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Embedding Decision Support in E-Sourcing Tools: Quotes, A Case Study

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Abstract

In the everyday business world, the sourcing process of multiple goods and services usually involves complex negotiations that include discussion of product and service features. Currently, this is a high-cost process due to the scarce use of tools that streamline negotiations and assist purchasing managers' and providers' decision-making. With the advent of Internet-based technologies, it became feasible the idea of tools enabling low-cost, assisted, fluid, on-line dialogs between buyer enterprises and their providers located anywhere. This article presents *Quotes*, an iSOCO's commercial application that, in addition to cover the whole sequence of sourcing tasks, incorporates decision support facilities based on Artificial Intelligence (AI) techniques that successfully address highly challenging issues in automated negotiation within a single and coherent framework.

Key words: artificial intelligence, B2B applications, e-procurement, e-sourcing, e-negotiation

1. Introduction

A strategic sourcing event can be defined as the sequence of actions to be performed in order to acquire goods or services that are of strategic importance to a company. One of the most important parts of a sourcing event is the negotiation phase, were prices, product configuration and service conditions specified by some buyer in a Request For Quotation (RFQ) are negotiated until the best possible agreement is reached. Recently, the application of on-line auction mechanisms as a way to resolve the negotiation-phase has attracted numerous companies as they have been able to achieve enormous benefits.

In fact, several commercial systems to support on-line negotiations and auctions have become available. However, to the best of our knowledge not a single system can claim to address the full complexity of the negotiation phase. Most of them merely incorporate single-item, price-quantity reverse auction mechanisms with limited multi-stage capabilities, but do not support traditional negotiation procedures which are of interest and common practice. Others only offer basic negotiation capabilities that are usually reduced to a demand-offer matching tool. In general terms, on the one hand, there is a lack of decision support functionalities that help handle negotiations involving hundreds of offerings, each one described by multiple attributes. In particular, there a lack of support for computationally complex negotiation paradigms, which inhibits the application of interesting

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models such as multi-item (combinatorial) auctions (Vries and Vohra 2001). On the other hand, there is a lack of support for conducting multi-stage negotiations.

Focusing on decision support, we have identified three processes where to apply Artificial Intelligence (AI) techniques: (1) Winner determination in multi-item (combinatorial) negotiations; (2) Multi-attribute scoring of offers/RFQs. (3) Automatic creation and submission of optimal offers.

This article presents *Quotes* (Reyes-Moro *et al.* 2001 a,b,c) as iSOCO's e-solution for strategic sourcing that we believe satisfactorily address previous limitations within a single and coherent framework.

2. Sourcing Event Set-Up

A sourcing event encompasses from the identification of some buyer's needs to the close of a deal via negotiation. Prior to the negotiation phase, the buyer specifies his requirements about the goods to be acquired in the so called Request for Quotation (RFQ). An RFQ contains the needs and preferences over the features (attributes) of products and services as well as the negotiation protocol (be it auction-based or not) to be used to negotiate for the RFQ.

Quotes supports multi-attribute, multi-item, multi-lot RFQ, enabling the creation of multiple RFQ types (commodity, catalogue, BOM[1] or group by) that may evolve through different negotiation stages (through the interleaving of auctions and/or offer/counteroffer negotiations). Furthermore, it provides the expressiveness needed to cope with multi-criteria negotiation procedures, thus overcoming rigid and unreal price-discovering approaches.

A typical buyer creates an RFQ by sequentially adding items. Each item accounts for a good, be it either a product or service, whose definition is based on a template. Templates are previously created by specifying a list of attributes that stand for both goods' characteristics and contract terms. Each attribute is defined by specifying its type (number, range, set of labels, etc.) and possible values. Therefore, in order to add an item to an RFQ, the buyer selects a template and specifies the desired values for each attribute along with its preferences and importance. Additionally, he can decide whether to reveal his preferences to providers and whether to force offers to satisfy requested values. Finally, the buyer assigns a reserve score to be used for filtering out providers' offers not matching enough with the buyers' requirements. Figure 1 shows item definition interface.

3. Sourcing Stages

This section aims to describe the main processes that occur when a newly created RFQ is launched into *Quotes.* Figure 2 shows a sample of a typical sourcing event containing some negotiation stages. After some buyer submits an RFQ, potential providers are automatically identified (on the basis on their production/service capabilities and preferences) as RFQ recipients. On the providers' side, offers may be either automatically or manually built as responses to received RFQs. Thereafter, the buyer can conduct simultaneous one-to-one

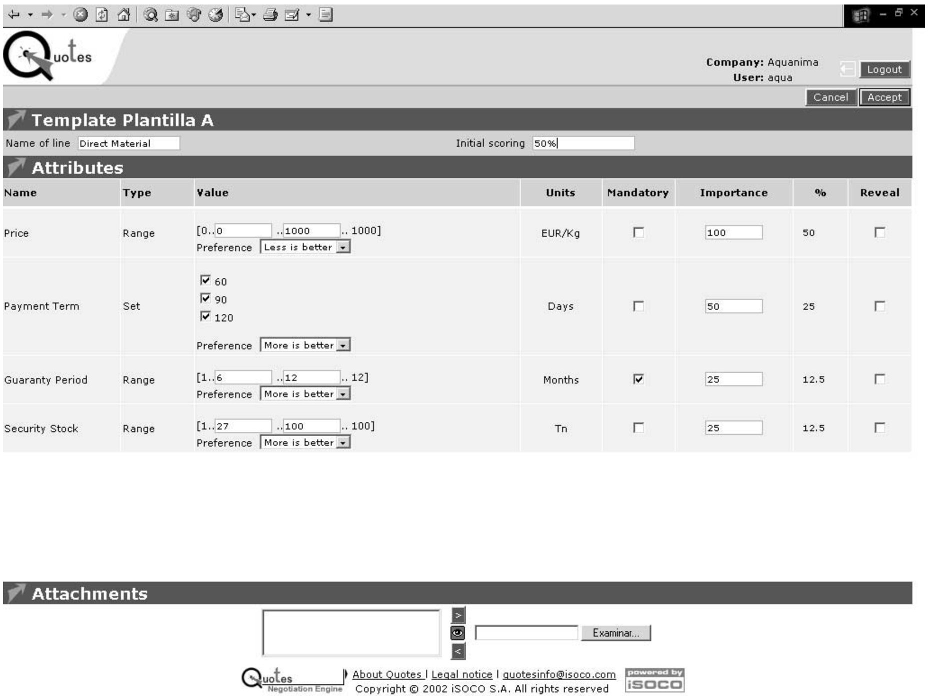

Figure 1. RFQ item creation interface.

negotiations as part of a 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. In the most general case, Quotes allows for the interleaving of different types of sourcing stages.

3.1. Provider selection: smart-matching algorithm

Providers specify their production capabilities and selling preferences using the templates of the goods they aim at providing. Whereas capabilities determine which demands the provider can actually accept, selling preferences allow a provider to state which RFQs he may prioritise. For example, some provider might be more interested in quickly identifying either RFQs for large volumes or for a specific product model than in those for discontinued products.

Consequently, provider selection consists of two filtering steps. While the first filtering step aims at the identification of providers servicing goods based on the very same template specified by the buyer; the second filtering step focuses on attribute values and preferences given by both the buyer and potential providers. Attribute values are internally fuzzified by generating associated fuzzy functions so that fuzzy preference values can be

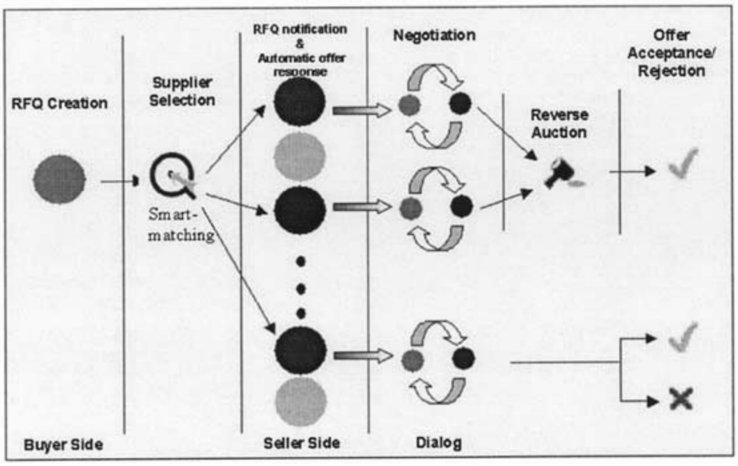

Figure 2. A sample of Quotes' e-sourcing event.

subsequently matched to the providers' capabilities. A provider receives an RFQ whenever all its attribute values match up to some degree to his capabilities.

3.2. Provider response: automatic generation of offers

Beyond declaring attribute capabilities and preferences, Quotes allows providers to declare their business rules in the form of bidding rules that automate the generation of offers. A typical rule looks like this: "*if requested_ material = X and requested_start_date ∈ [Y..W] days then offer a price_per_meter of $Z*". Business rules allow to capture both common and particular offering behaviours such as: discount per volume, additional charges for express delivery, no delivery charge when a minimum price is offered, etc.

The automatic generation of offers is run by an algorithm that implements an optimisation search in the space of offers defined by product capabilities and the corresponding bidding rules. It starts by taking into consideration the buyer RFQ to build an initial offer for which a random neighbourhood search explores whether changing an attribute's value results in an alternative offer that better matches the RFQ or not. 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 any is found) is returned and automatically sent to the buyer as an indicative offer.

3.3. Negotiation stage

So far potential providers have been notified and even some of them have already submitted automatically-generated, indicative offers while others have manually submitted theirs.

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. Notice though that *Quotes* also allows the buyer and each provider to hold multiple dialogs corresponding to different offers. Buyer actions can be: offer acceptance, offer rejection, counter-offer submission, and request for firm offer. Provider actions are limited to the submission of either firm or indicative offers.

The following is an example that illustrates a typical negotiation:

1. A buyer submits an RFQ for *service1* and *service2.*
2. *Quotes* identifies one 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 extending offer1 to include an offer for service2. In other words, he is accepting a price reduction provided the buyer acquires both *service1* and *service2* from him.
5. The buyer evaluates the modified *offer1,* agrees with it and requests a firm offer.
6. The provider responds making his offer firm.
7. The buyer accepts the offer, closing the negotiation with success.

Notice that the example above corresponds to a one-to-one dialog between the buyer and a single provider out of all potential providers that are competing to have the RFQ awarded.

Finally, Quotes implements a full combinatorial reverse auction engine to conduct negotiations in an auction-like manner. Figure 3 shows how to configure the engine based on typical auction parameters (Sandholm 2000). The buyer can opt for either multi-attribute or price only auctions as well as for single-line / multi-line auctions. Items in multi-line auctions can be arranged in closed lots, allowing combinatorial bidding on bundles of lots/lines.

3.4. Decision support modules

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 (RFQs and offers) they receive based on their own preferences. In this manner, a buyer can order incoming offers from different providers in the same way that a provider can order incoming RFQs from different buyers. This is specially useful when dealing with a large number of messages because the more interesting a message the earlier it should be identified and answered. And the sense of interest is extracted from buyers' and providers' preferences.

Most commercial offer selection tools are based on simple implementations of Multi attribute utility theory (MAUT, Keeny and Raiffa 1993). We extend these techniques by incorporating *fuzzy* functions in the RFQ-offer matching module (see Ribeiro 1996). We do it by first representing as fuzzy functions both requested and offered attribute values. Secondly, this pair of fuzzy functions are combined and defuzzyfied (that is, computing the supremum of their intersection) in order to obtain a scoring of the matching at attribute

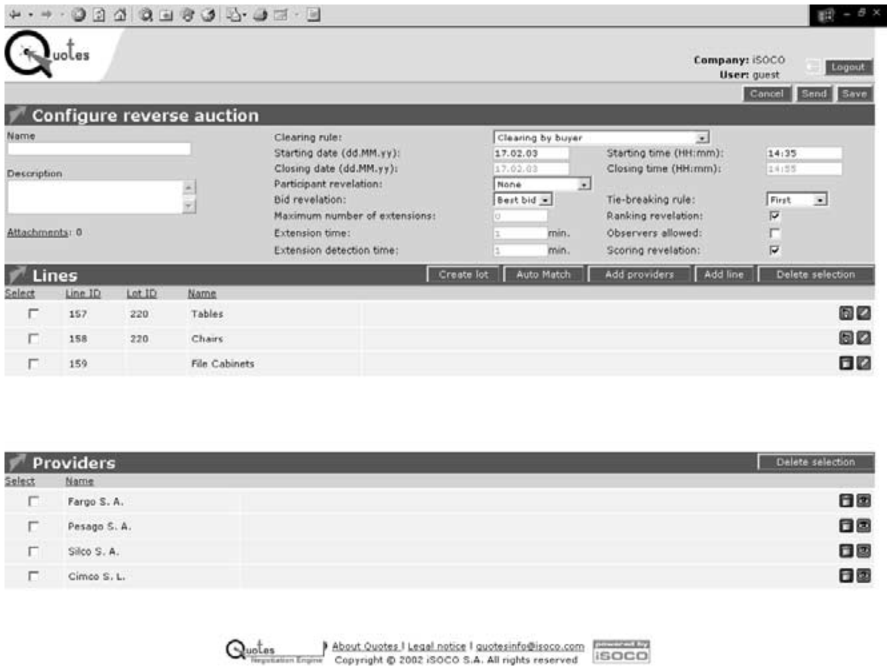

Figure 3. RFQ configuration as a Reverse Auction.

level. These crisp values are then weighted with the importance of each attribute so that the scoring for an item is obtained. Finally, all items in a message are aggregated to end up with a total scoring value.

Since the work by Baas and Kwakernaak (1977) fuzzy functions have been mostly applied as triangular fuzzy numbers representing preferences. On the other hand, preferences over continuous attributes can be modelled by linear functions in the [0, 1] interval. We go further in three aspects: we parametrize fuzzy functions' support (positive values), we model interval preferences with trapezoidal fuzzy functions, and we allow values in the central part of the trapezoid to increase or decrease linearly. And all three extensions are determined based on users' preferences.

3.4.2. Winner determination in multi-item (combinatorial) negotiations

Multi-item sourcing events which allow providers to bid on combinations of items have the interesting feature of enhancing economic/service efficiency (Rothkopt, Pekec, and Harstad 1995). Combinatorial offering (as opposed to single offering) is more suitable in scenarios where not all providers can provide all requested items, and where providers have non-additive values for bundles of items. Additionally, they allow providers to express complementarities over the requested items to avoid the risk of obtaining incomplete bundles.

However, winner determination in multi-item (combinatorial) negotiations is a complex problem which, excluding very small instances, can not be solved manually with common data analysis tools (Fujishima *et al*. 1999, Sandholm 1999). *Quotes* provides an optimisation module to assess the winner(s) in such complex scenarios. The core of this module is a Branch & Bound (Korf 1998) systematic global search algorithm. The buyer decides the target attribute (for instance, overall score, price, quality, etc.), and the optimisation criterion (minimise/maximise); *Quotes* returns a collection of offers which, in case of being accepted, would optimise the desired target.

4. Conclusions and Results

This article has presented *Quotes* as an Internet-enabled sourcing solution capable of streamlining the sourcing process. Quotes is a powerful e-negotiation engine based on structured multi-attribute, multi-item negotiation protocols. Moreover it incorporates a set of AI-based decision support modules that assists both buyers and providers in the decision making process.

ISOCO Quotes has been successfully applied to several real-life negotiation scenarios of varying complexity (from single line to multi-line, multi-attribute) and economic value (few thousand • to frame contracts of several million •). Next we summarize the most remarkable outcomes.

- Actual buyers encountered Quotes scoring mechanism as a simple, intuitive, and powerful way to quickly differentiate good from bad offers. However, when making final decisions or comparing similar offers they often obviated the scoring values provided by Quotes and fine-analysed offers by means of other evaluation functions. iSOCO is currently trying to incorporate alternative scoring functions that cope with the full needs of sourcing professionals along with preference elicitation mechanisms (although this issue remains the Achilles tendon of sourcing applications).

- A common agreement was the convenience of modelling off-line negotiation processes in a natural way, without introducing inefficiencies and frictions derived from changing the “rules of the game” (that is, for example, substituting the off-line negotiation processes by on-line auctions or using negotiation artefacts that do not model previous processes). Furthermore, providers appreciated the transparency introduced by the tool (since all participants actions can be audited).
- Buyers belief is that combinatorial offering introduces high complexity for providers to bid and to understand auction dynamics. Consequently, Quotes’ combinatorial capabilities have been solely applied to small set of actual-world scenarios where the buyer predefines valid item combinations on which providers can bid.
- The possibility of automatic offer submission is seen with interest for repetitive sourcing events in private e-sourcing platforms where providers and business rules are well known or belong to a provider qualification procedure or a frame contract. Nonetheless, the full application of such automatisms faces cultural barriers such as providers being not so

keen on revealing capabilities/preferences to third parties; perception of e-sourcing tools as a hazard for sourcing professionals, etc.

- Leading users suggested additional auction rules that best suited their necessities. For example, a buyer forced Quotes to incorporate a bidding rule that resulted in an increase of the number of participants in an auction event. This rule allowed inactive bidders to send their first bid without overbidding the best bid.

Finally, the results obtained in terms of economic outcome were no different than the promises made by e-sourcing analysts. Negotiation time was reduced from weeks to days, mostly due to the elimination of communication synchronism (telephone, fax) and administrative tasks. Price and condition benefits were also obtained. Obviously, price savings were more noticeable in auctions (13.6% in average), but on-line negotiation also achieved price/service reduction below target, a result that increased buyer's satisfaction with the tool.

Notes

1. BOM: Bill of Material.

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