the paper

The paper is organized as follows: Section 2 deals with some Related work. A brief overview of our approach for supporting B2C activities is presented in Section 3. The MAST framework is described in details in Section 4, while in Section 6 the adopted functionalities for customer and merchant support are introduced. Section 5 briefly illustrates the AIPP protocol. In Section 7, some experiments performed using a MAST prototype are discussed and finally, in Section 8, some conclusions are drawn.

2. Related work

The various aspects related to B2C commerce have been dealt with by using software agents in a large number of models and

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