

## Matchmaking Framework for B2B E-Marketplaces

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*In the recent years trading on the Internet become more popular. Online businesses gradually replace more and more from the conventional business. Much commercial information is exchanged on the internet, especially using the e-marketplaces. The demand and supply matching process becomes complex and difficult on last twenty years since the e-marketplaces play an important role in business management. Companies can achieve significant cost reduction by using e-marketplaces in their trade activities and by using matchmaking systems on finding the corresponding supply for their demand and vice versa. In the literature were proposed many approaches for matchmaking. In this paper we present a conceptual framework of matchmaking in B2B e-marketplaces environment.*

**Keywords:** *B2B Electronic Marketplaces, Conceptual Framework, Matchmaking, Multi-Objective Genetic Algorithm, Pareto Optimal*

### 1 Introduction

An important part of the B2B e-commerce activities are conducted using e-marketplaces. Electronic marketplaces become popular because they promise to greatly improve market efficiency, to reduce transaction cost and to generate new revenue. *Garicano and Kaplan* studied a used car EM, and concluded that the EM lowered car prices by 5%, and the tangible transaction cost by 80% [5]. The e-marketplaces have success worldwide. In China the biggest B2B e-marketplace in the world (Alibaba) has attracted 24 million corporate users (<http://www.alibaba.com>).

The growth of electronic marketplace popularity and usage attracted interest from many researchers in recent years. Analyzing the scientific papers about e-commerce in the past 12 years, we can see an increase in e-marketplace research [12]. The e-marketplace researches were conducted in many different themes like *EM success, EM adoption, EM impact, EM design, trust, EM and SMEs, intelligent agents, and overview of EMs*. Among them, EM success, adaptation, impact and design were the most interested topics [11].

According to *Martin G.* the electronic marketplace “allows customers and suppliers to meet at a certain place and at a certain time in order to communicate and to

announce buying or selling intentions, which eventually match and may be settled” [8]. The central function of EM is to bring together multiple buyers and sellers in one central market space. It also enables them to buy and sell products and services at a dynamic price between each other. The price is determined in accordance with the rule of the exchange.

With the increasing availability of e-commerce, transaction efficiency is a critical factor for a company to have success. The e-marketplace will be gradually a mainstream in the future on trading goods. With the increasing number of participant on the EM the matchmaker will play a crucial role in finding the optimal match between demands and supply. Matchmaker provides a flexible service for buyers and sellers. Matchmaking is the process of searching the space of possible matches between demand and supplies. In this paper we will present a conceptual framework of a matchmaker for B2B e-marketplaces.

### 2 Literature Review

*Grieger at al.* classified e-marketplaces in three groups: public, consortia based and private e-marketplaces [6]. Public e-marketplaces are owned by a third party, serving multiple buyers and suppliers. Consortia-based e-marketplaces are those

that have been created by several big industry players. Private e-marketplaces are created by single companies to support their own purchasing and selling activities. According to the number of participants on both side, the e-marketplaces can be classified on many-to-many, many-to-few and many-to-one EMs. [9]

In the literature several models of market transaction in EMs have been proposed. *Schmid and Lindemann* classify the electronic marketplace transactions based on four successive phases: information (*i.e.*, participants in the market seek potential partners), agreement (*i.e.*, negotiation on the terms of the agreement and agreement on a contract), settlement (*i.e.*, payments and logistics), and after-sales (*i.e.*, customer support) [10]. Most researches were conducted on the agreement and settlement (payment and logistic) theme.

The existing literature focused primary on two factors: the price competition and the cost reduction. Many studies in the literature recognize the positive effects of e-marketplaces on supply chain management. Some researches were also conducted to study the impact of participation in e-marketplaces on participants' supply chain operations, including inventory management and order fulfillment. Most of the studies regarding to the price competition conclude that the prices become lower on e-marketplace than in the traditional market due to more intensive competition between sellers. *Chaturvedi et al.* show that the introduction of B2B e-marketplace to an industry force the manufacturers to lower the price to their marginal cost because e-marketplace makes industry-wide price and demand information more transparent than in traditional supply [4]. *Bandyopadhyay et al.* demonstrate that the larger the number of sellers on an e-marketplace the lower the average price, in case that the aggregate production capacity of the sellers remains the same [3].

One of the central activities in an e-marketplace is matchmaking which is the process of finding the matches between the

trading intentions of the market participants. *Marlon D. et al.* present a configurable matchmaking framework for e-marketplaces in which "identifies a core set of concepts and functions that are common to all types of marketplaces and can serve as the basic of describing the distinct styles of matchmaking employed within various market mechanism"[7]. In this paper the authors also presented a prototype implementation of the framework based on web services technology, illustrating its ability to be dynamically configured to meet specific market need and its potential to serve as a more fully-fledged e-marketplace framework.

*Tommaso Di Noia et al.* present a semantic-based matchmaking facilitator for peer-to-peer electronic marketplaces. "The definition and properties for the matchmaking problem were devised in a framework based on descriptive logic. The proposed classification of matches as potential and partial overcomes basic subsumption-based matchmaking, and the devised algorithms allow ranking of advertisements with respect to a given request, well modeling common sense reasoning in the analysis of commercial advertisements" [13].

*Azzurra R. et al.* propose a semantic matchmaking approach that mixes various knowledge representation technologies to find the most promising agreements in P2P e-marketplace. "By exploiting ontologies in DLR-Lite and fuzzy rules the authors are able to model both hard constraints and soft constraints, while taking into account both buyer's and seller's preferences to find mutually beneficial for them. The authors model the information needed for the P2P matchmaking process are modeled as a vague knowledge base, taking into account domain knowledge, while keeping the approach effective a scalable" [2].

In this paper we will exclude private and one-to-many EMs, and we will focus on public and many-to-many e-marketplaces. We will present a conceptual framework for many-to-many matchmaking in B2B e-marketplace, and a multi-objective

mathematical model for finding the matching solution with the constraint that the buyers and sellers total satisfaction must be optimal.

### 3 A Conceptual Framework of Creating a Matchmaking System

An essential part of every e-marketplace is represented by the process of matching the demand with the supply. "Matchmaking is the process of searching the space of possible matches between demand and supplies"[13]. Without a matchmaking system the e-marketplace buyer requirements and supplier proposals can't be connected.

We propose a conceptual framework for matchmaking system development. The matchmaking process is by which the parties who want to exchange goods can be put in connection with counterparts. Buyers can find the suppliers who can supply their demand, and can choose the most promising ones. The suppliers can find the buyers who request their goods. Matchmakers are vital part of every e-marketplace because they can find the match between proposals and requirements and can gain competitive advantages against their traditional way trading competitors and increasing the popularity and acceptance of the e-marketplaces.

We will discuss the situation when on the e-marketplace the relationship between the buyers and sellers is many-to-many. There are many buyers who can buy goods from many sellers. The matchmaker has two functions. First is to match buyer requirement constraints to the sellers capabilities and proposal constraints. The second function is to find the most profitable trade for buyers and sellers from the feasible solution.

#### 3.1 Buyers Requirement

On the e-marketplace every registered buyer can place one or many product and service

requirements. These requirements must be described by completing a form. The required good must be described with attributes having hard and soft constraint values. The hard constraints are "equal to" type values. For example the buyer wants to buy a laptop which is produced by DELL. Here the brand attribute value must be equal with "DELL".

The required product attributes can have soft constraints. These constraints are "bigger then" or "smaller then" type constraints, where can be specificities the "more is better" or "less is better" option depend on attribute nature. For example in case of a laptop the processor attribute must be bigger than 1.7 MHz. This is "more is better" type option because the bigger processor frequency increases laptop's speed. In case of the price attribute of the laptop the buyer usually chose the option "less then better" because everyone want to minimize the price. These types of attributes are important in the optimization process of the matching solution.

#### 3.2 Sellers Proposals

On the marketplace every registered seller can place one or many product and service offers (proposals). These offers must be introduced to e-marketplace using a form. The product proposal must be described by attributes (characteristics) which have hard constraint values. These values describe the good characteristics, which are important on setting the match between requirements and proposals. On the e-marketplace must be describe the product core characteristics (ex. brand, size, price, quantity, performance attributes) and product purchase and delivery characteristics (ex. delivery time, payment method).

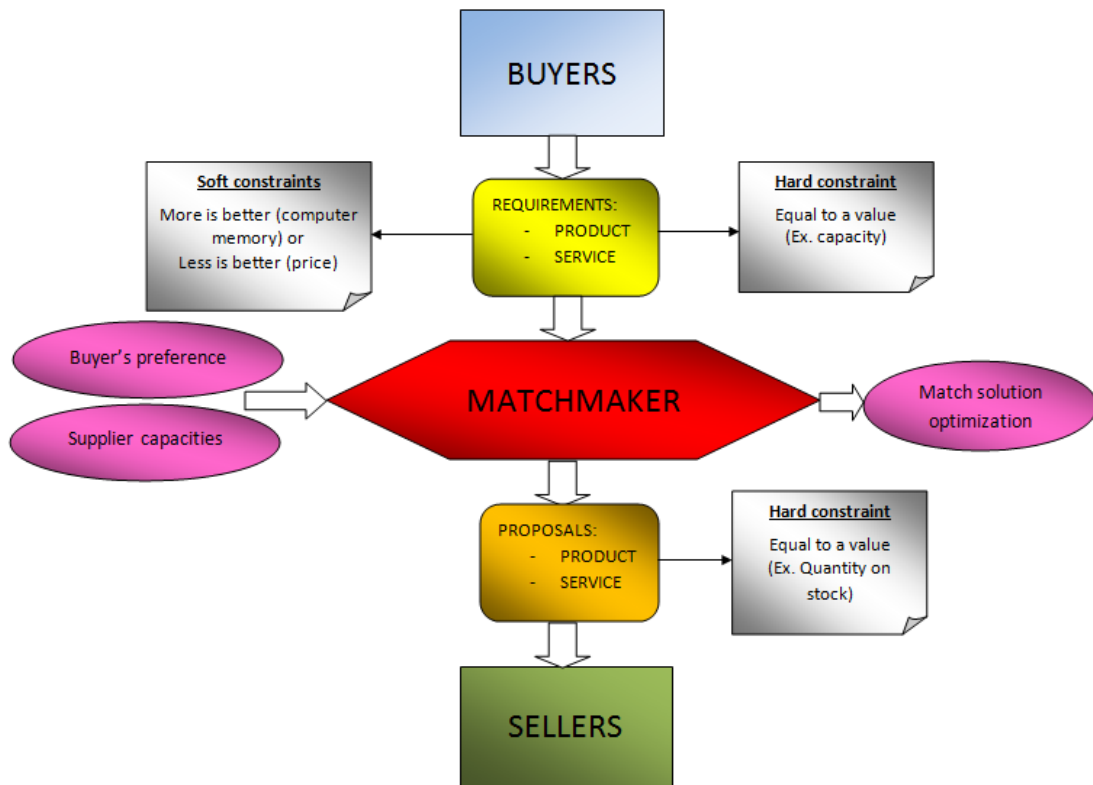


Fig. 1. The conceptual framework of a matchmaker for B2B e-marketplaces

### 3.3 Matchmaker

The matchmaker first important function is to find matches between buyer requirements and seller proposals which meet buyer preferences and supplier capacities. The second function of the matchmaker is to find the most profitable trade for the buyer and seller from the feasible solution find on the first step. There can be in case of many-to-many relationships three eligible matching

situation: ❶ one buyer demand matches one seller supply, ❷ several buyers demand matches one seller supply, ❸ and one buyer demand matches several seller supplies. We consider that our matching problem is a multi-objective combinatorial optimization problem. This problem can be solved using a 4 step process: *Analysis, Modeling, Implementation, and Optimization.*



Fig. 2. Matchmaker working process

#### 3.3.1 Analysis

In this step matchmaker identifies the attributes of buyers' requirements and sellers' proposals, and then display all the feasible matches according to hard constraints. We proposed the bipartite graph matching method for extracting the feasible matches between buyers' requirements and sellers' proposals. According to Wikipedia bipartite graph is a "graph whose vertices can

be divided into disjoint sets U and V such every edge connects a vertex in U to one in V; that is U and V are independent sets. A bipartite graph is a graph that does not contain any odd-length cycles." Bipartite graphs can be used for matching problem. An example given by Wikipedia is the job matching problem. "Suppose we have a set P of people and a set J of jobs, and not all

people is suitable for all jobs. We can model this as a bipartite graph (P,J,E). If a person  $p_x$  is suitable for a certain job  $j_y$  there is an edge between  $p_x$  and  $j_y$  in the graph."

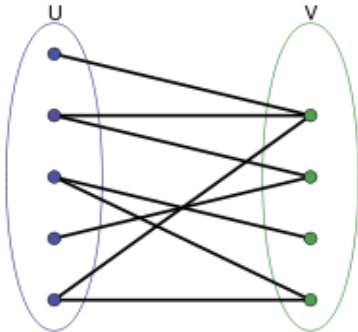


Fig. 3. Example of bipartite graph [14]

Bipartite graph allows perfect matching (Figure 3).

### 3.3.2 Modeling

In this step the matchmaker have to construct a satisfaction function for both the buyer and for the seller and have to establish a mathematical model. The matchmaker has to calculate the buyer's satisfaction and the seller's satisfaction for trading a specific good. On buyers satisfaction function calculation we have to consider the importance (weight) of the attributes, and in case of attributes with soft constrains we have to calculate the better value using a suitable function. On sellers satisfaction function calculation we have to take in consideration the bid of the buyer and the quotation of the supplier.

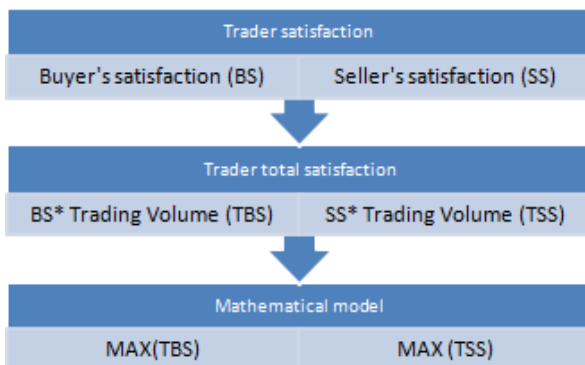


Fig. 4. Creating the mathematical model of matchmaking

The matchmaker must calculate the total

satisfaction of the buyers and sellers by multiplying their satisfaction value with the trading volume. The buyer's and seller's total satisfaction must be calculated for every match solution.

The mathematical model established will be the matching solution that maximizes both the total satisfaction of the buyer and of the seller regarded to their goals. The match with maximum buyer and seller total satisfaction is the best solution for the trading parts. The model is taking into account the trading quantity and the satisfaction of the buyers and sellers.

### 3.3.3 Implementation

We propose the use of a priority based multi-objective genetic algorithm for the implementation of the functionalities of the matchmaker. With multi-objective optimization algorithm we can resolve almost every important real world decision problem which involves multiple and conflicting objectives, which need to be tackled while respecting various constraints. The genetic algorithm realizes a stochastic search based on the mechanism of natural selection and natural genetics.

Multi-objective genetic algorithm starts with an initial set of random solutions called population satisfying boundary and system constraint of the problem. The next population comes from execute crossover and mutation operation for pre-population. Population-to-population approach is hopeful to explore all feasible solutions. The feature for the multi-objective GA is the multiple direction and global search by maintaining a population of potential solution from generation.

It is important to take in consideration the priority sequence of the buyers, because if the first buyer purchases all the supplier stock, the second buyer must accept the second most profitable proposal. Priority sequence of buyers and priority sequence of supplier are necessary to take in consideration when is calculate the trading quantity.

A detailed description of using GA for

solving multi-objective decision problem we can find in the paper entitled “Multi-objective optimization using genetic algorithms: A tutorial” [1].

### 3.3.4 Optimization

The matchmaker using priority based multi-objective GA finds multiple feasible solution. Our focus is to find the optimal solution from buyer and seller perspective. Because there are multiple objectives which are mutually conflicting on the same time, usually no single solution is optimum.

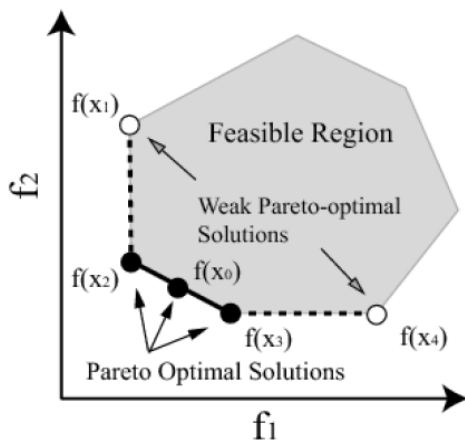


Fig. 5. Pareto optimal solution set [13]

In this situation we have to make compromise and choose the solution which makes an objective function to be optimal and other all objective functions are close to the true optimal solution functions as much as possible. These set which include multiple optimal solutions is known as Pareto optimal solution set. The optimal solutions are situated on the Pareto front.

The multi-objective genetic algorithm is not perfect but can find a very reasonable approximation to the Pareto front. A conceptual model of two objective Pareto optimal solutions set is shown in Figure 5.

## 4 Conclusions

In this article we have presented a conceptual framework of a matchmaker for B2B e-marketplaces. We have detailed the method to describe the buyer's good requirements and seller's good proposals using attributes having soft and hard constraints. We

presented also the matchmaker two important function: finding the feasible matching solution and determine the most profitable solutions from feasible ones. We proposed a four step process together with the proposed methods for every step for solving the matching problem: by **analyze** the requirements and proposals and create matches using the bipartite graph matching method; by **modeling** the matches (constructing buyer and seller satisfaction function and then the mathematical model), and by **implementation** and **optimization** of the matches using multi-objective genetic algorithm and finding the Pareto optimal solution set from feasible solutions.

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