RC 22049 (98950) 30 April 2001 Computer Science

IBM Research Report

ABSolute: An Intelligent Decision Making Framework for E-Sourcing

Martin Bichler, Juhnyoung Lee, Ho Soo Lee, Jen-Yao Chung
IBM Research Division
Thomas J. Watson Research Center
P.O. Box 218
Yorktown Heights, NY 10598

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Martin Bichler, Juhnyoung Lee, Ho Soo Lee, Jen-Yao Chung
IBM T.J. Watson Research Center
P. 0. Box 218, Yorktown Heights, NY 10598
{bichler, jyl, leehs, jychung}@us.ibm.com

Abstract

Efficient selection of bids and product offerings is a key requirement in today's procurement processes. Purchasing managers have to make comprehensible selections among hundreds of alternatives considering several dozens of criteria. Selection problems like this are challenging, because they require the balancing of multiple, often conflicting objectives. Traditional approaches to multi-attribute decision making (MADM) are often insufficient in situations with a large number of attributes and alternatives. ABSolute is an application framework for electronic sourcing. The core component of ABSolute is an intelligent decision analysis engine for electronic procurement, which is designedfor large amounts of alternatives and attributes. ABSolute enhances traditional approaches to decision making with advanced visualization capabilities and WORA, a new technique for weight assessment based on ordinal rankings of alternatives.

1. Introduction

Sourcing is a disciplined process that involves several steps organizations implement to efficiently purchase materials and services from suppliers. It addresses the critical decisions of what to buy, how much to buy, whom to buy from, and how to manage relationships with suppliers. The promise of this process is to reduce total acquisition costs, while improving the total value. Successful strategic sourcing requires a holistic process that automates the entire sourcing process, including order planning, RFQ creation, RFQ evaluation, bid creation, bid evaluation, negotiation, settlement, and order execution. An RFQ (Request-For-Quote) is submitted by a buyer to invite potential sellers to bid on specific products or services needed by the buyer. Figure 1 depicts the sourcing process as a cycle reflecting that it is a continuous process of analyzing expenditure flow, vendor performance, user requirements and market conditions to optimize the total value.

This sourcing process provides an interesting business domain, where intelligent decision analysis is indispensable. When evaluating and selecting suppliers' offers to an RFQ or bids in a multi-attribute auction [1], the buyer needs to take a number of different factors into account. For example, there may be factors related to the product specification such as price, material quality and properties, color and size. In addition, there may be factors related to the service specification such as delivery time and cost, and warranty. Furthermore, there may be supplier qualification factors such as trading history, experience and reputation. Note that often some factors are more important in making sourcing decisions than others.

It is important that decision makers should have *confidence* when making decisions on large size transactions. A decision analysis system should therefore be able to account for decisions it recommends (e.g., why certain suppliers won and others lost). Accountability is crucial particularly for business buyers such as sourcing professionals whose decisions always need to be justified in terms of savings in time and cost. To achieve this goal, it is important that the decision support system allows the users to navigate through the information space comprised of the given options, understand the properties of alternatives, compare their values, and inspect the recommendations. It should also be able to take into account complex business rules of organizations. For example, business rules of the B2B space include purchasing policies such as limiting the min/max number of winning suppliers to avoid dependency on too few suppliers. Finally, the decision analysis system should be able to help configure complex business entities such as RFQs and bids, and automate the creation of RFQs/bids.

In the following we will describe the decision analysis components of ABSolute, an application framework for electronic sourcing. Section 2 outlines existing approaches to bid selection and multi-attribute decision analysis, as well as their shortcomings. Based on this, we will introduce the core components of the ABSolute framework in section 3. Section 4 provides a brief description of the software architecture. Finally, section 5 concludes with a brief summary and potential application areas.

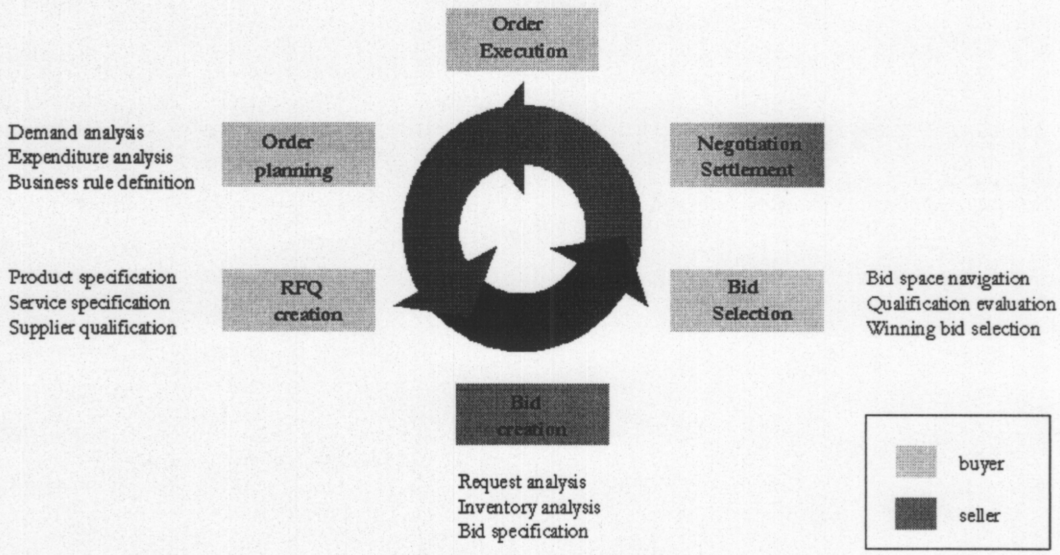

Figure 1: Sourcing Cycle

2. Traditional Approaches

Despite the imminent needs for strategic sourcing in organizations, only a little work has been done for sourcing decision support. There are only a few bid analysis products currently available from companies such as Emptoris (www.emptoris.com), Frictionless Commerce (www.frictionless.com), Perfect (www.perfect.com), and Rapt (www.rapt.com). All of these products depend on a single decision analysis method and are limited in their capabilities for supporting the decision-making processes.

Bid analysis products from Frictionless Commerce and Perfect use traditional decision analysis techniques, which have been actively studied in multi-attribute decision making (MADM), an area of operations research. The primary techniques in the field are Multi-Attribute Utility Theory (MAUT) [2], Simple Multi-Attribute Rating Technique (SMART) [3] and the Analytic Hierarchy Process (AHP) [4], all of them implemented in several software applications. The essence of all these widely used decision aids is breaking complicated decisions down into small pieces that can be dealt with individually and then recombined in an additive manner. The key difference is the way the scores on individual attributes and their weights are assessed.

Perfect and Frictionless Commerce are based on MAUT. They request a user to assign relative weights to individual attributes of alternatives (i.e., bids), and then use an additive value function in order to compute the scores of the alternatives (see section 3.2). The systems then rank the alternative bids by score, and the user selects the winning bids among the top-rankers.

A fundamental weakness of these packages is that they provide little guidance for weight assessment. Consequently, the resulting bid scores may not be reliable. When a user assigns weights to attributes for the first time, s/he might not understand their effect well. Assigning weights in the presence of several dozens of attributes is a difficult task and also traditional forms of weight elicitation such as pricing out or swing weighting which are traditionally used with MAUT do not work well in these cases [5].

Another approach used in commercial bid analysis products is optimization such as integer programming, and/or constraint programming. Bid analysis products from Emptoris and Rapt belong to this category. These products recommend a set of bids from multiple suppliers that optimizes one or more objectives, e.g., minimizing the total cost, set by the user. A drawback of this approach is that its capability for recommending a combination of bids is limited by its inability to express multiple objectives for optimization, which is necessary for the procurement of complex products. While this approach can be effective for simple objectives such as minimizing the total cost, it does not work well if the objectives involve complicated business rules over multiple attributes. Most importantly, this approach is weak in explaining its analysis results. These optimization-based systems do not allow the users to easily inspect the results and navigate through the bid information space, understand the properties of different bids, and compare the given options.

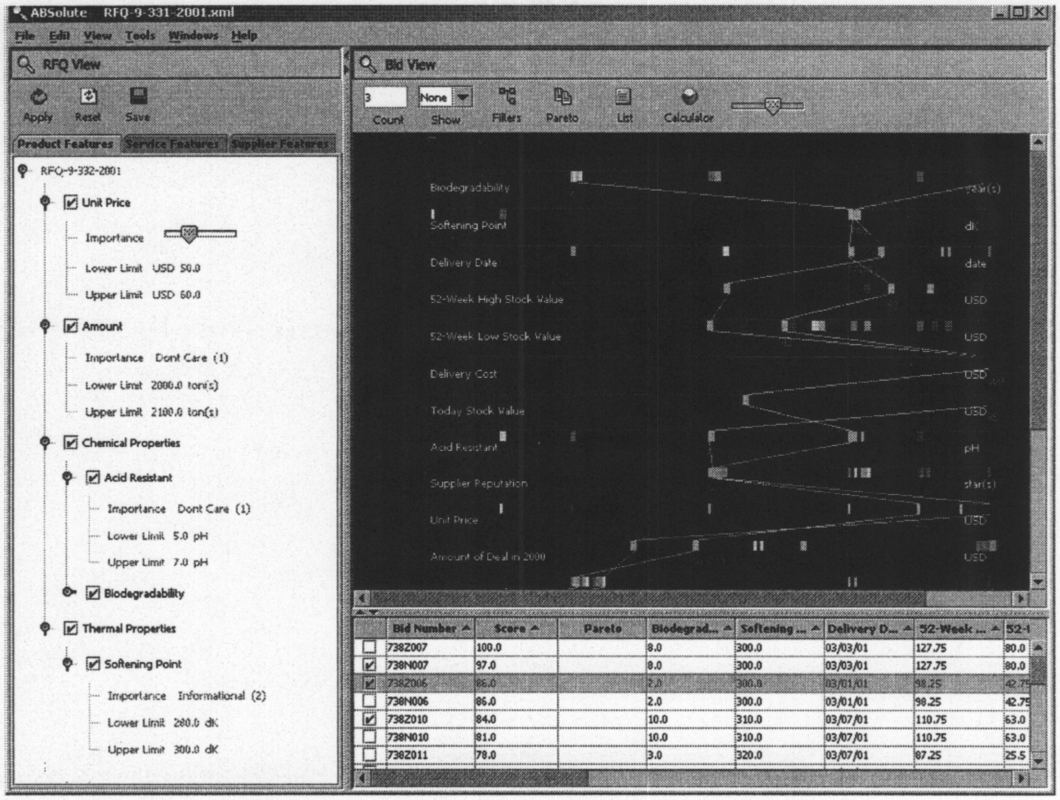

Figure 2: Screenshot of the ABSolute visualization

3. The ABSolute Approach

ABSolute provides an integrated approach to support complex purchasing decisions and an opportunity to satisfy analysis capabilities required in large-scale purchasing processes. In this application framework we integrate methods from multi-attribute decision analysis with visualization techniques. The core components of the ABSolute decision analysis framework are

- a user interface for interactive visual analysis,
- MAUT – a traditional and widely used decision aid, and
- WORA – a new methodology designed to determine weights in the presence of a large number of criteria

3.1. Interactive Visual Analysis

The ABSolute user interface combines the features of different analysis methods, and allows the users to selectively utilize alternative methods for different analysis needs. The visual analysis provides an effective means to navigating through the information space, intuitively understanding the properties of given options, and perceiving interesting patterns in the subject data set. In several ways, the visual analysis mechanism is designed to assist users in the RFQ/bid analysis process: (1) It presents the entire information space of submitted RFQs/bids in a single page. This compact display makes it easy to navigate through the information space and visually compare all the RFQs/bids s/he is interested. Despite the large amount of information shown in a single page, the visual presentation alleviates the possibility of information cluttering. (2) It helps users by visually showing them concrete comparison data that might otherwise be only abstractly in their heads or on paper in non-visual form. (3) Only essential information in the decision-making process is represented in the view; however, more detailed information is accessible through operations with the mouse pointer on the data points in the view. The user determines what is essential information and what is extra information. (4) Easy-to-use visual facilities for filtering, tagging, color-coding, and dynamic querying are also effective for navigation and analysis. A sample screenshot of the visualization is shown in Figure 2.

3.2. Bid Scoring Based on MAUT

ABSolute implements MAUT, one of the most accepted decision analysis techniques. The essence of MADM is to decompose decisions into small entities that a user can deal with individually, and then recombine them by using a predefined mechanism. The key question is how to model decision maker's preferences in form of weights and utility functions because it is required to rank outcomes in a way that is consistent with his/her preference for those outcomes.

The most widely used technique used to decide between alternatives with multiple objectives is the *Multi-Attribute Utility Theory* (MAUT). The basic hypothesis of MAUT is that in any decision problem, there exists a real valued function U defined along the set of feasible alternatives, which the decision maker wishes to maximize. This function aggregates the criteria $x_1 \ldots x_n$. Besides, individual (single-measure) utility functions $U_1(x_1), \ldots, U_n(x_n)$ are assumed for the n different attributes. The utility function translates the value of an attribute into "utility units". The overall utility for an alternative is given by the sum of all weighted utilities of the attributes. For an outcome that has levels $x_1, \ldots, x_n$ on the n attributes, the overall utility for an alternative is given by

$$U(x_1 \ldots x_n) = \sum_{i=1}^{n} w_i U_i(x_i)$$

The alternative with the largest overall utility is the most desirable under this rule. Each utility function $U_i(x_i)$ assigns values of 0 and 1 to the worst and best levels on that particular objective and

$$\sum_{i=1}^{n} w_i = 1, \quad \forall w_i > 0$$

Consequently, the additive utility function also assigns values of 0 and 1 to the worst and best conceivable outcomes, respectively. Alternatives with the same overall utility are indifferent and can be substituted for one another. MAUT provides one of the ways to rank a set of bids having multiple attributes by score, and is a widely accepted method for the normative analysis of choice problems.

3.3. WORA Weight Assessment

The assessment of weights is a core issue when MAUT is used. Often, some kind of subjective judgment forms the basis for the weights, and yet the interpretation of the weights is not always clear. Many different methods exist for assessing the attribute values and weights [5]. One approach is called *pricing out* because it involves determining the value of one objective in terms of another canonical objective (e.g. dollars). For example, one might say that 5 days faster delivery time is worth $400. The idea is to find the indifference point, i.e. determining the marginal rate of substitution between two attributes. Although this concept seems straightforward, it can be a difficult assessment to make.

The *swing-weighting approach* requires the decision maker to compare individual attributes directly by imagining hypothetical outcomes. Starting with a hypothetical alternative that has the worst outcome in all attributes, the decision maker writes down other hypothetical alternatives, which have the best outcome in only one of the attributes. The various hypothetical alternatives are then ranked. The worst alternative gets 0 points, the best alternative gets 100 points. From this one can compute the weights by dividing the points by the sum of all points.

AHP takes a different approach in that it only requires pairwise comparisons of all attributes and alternatives from the decision maker. These pairwise comparisons are summarized in a matrix, which then is transformed into weights based on the Saaty's Eigenvector method [4]. All of these techniques are having problems, when it comes to hundreds of alternatives and dozens of attributes [6], which is typically the case in procurement. Weight assignment becomes quite difficult, and decision makers often feel uncomfortable with the decided results. For example, the exponential increase of pairwise comparisons makes AHP impracticable in these situations.

To overcome the weaknesses of traditional scoring methods, ABSolute provides WORA (Weight determination based on Ordinal Rankings of Alternatives), a new approach where decision makers only provide ordinal rankings over subsets of bids. The visual interface of ABSolute helps users examine and select subsets of offers, and create and arrange ordinal rankings over these subsets. From the information implied by these ordinal rankings, the system derives a set of weights of attributes, and then an overall ranking of all the given offers using optimization techniques. With additional information from the decision maker, these results are iteratively refined. Simulations show that after only a few iterations WORA generates very good estimates of the decision maker's true weights. The basic process is illustrated in Figure 3.

4. Software Architecture

Figure 4 shows the current architecture of ABSolute. It can be connected to one or more private exchanges, receiving information on RFQs and bid offers from the exchanges in XML format. Different views and decision analysis facilities share the common set of data controllers, which helps synchronize the status among different views.

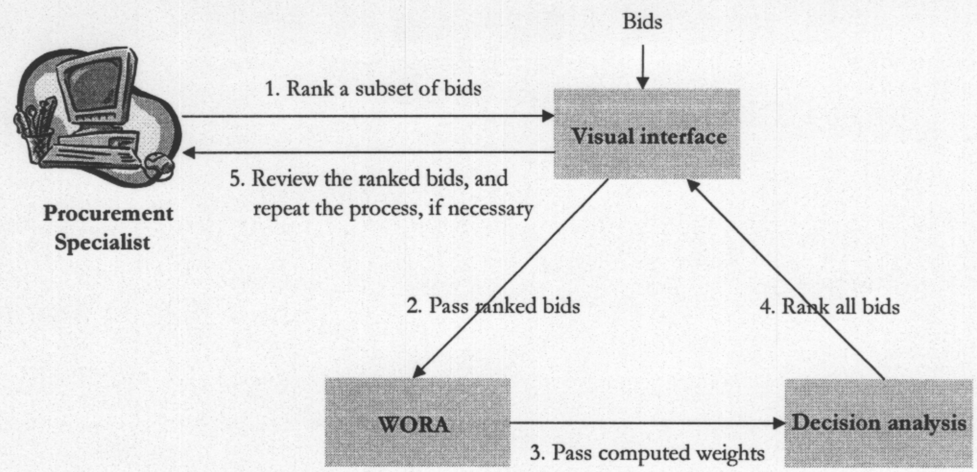

Figure 3: WORA Process of Weight Determination

The system is a pure Java application. The software is designed so as to make it easy to customize and add new features. Its interface, including the visualization of bid offers, is implemented by using only Java Foundation Classes (JFC) [7]. The ABSolute system uses IBM's XML for Java parser to handle RFQ and offer data in XML format. Also, it uses an optimization package for attribute weight computation. Currently, the ABSolute system is a stand-alone Java application communicating with private exchanges through file systems, but it will later provide network connections over the Internet.

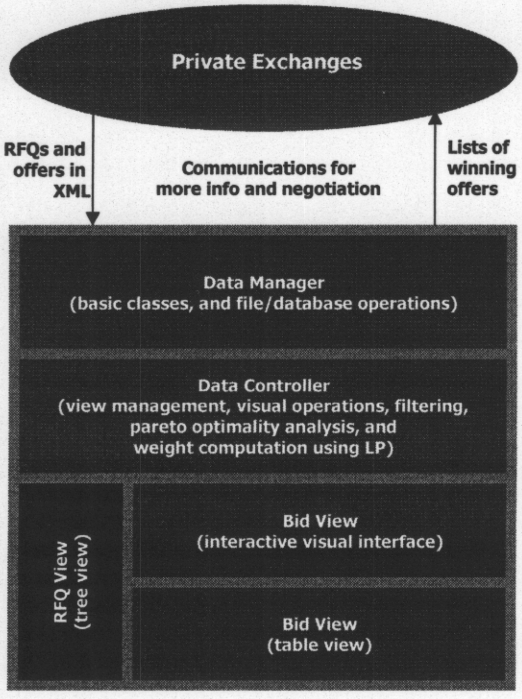

Figure 4: ABSolute Software Architecture

5. Conclusions

The promise of strategic sourcing is to reduce total acquisition costs, while improving the total value. ABSolute provides advanced decision analysis capabilities for bid selection and requires a minimum of human labor in making decisions with confidence. The advanced visualization enables to easily navigate through a large information space, perceive interesting patterns among and within objects, understand the detail properties of given options, and customize information views and analysis steps.

MAUT provides the strength of a traditional decision analysis technique, which has already been applied to numerous real-world situations. WORA provides an innovative approach to weight assessment in the presence of large numbers of attributes. The techniques used in ABSolute are equally beneficial to business applications such as catalog management, analytical product selection, procurement, and customer/supplier relationship management (CRM/SRM).

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