Studying how e-markets evaluation can enhance trust in virtual business communities

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Abstract

One of the major drawbacks of conducting business online is the raised level of risk associated with business transactions. Potential business partners usually have limited information about each other's reliability or product / service quality before an online transaction. In this paper, we focus on the problem of selecting a trustful electronic market (e-market), in order to perform business transactions with it. In particular, we examine how the decision of selecting an appropriate e-market can be facilitated by an e-market recommendation algorithm. For this purpose, a metadata model for collecting and storing e-market evaluations from the members of a virtual business community in a reusable and interoperable manner is introduced. Then, an e-market recommendation algorithm that can synthesize existing e-market evaluations stored using the metadata model, is designed. Finally, a scenario of how the presented e-market recommendation algorithm can support a virtual agribusiness community of the organic agriculture sector is discussed.

Keywords: *E-market, metadata, recommender system, virtual community*

1. Introduction

Increasing use of the World Wide Web (Web) as a business commercial tool raises interest in understanding the key issues in building relationships between business partners on the Internet (Fritz et al., 2005). Trust, a fundamental principle of every business relationship, is defined as the expectation that the other partners will behave in accordance with commitments, negotiate honestly, and not take advantage, even when opportunity rises (Hosmer, 1995). It has a vital influence on physical business transactions and even more on electronic ones. In an environment of risk and uncertainty as the Web, enterprises must develop strategies for establishing trustworthiness, and systems should be developed to assist business partners in assessing the level of trust they should place in an e-commerce transaction (Patton & Josang, 2004).

When transacting with Internet-based electronic markets (e-markets), one of the major drawbacks is the raised level of risk associated with business transactions. An e-market is an information system intended to provide potential business partners with online services that will facilitate information exchange, and will support business transactions. When it is operated from an unknown (and therefore still untrusted) entity, potential business partners

usually have limited information about its reliability and product/service quality before the transaction. Therefore, alternative sources of information, other than own experience, have to be used to help a potential business partner decide whether a particular e-market should be trusted and a transaction can be safely carried out with it. One of the major constituents that can facilitate this decision is the opinion of other business partners that have previously been engaged in a transaction with the particular e-market. In the context of a virtual community (VC) of business partners, this opinion can take the form of e-markets' evaluations, which can be collected from the VC members. These collected evaluations can serve as a common corpus of knowledge and experience, which can be taken advantage of in order to help the VC members in selecting appropriate e-markets to commit transactions with.

In this paper, we present an e-market recommendation algorithm that takes advantage of this common knowledge and experience in the VC. More specifically, the paper first identifies a metadata model for storing multi-criteria evaluations of e-markets. Metadata (data about an information source or simply "data about data") is generally used to describe information resources, in order to facilitate their categorization, storage, search and retrieval (Miller, 1996). Second, it demonstrates how this meta-model can serve as the basis for developing a recommendation algorithm that synthesizes the evaluations that members of a VC have provided, in order to propose appropriate e-markets to other members. Third, this paper examines the applicability of this algorithm, by presenting how it can support the members of an Organic Agriculture VC to find trustful e-markets with certified organic products.

2. Metadata for evaluating e-markets

Several evaluation instruments (e.g. online questionnaires) exist that measure the satisfaction of a business partner from the use of an e-market. Examples of such instruments include the proposals of Barnes & Vidgen (2002), Mich et al. (2003), and Olsina Santos & Rossi (2002). To collect and store e-market evaluations that are provided from such instruments, we have developed the E-Commerce Evaluation Metadata (ECEM) model that uses a common and reusable XML data format to store information (Manouselis, 2005; Manouselis & Costopoulou, 2005). ECEM is a metadata model that facilitates the description of evaluation instruments for e-markets and the storage of evaluation results. The proposed e-market recommendation algorithm requires the use of a subset of the ECEM metadata elements, the experience ECEM (expECEM) subset. This subset includes elements that do not store information about the instrument itself, but rather the evaluation experience results. In particular, expECEM consists of the following elements:

- *Title*: refers to a title used to distinguish the evaluation experience from others.
- *Description*: contains a short description of the experience.
- *Source*: includes a reference to a resource from which the experience can be acquired from.
- *Meta-Metadata*: contains information about who contributed the experience. It identifies the metadata record in a classification system (e.g. a database with experience descriptions).

- *Date*: contains the time period(s) during which the experience took place.
- *Coverage*: includes information about the particular coverage of the experience (e.g. coverage of a particular geographical area, of a particular type of e-markets, or of a particular transaction phase).
- *Subject*: stores information about the topics that the experience referred to, in terms of the business sector that the evaluated e-market belongs to, and the product / services it offers.
- *Evaluation*: stores the results of the experience, according to the multiple dimensions of the evaluation instrument used, and from multiple evaluators.
- *Audience*: stores information about the roles of the audience that have taken part in the evaluation experience (e.g. customers/users, operators, evaluators).
- *Relation*: stores information about which is the evaluation instrument used to collect evaluation results, and which is the evaluated e-market.

3. Designing the e-market recommendation algorithm

During the years, the term 'recommender systems' has been introduced to generally describe systems in which "…people provide recommendations as inputs, which the system then aggregates and directs to appropriate recipients."(Resnick & Varian, 1997). The envisaged recommendation algorithm will have to synthesize e-market evaluations that have been stored using expECEM. It is assumed that all the e-market evaluations are performed using the same evaluation instrument, and have the same, multiple evaluation dimensions. In this section, the e-market recommendation problem is modeled as a multi-criteria decision making one, and therefore a multi-criteria recommendation algorithm is designed.

The problem of recommendation in a VC is referred to as the way to help the VC members to identify the items (or 'alternatives') that are most likely to be interesting to them or relevant to their needs (Konstan, 2004). Following the formalization of Adomavicius & Tuzhilin (2005), we describe the e-market recommendation problem in the context of a business VC. In particular, let C be a set of all the members of the VC and S a set of e-markets that some of these members have already transacted with (e.g. for finding appropriate supplies or for promoting their products). If u is a utility function $u : C \times S \to \Re^+$ that measures the appropriateness of recommending an e-market s to a business partner c, then for each partner $c \in C$ we want to choose the e-market $s' \in S$ that will maximize this partner's utility function. More formally:

$$\forall c \in C, s'_c = \arg\max_{s \in S} u(c, s) \qquad (1)$$

In a real life situation, the utility function u is not defined on the whole CxS space but only on some subset H of it ($H \subseteq S$). Thus, the goal of recommendation is to estimate (or approach) the utility function u, in order to be able to predict utility values for the e-markets of the space (CxS - H) for which u has not yet been defined. In most recommendation systems, the utility function u is single-criterion (refers to only one attribute of an item s), e.g. an overall rating. Nevertheless, utility can be an arbitrary function that involves more criteria of an item. In the case that we examine, an e-market is evaluated upon the multiple criteria (attributes) of an

applied evaluation instrument. The e-market recommendation problem is therefore a multi-criteria decision making one.

According to the multi-criteria decision making literature (Roy, 1996; Jacquet-Lagreze & Siskos, 2001), each criterion is a non-decreasing real valued function defined on *C*x*S* as follows:

$$g_i : C \times S \to \Re / s \to g_i(s) \in \Re \qquad (2)$$

where g_i(s) is the evaluation of the e-market *s* on the i^{th} criterion (i=1,…,n). Thus, the multi-criteria evaluation of an e-market $s \in S$ is given as a vector $\boldsymbol{g}(s)$ or $\underline{g}(s) = [g_1(s), g_2(s), ..., g_n(s)]$. We have previously assumed that the evaluation instrument to be used for evaluating all e-markets in the context of the VC will be the same. In this version of the algorithm, we choose the WebQual instrument (Barnes & Vidgen, 2002) and therefore the criteria set is: Usability (g_1), Information Quality (g_2), and Service Interaction Quality (g_3). The developers of WebQual claim that these criteria are independent and sufficient for measuring the satisfactions of users from e-commerce resources. The above criteria take values from a 7-point scale {1,…,7}, where '1' is the lower value of the criterion, and '7' the higher one. Since each criterion g_i is a non-decreasing real valued function, and that there is no uncertainty during the decision making, the total utility of an e-market $s \in S$ for a business partner $c \in C$ can be expressed as:

$$u^c(s) = \sum_{i=1}^{3} w_i^c g_i^c(s) \qquad (3)$$

where $g^c{}_i(s)$ is the evaluation value of e-market *s* on criterion g_i, and $w^c{}_i$ is a weight indicating the importance of criterion g_i for the particular business partner *c*, with:

$$\sum_{i=1}^{3} w_i^c = 1 \qquad (4)$$

The linear function of Eq.(3) is the simplest and most popular form of an additive value function, according to the principles of Multi-Attribute Utility Theory (MAUT). Others could include an ideal point model, dependencies and correlations, as well as diminishing utility forms (Price & Messinger, 2005).

Assuming that there has been a subset of business partners *M* in the overall community C (that is $M \subseteq C$) that has evaluated a subset of e-markets *K* from the whole population of available e-markets S (that is $K \subseteq S$), then the following hold:

- For each business partner $m \in M$ that has evaluated an e-market $k \in K$, this evaluation is defined as the vector $\underline{g}^m(k) = [g_1^m(k), g_2^m(k), g_3^m(k)]$, and there is also a set of importance

weights $\underline{w^m} = [w_1^m, w_2^m, w_3^m]$ that are associated with the three criteria. It is assumed that the weights w_i^m (i=1,…, 3) that a business partner m gives to each criterion remain the same (that is, the partner considers the same criteria important when evaluating different e-markets). The evaluations $g^m{}_i(k)$ are referred to as the *evaluations* of the business partner m, and the weights w_i^m as the *properties* of partner m.

- The total utility function of the e-market k for the business partner m is therefore:

$$u^m(k) = \sum_{i=1}^{3} w_i^m g_i^m(k), \quad \forall m \in M \quad (5)$$

The goal of the e-market recommendation algorithm is to provide to a particular business partner $a \in C$ that has not rated a particular e-market $k' \in S$ (who we will refer to as the *active user*), a *ranking* of the e-markets. In the light of the 'neighborhood-based' algorithms discussed by Herlocker et al. (2002), we therefore design a recommendation algorithm that is based on the following principle: it creates a 'neighborhood' of $D \subseteq M$ business partners that have similar priorities to the properties w_i^a of the active user, and examines how they have evaluated k' (therefore, $k' \in K$ should hold in order for the recommendation algorithm to be able to produce a prediction). That is, it bases its recommendation on the opinion of the business partners that assign similar importance weights to the evaluation criteria. If we assume that $z \in \Re^+$ is the number of members in the neighborhood, the goal of the recommendation algorithm is to predict the total utility $u^a(k')$ according to the z utilities $u^d(k')$ of this e-market for each $d \in D$ business partner in the neighborhood.

For this purpose, the similarity of the active user a to each user $m' \in M$ (denoted as $sim_{a,m'}$) can be calculated using one of the classical measures used in recommendation literature (Herlocker et al., 2002). In particular, we calculate similarity as the distance between the vectors of the weights of the active user a ($\underline{w^a} = [w_1^a, w_2^a, w_3^a]$) and each business partner m' ($\underline{w^{m'}} = [w_1^{m'}, w_2^{m'}, w_3^{m'}]$), using the Cosine metric:

$$sim_{a,m'} = \frac{\sum_{i=1}^{3} (w_i^a \times w_i^{m'})}{\sqrt{\sum_{i=1}^{3} (w_i^a)^2} \times \sqrt{\sum_{i=1}^{3} (w_i^{m'})^2}} \quad (4)$$

After the similarity of each business partner m' with the active user a is calculated, the neighborhood D of business partners from which the prediction of $u^a(k')$ can be produced is either formulated by selecting only partners with similarity over a pre-defined threshold (called Correlation Weight Threshold) or from a pre-defined maximum number of users (Max Neighbors Number). Both options can be considered in our algorithm.

Additionally, further improvements to this neighborhood-based algorithm can be carried out, as for example the weighting of the neighbors' total utilities $u^d(k')$ ($d \in D$) according to how similar they are to the active user *a*. Therefore:

$$u^a(k') = \frac{\sum_{d=1}^{z} u^d(k') \times sim_{a,d}}{\sum_{d=1}^{z} sim_{a,d}} \quad (7)$$

This normalization formula gives more weight to the opinion of the business partners whose priorities are closer to the ones of the active user, than the other partners in the neighborhood.

Based on the estimation of the utility $u^a(k')$ for each candidate e-market, the e-market recommendation algorithm can rank the alternatives and present the active user with a prioritized list of recommended e-markets.

4. Case scenario

In this section, we briefly present the applicability of the proposed recommendation algorithm to support the members of a VC of agribusinesses, who are interested in finding trustful e-markets with certified organic products. This scenario is envisioned in the context of the online services that the BIO@GRO portal, a large Web portal for the OA sector, is expected to provide. BIO@GRO (http://bioagro.aua.gr) is a European project that aims provide OA actors (e.g. farmers, processors, consumers) with a variety of online services, including information catalogues, educational and e-government resources, as well as, e-business and e-commerce resources. In this context, the BIO@GRO portal is going to host an Internet-based directory of e-markets that offer organic products (Manouselis & Costopoulou, 2005). The visitors of the BIO@GRO Web portal will be able to register in particular services, formulating thus VCs of people with common interests and needs.

We therefore assume the hypothetical scenario of a VC of agribusinesses that are interested in organic products. The members of this VC are expected to use the BIO@GRO discussion forum and communication capabilities in order to exchange opinions and experiences, related to the production and trade of organic products. They are also expected to use the Internet-based directory of OA e-markets, in order to find ones with organic products that are appropriate for their needs. In this scenario, we introduce the VC members with the possibility to contribute their overall satisfaction from e-markets that they have transacted with (that is, evaluate them using the WebQual instrument). The evaluation results are stored in the Web portal according to expECEM. We have to note here that, at this level of analysis, the type of products that an e-market is offering is not considered in the evaluation criteria. Thus, we assume that all e-markets more or less offer the same kind of organic products. In this way, a common pool of experiences with e-markets is created, which every VC member can share and take advantage of.

In this context, the e-market recommendation algorithm can propose interesting e-markets to the members of the VC. For example, a new member of the VC can submit its priorities regarding the quality criteria that a desired e-market should obey to. According to the presented recommendation algorithm, the members of the VC that have previously evaluated existing e-markets, and which have similar properties with the new member, will be identified. Then, the evaluations that these members have provided will be considered, and a prediction of how much each e-market in the directory is suitable for the new member will be estimated. Finally, a ranked list of proposed e-markets will be recommended to the new member. An overview of this scenario is graphically illustrated in Figure 1.

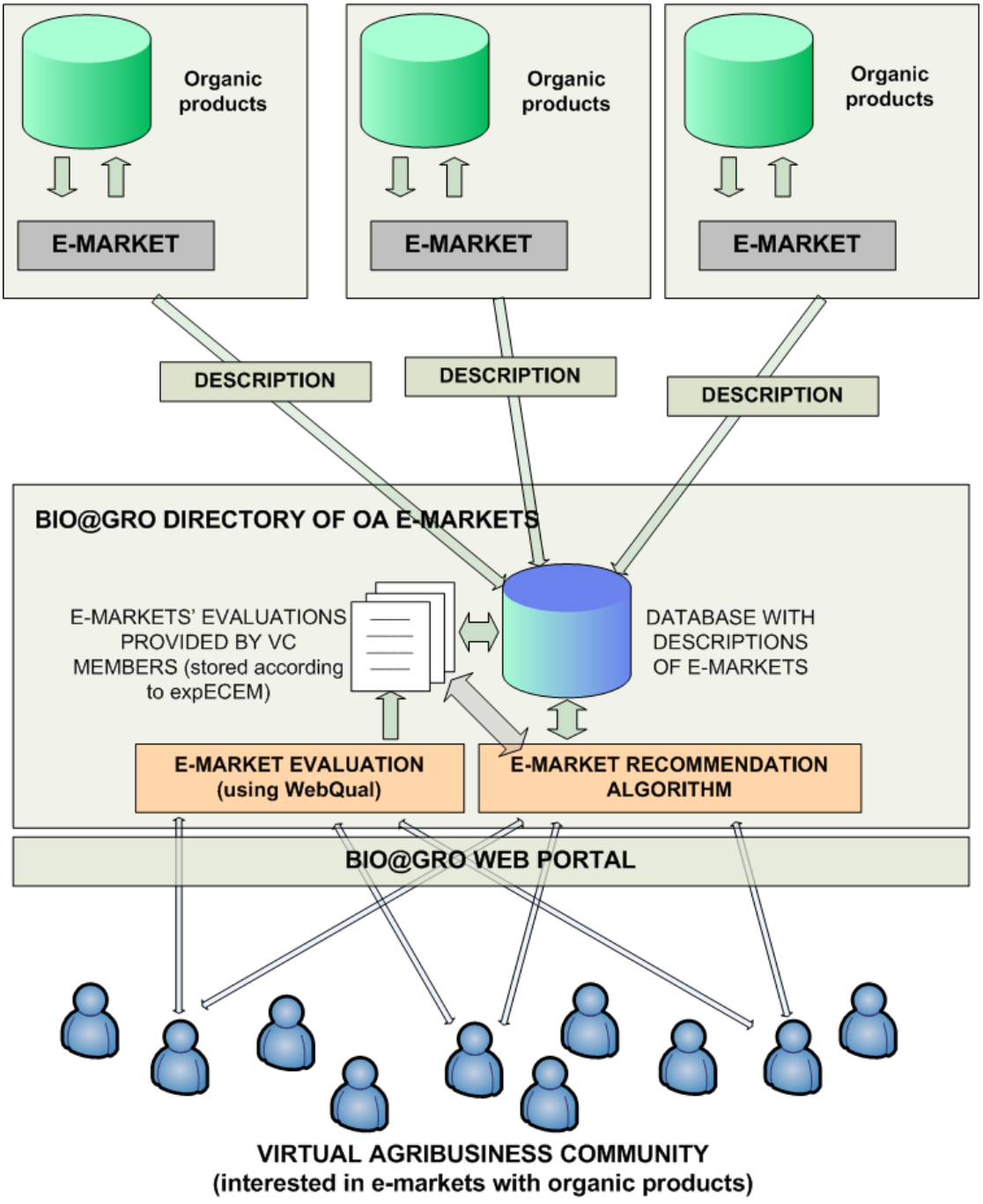

Figure 1. Example of e-market recommendation for an organic agriculture business VC

5. Conclusions

One of the major drawbacks of conducting business online is the raised level of risk associated with business transactions. Potential business partners usually have limited information about each other's reliability or product /service quality before the transaction. In this paper, we presented an e-market recommendation algorithm that aims to support members of a business VC. In particular, this paper first introduced the expECEM metadata elements for collecting and storing e-market evaluations from the VC members. Second, it described the design of a multi-criteria recommendation algorithm that can synthesize past evaluations in order to propose appropriate e-markets to the VC members. Finally, it has demonstrated a scenario of applying the e-market recommendation algorithm in the context of the BIO@GRO Web portal for organic agriculture, in order to support the members of an agribusiness VC to find suitable e-markets with certified organic products.

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7. References

Adomavicius, G., Tuzhilin, A. (2005). Towards the Next Generation of Recommender Systems: A Survey of the State-of-the-Art and Possible Extensions. IEEE Transactions on Knowledge and Data Engineering, 17(6), pp. 734-749.

Barnes, S.J., Vidgen, R.T. (2002). An Integrative Approach to the Assessment of E-Commerce Quality. Journal of Electronic Commerce Research, 3(3), pp. 114-127.

Fritz, M., Hausen, T., Schiefer, G. (2005). Trust and E-Commerce in Agrifood Networks: Configuration of an Electronic Trust Environment. In Proc. of the EFITA/WCCA Joint Conference 2005, July 25-28, 2005, Vila Real, Portugal.

Herlocker, J., Konstan, J.A., Riedl, J. (2002). An Empirical Analysis of Design Choices in Neighborhood-Based Collaborative Filtering Algorithms. Information Retrieval, 5, pp. 287-310.

Hosmer, L. (1995). Trust: the connecting link between organizational and philosophical ethics. Academy Management Review, 20(2), pp. 370-403.

Jacquet-Lagreze, E. Siskos, Y. (2001). Preference disaggregation: 20 years of MCDA experience. European Journal of Operational Research, vol. 130, pp. 233-245.

Konstan, J.A. (2004). Introduction to Recommender Systems: Algorithms and Evaluation. ACM Transactions on Information Systems, 22(1), pp. 1-4.

Manouselis, N. (2005). ECEM: E-Commerce Evaluation Metadata. Technical Report, Informatics Laboratory, Agricultural University of Athens, TR179.

Manouselis, N., Costopoulou, C. (2005). Designing an Internet-based directory service for e-markets. Information Services & Use, 25 (2), pp. 95-107.

Mich, L., Franch, M., Gaio, L. (2003). Evaluating and Designing Web Site Quality. IEEE Multimedia, January-March 2003.

Miller, P. (1996). Metadata for the Masses. Ariadne 5.

Olsina Santos, L., Rossi, G. (2002). Measuring Web Application Quality with WebQEM. IEEE Multimedia, October-December Issue, pp. 20-29.

Patton, M.A., Josang, A. (2004). Technologies for Trust in Electronic Commerce. Electronic Commerce Research, 4, pp. 9-21.

Price, B., Messinger, P.R. (2005). Optimal Recommendation Sets: Covering Uncertainty over User Preferences. In Proc. of the AAAI, 2005.

Resnick, P., Varian, H.R. (1997). Recommender Systems. Communications of the ACM, 40(3), pp. 56-58.

Roy, B. (1996). Multicriteria Methodology for Decision Aiding, Kluwer Academic Publishers.