Quotes: a negotiation tool for industrial e-procurement

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Abstract

The sourcing process of multiple goods or services usually involves complex negotiation (via telephone, fax, etc) that includes discussion of product features as well as quality, service and availability issues. Currently, this is a high-cost process due to the scarce use of tools that streamline this communication and assist purchasing managers' decision-making. With the advent of internet-based technologies, it becomes feasible the idea of an affordable tool that enables to maintain an assisted, fluid, on-line dialog at virtually no cost and wherever your providers are. Consequently, several commercial systems to support on-line negotiations become available. However there is still a need that these systems incorporate effective decision support techniques. This article presents *Quotes* as iSOCO's e-solution for strategic sourcing that incorporates Artificial Intelligence (AI) based techniques that successfully address previous limitations within a single and coherent framework

Keywords: B2B applications, e-procurement, sourcing, artificial intelligence.

1. INTRODUCTION

Traditionally, the sourcing process comprises the following tasks: Request for Quotation (RFQ) elaboration, provider selection for RFQ delivery; best candidate offer analysis, negotiation through offer-counteroffer interaction, and selection of best offers.

Recently, several commercial systems to support on-line negotiations have become available. However, to the best of our knowledge not a single system can claim to address the full complexity of on-line negotiations. Most of them merely incorporate single-item, price-quantity reverse auctions mechanisms. Others only offer basic negotiation capabilities that are usually reduced to a demand-offer matching tool. In general terms, there is a lack of decision support functionalities (Decision making in sourcing can involve a few hundred offerings each of which is described by several dozen attributes). Finally, there is a lack of technology support for computationally complex negotiation paradigms, which inhibit the application of interesting models such as combinatorial reverse auctions [8].
This article presents *Quotes* [9][10][11] as iSOCO's e-solution for strategic sourcing that we believe satisfactorily address previous limitations within a single and coherent framework.

From the point of view of decision support, we have identified 3 processes where to apply Artificial Intelligence (AI) techniques that helps the user in the decision making process. These 3 processes has been studied and implemented in *Quotes* with satisfactory results. Summarized below are the main ideas of all three.

1. Computation of the optimal bid set for combinatorial auctions. Given a set of offers for a multi-item RFQ, an AI search algorithm obtains the subsets of offers that optimizes a given criteria such as: minimization of price, start/finish date, maximization of product quality, etc. iSOCO applies leading edge algorithms that compete with the current state-of-the art techniques being studied in academia.

2. Multi-parameter scoring algorithm. Based on the importance that the buyer gives to each parameter of an item in a RFQ (price, quality, delivery time) and his flexibility to accept offers beyond his preferences, a *fuzzy* offer-matching algorithm scores each offer and ranks it accordingly. This helps the user to easily identify both interesting offers as well as non-competing ones. By defining a reserve score, users can tell the system to automatically reject offers that are clearly a bad choice.

3. Automatic offer submission. Providers can translate their business knowledge into *bidding* rules that allow the instantaneous and automatic construction of indicative offers. A typical rule looks like this: *"if requested_ material = X and requested_start_datet [Y..W] days then give a price_per_meter of $Z."*. A random neighborhood search algorithm controlled by a rule based system reasons with these rules in order to construct an initial offer that maximizes both buyer and provider

preferences, thus rapidly conduct negotiations to *win-win* situations.

The article is organized in three sections: section 2 describes how RFQs are created. Section 3 introduces the seller side by summarizing the steps in defining product profiles. Finally, section 4 outlines the negotiation stages.

2. CREATING AN RFQ

Quotes supports multi-attribute, multi-line RFQs, enabling the creation of multiple types of RFQs (commodity, catalogue, BOM or group by). Furthermore it provides the expressiveness needed to cope with multi-criteria negotiation procedures.
A typical buyer creates an RFQ by sequentially adding lines. Each line specifies a product, be it either a good or service. Figure 1 shows an ***RFQ*** composed of several lines, a so-called multi-line RFQ.

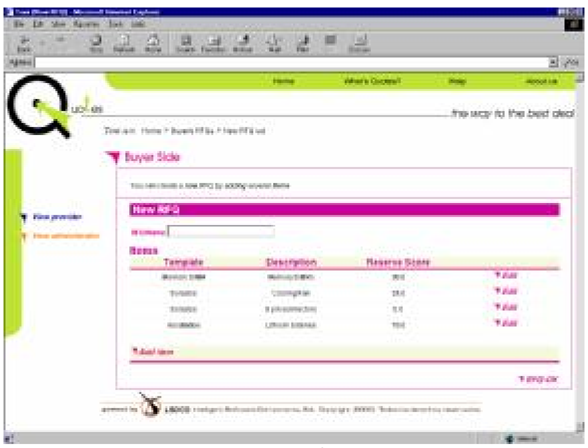

Figure 1: Example of a multi-line RFQ

The process for including an item (line) is summarized as follows:

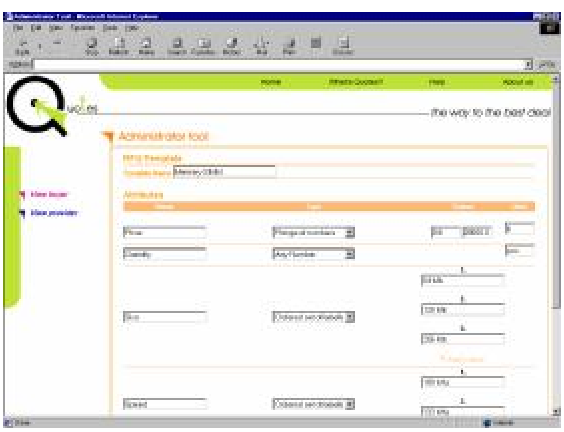

Figure 2: A product template definition

- Some buyer selects a product from a list of product templates. Product templates are previously created and consist of a list of attributes. Each attribute makes reference to a physical characteristic or negotiable condition or term. Each of these attributes is defined in terms of a data type (number, range, set of labels, etc.) and its domain. Figure 2 shows a typical product template.

- Once a product template is selected, the buyer specifies desired values for each attribute. He can do it so by either defining a single value or a range of values. He can also express his preferences among possible values within a set. A typical example will be to express that we will accept any value for attribute ***quality*** that is at least ***standard*** and specify that the more quality, the better. Figure 3 shows this interface.

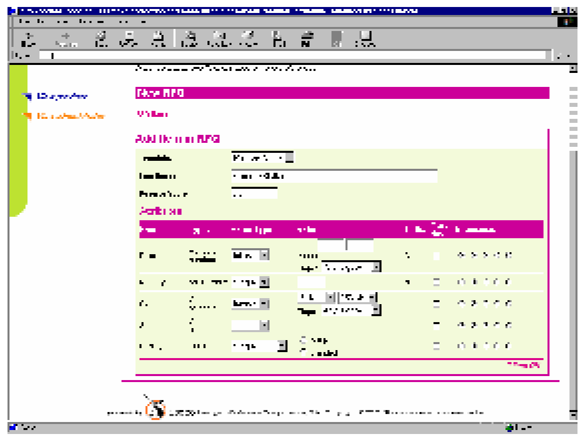

Figure 3: RFQ Specification

- The buyer has also the choice to express the importance that each attribute is expected to have during the selection phase and the negotiation process. Basically, he assigns a value ranging from ***don't care*** to ***extremely important***. ***Additionally***, if it is compulsory that offers satisfy the requested values, the user must then tick the ***must-have*** checkbox. The way Quotes exploits preferences and importance values is latter explained.

- Finally, the buyer assigns a reserve score, a threshold value. Thus offers whose percent of matching with the RFQ fall below the reserve score are filtered out. That is, depending on the matching score value, Quotes automatically rejects offers that unsatisfactorily match buyers' requirements.

2. DECLARING PRODUCT PROFILES

2.1 CAPABILITIES & PREFERENCES.

While buyers need to specify what their product requirements are in terms of negotiable attributes, sellers can do the same regarding their product capabilities and their proposals preferences.

Usually, a seller would declare the list of goods or services he is able to provide, the so-called production profiles. Figure 4 shows a production profile for the product described in the template shown in Figure 2.

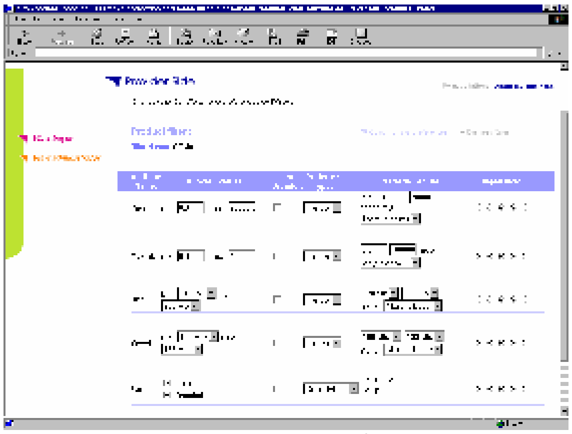

Figure 4: Production profile example

As discussed above, Quotes describes a product in terms of its negotiable attributes. Consequently, three concepts need to be specified for each attribute: the provider production capabilities, his selling preferences and, once again, a measure of importance. The production capabilities determine which product demands the provider can actually accept. For example, suppose that some provider needs a minimum of 5 days to deliver the goods or that he can only provide a maximum cable thickness. Selling preferences allow a provider to state which requests he may favor. He might be interested in quickly identify requests for large volumes or for a specific product model, while being less interested in offers for discontinued products.

2.2 BUSINESS RULES AND BIDDING RULES.

Beyond declaring attribute capabilities and preferences, Quotes allows the seller to declare his business rules in the form of bidding rules.

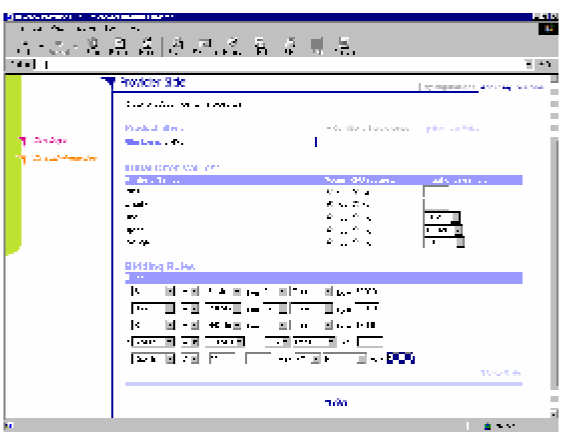

Figure 5: Bidding rule examples

A bidding rule is an ***if-then*** rule that checks and changes the value of one or several attributes. Examples of rules include discount per volume, additional charges for express delivery, no delivery charge when a minimum price is offered, etc. Figure 5 shows these examples.

3. NEGOTIATION STAGES.

This section aims to describe the main processes that occur when a newly created RFQ is launched into *Quotes.* Figure 6 shows the main stages. After some buyer submits an RFQ, potential suppliers are automatically identified and conveyed the RFQ. On the suppliers' side, offers are automatically built as responses to received RFQs. Thereafter, the buyer can conduct simultaneous one-to-one negotiations as part of the one-to-many negotiation process. This negotiation phase may end with success (that is, the buyer accepts an offer) or may be used as an initial selection of providers that are invited to participate in a reverse auction.

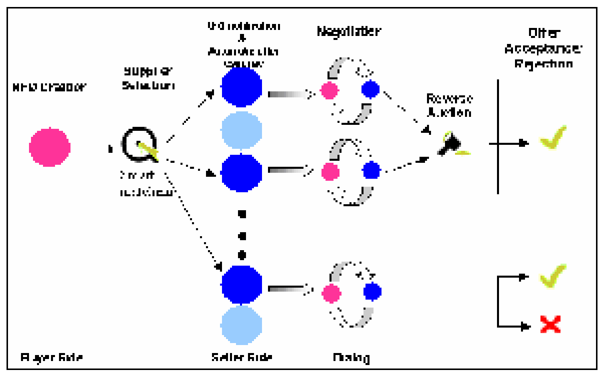

Figure 6: Quotes' e-sourcing process description

3.1 SUPPLIER SELECTION: SMART-MATCHING ALGORITHM.

Supplier selection consists of two filtering steps. It has been already described how buyers and providers have interfaces that allow them to describe their necessities and capabilities based on common product templates. Therefore, the first filtering process is a straightforward approach that just requires to identify those sellers that provide products specified with the same template than the product the buyer is requesting.

For every identified seller producing the required product, the second filtering process focuses on attribute values. Internally, this common language provided by templates allows to match values over the same domain. It has been already explained that when a buyer specifies its requirements by assigning values to each attribute in a template, these values can be single values, sets of values or intervals. Those values are then internally fuzzified by generating associated fuzzy functions. Those fuzzy values are afterwards matched with the values described by the providers and, if the resulting membership degree is not null for any attribute, then the corresponding provider will receive the RFQ from the buyer.

3.2 AUTOMATIC SUPPLIER RESPONSE: OPTIMAL GENERATION OF INDICATIVE OFFERS.

Once potential suppliers have been identified, an optimisation search algorithm is executed for each of these providers taking the received RFQ as input, the product profile and its related bidding rules. The objective of the algorithm is to build a complete offer (where all attributes have been given a value), however, the algorithm pursues to build the *best* offer in terms of either buyer preferences or provider's or both.

The algorithm implements an optimisation search in the space of offers defined by the product capabilities and the bidding rules. It starts by taking into consideration the buyer request to build an initial, tentative offer and from here, a random neighborhood search explores whether changing an attribute's value results in an alternate offer that is better scored or not (scoring is presented in section 4.4.1). When a change in the attribute' value is performed, a rule engine runs to determine if such a change causes the application of any bidding rules. For example, offering a better quality increases the buyer satisfaction but also results in a price increase. When the finishing condition is reached the algorithm stops and the offer (if one has been founded) is returned.

If the algorithm manages to produce an offer, it is automatically sent to the buyer as an indicative offer.

3.3 NEGOTIATION PHASE.

So far potential suppliers have been notified and even some of them have already submitted automatically-generated, indicative offers. The process now enters into a negotiation phase. Negotiation is conducted through multiple structured dialogs that are performed in parallel. Each dialog is established between the buyer and a single provider and it is ruled by a negotiation protocol. Buyer actions can be: offer acceptance, offer rejection, counter-offer submission, and request for firm. Seller actions are limited to the submission of both firm and indicative offers.

The following is an example that illustrates a typical negotiation.

1. The buyer submits an RFQ asking for *service1* and *service2*.
2. *Quotes* identifies a potential provider and automatically constructs two indicative offers on his behalf: *offer1* for *service1* and *offer2* for *service2*.
3. The buyer evaluates *offer1* and submits a counter-offer asking for lowering the price.
4. The provider responds with an extension of offer1 so that it also includes an offer over service2. In other words, he is accepting a price reduction provided the buyer buys him both *service1* and *service2*.
5. The buyer evaluates the modified *offer1,* agrees with it and requests a firm offer.
6. The provider responds with a firm offer.
7. The buyer accepts the offer, closing the negotiation with success.

Notice that this is just a one-to-one dialog between the buyer and a single provider among all potential suppliers that are competing to gain the RFQ. Moreover, the dialog is related to a specific offer for this provider. *Quotes* enables that multiple dialogs take place in parallel both with different providers and for different offers of a same provider.

3.4 DECISION SUPPORT MODULES.

Quotes provides with the necessary tools to help users manage the complex sourcing mechanisms involved in multi-line, multi-attribute RFQs.

3.4.1 Fuzzy matching scoring function.

Quotes provides both buyers and providers with a fuzzy matching module that allow them to score negotiation messages they receive based on their own preferences. In this manner, a buyer can order incoming offers from different suppliers in the same way that a provider can order incoming RFQs and counteroffers from different buyers. This is specially useful when dealing with many messages because the more interesting is a message the earlier it should be identified and answered. And the sense of interest is extracted from the preferences both buyers and providers specify.

Most commercial bid selection tools are based on Multi attribute utility theory (MAUT) [2]. We extend these techniques by incorporating *fuzzy* functions (see [4] for reference).

The fuzzy matching module that internally represents attribute values as fuzzy functions, and the scoring is computed by defuzzyfying the combination of pairs of functions that correspond to each attribute. These crisp values are then weighted with the importance of each attribute so that the scoring for a product is obtained. Finally, all products in a message are aggregated to end up with a total scoring value.

3.4.2. Combinatorial reverse auction solver.

Allowing providers to bid on combinations of products of an *RFQ* has the interesting feature of enhancing economic/service efficiency (suppliers would offer price discounts or/and better service if they obtain all the business) [5]. However, the determination of an optimal winner combination is a complex problem which, excluding very small instances, can not be solved manually with common data analysis tools. This has recently attracted some research [1][6]. *Quotes* provides with an optimization module to cope with this situation. The core of this module is a Branch & Bound [3] systematic global search algorithm. The buyer decides the target attribute (overall score, price, quality, etc) and the optimization criterion (minimize/maximize); *Quotes* returns a collection of offers which, in case of being accepted, would optimize the desired target.

3.5 AUCTIONS

Eventually buyers may prefer to employ the negotiation phase to better qualify providers. Through offer and counter-offer dialog rounds, a buyer can finally identify a set of suppliers who are able to approximately provide the requested product'sfeatures .At this point, the buyer may opt for launching a multi-attribute combinatorial reverse auction with the objective of lowering the price while increasing quality of service. Only selected providers will be invited to participate in a buyer-customised auction event . For this purpose, auctions in Quotes include several parameters[7]:

- When to clear the auction (by buyer, when a specific time is reached, no bids have been received for a specified time).
- Tie-breaking rule (random, older bid overrides, newer bid overrides).
- What information is revealed to bidders during bidding concerning contenders' identities (none, nickname, full identity).
- What information is revealed to bidders during bidding (highest bid, all bids, none).
- Whether or not bid retraction is allowed before winners are determined.
- Whether or not bid retraction is allowed after winners are determined.
- Maximum number of auction extensions and time per extension

Quotes' combinatorial reverse auctions allow providers to directly bid for bundles of items. They are convenient for providers that have non-additive values for bundles of items. Furthermore, they allow buyers to express complementarities over the requested items to avoid the risk of obtaining incomplete bundles. Notice also that providers are allowed to place multiple bids for bundles of items.

4. CONCLUSIONS.

The sourcing process can be highly automated, allowing you to achieve enormous benefits: cost savings, processing time reduction, less time-to-market and more time left to strategy.
This article has presented *Quotes* as an internet-enabled sourcing solution capable of streamline the sourcing process. Quotes main strengths can be summarized as follows:

- *Quotes* allows goods and services to be represented and managed with all their attributes, overcoming rigid and unreal price-discovering approaches.
- *Quotes* provides a powerful negotiation scenario based on structured negotiation protocols and flexible reverse auctions.
- *Quotes* provides with the necessary tools to help users manage the complex sourcing mechanisms involved in multi-line, multi-attribute RFQ.

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Intelligent Software Components, iSOCO, is a Spanish company founded in 1999 by a group of researchers of the Artificial Intelligence Research Institute (IIIA) of the Spanish Scientific Research Council (CSIC) located at the Campus of the Autonomous University of Barcelona (UAB). iSOCO provides e-commerce solutions, powered by the use of artificial intelligence techniques, and combining the cutting-edge technologies of knowledge engineering and component-based development.