# A Cased-Based Reasoning Decision Support System

## SYSTEME DU SUPPORT DECISION CBR DANS L'ACQUISITION GOVERNMENTALE

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**Abstract:** Each bidding contractors estimates his likely costs of carrying out the work detailed in the project schedules and adds a percentage markup to form the bid value. The value of the markup crucially influences the chances of a bidder winning the contract. Clearly, a low markup value should increases the chance of winning but decrease the profit, whilst a high markup should increase the profit but decrease the chance of winning the contract. It is very difficult for contractors to decide a proper markup, which happens to produce a satisfactory balance between the probability of winning the contract and the profit generated as a result of winning the contract. This paper presents a case-based reasoning decision support system (CBR-DSS) that assists contractors in solving markup estimation problem. The CRR-DSS uses successful cases of previous completed projects to derive solution to new project markup estimation problem. The principle of the CBR-DSS is to analogy new project with previous projects.
**Key Words:** Case-Based Reasoning, DSS, Bidding, Markup

**Résumé:** Chaque contracteur demandé estime son coût d'application d'un travail détaillé dans les horaires et ajoute un percentage de maquillage pour avoir l'offre qui influence crucialement une éventuelle réussite d'un contrat. Evidemment une petite valeur de maquillage doit augmenter les chances de gagner mais réduire le profit tandis que un grand maquillage doit augmenter le profit mais réduire les chances d'arriver à un contract. Il est très difficile pour les contracteurs de décider une offre convenable, qui éventuellement produit une balance de satisfaction entre la probabilité d'achever le contrat et le profit considéré comme une réussite d'un contrat. Ce document présente un système du support decision rationnel basé sur les cas (CBR-DSS) qui permet aux contracteurs de s'engager dans la solution des problèmes estimés et demandés. Le CRR-DSS utilise des réussites de programmes pré-achévés qui servent à résoudre les problèmes d'estimation dans un nouveau programme. Le principe de CBR-DSS est trouver les solutions pour de nouveaux programmes par analogie ceux pré-achévés.
**Mots clés**: Raisonnement basé sur les cas, DSS, offre, maquillage, acquisition Governmentale

### 1. INTRODUCTION

The bidding decision is a complex decision-making process that is affected by a lot of factors, especially for markup decision-making process. In fact, the markup, M, which is the price quoted minus the cost, is usually taken as the key decision variable and the total expected profit is then the product of the estimated cost, the markup chosen and the probability, P (m), of winning the contract with a markup M.

Each bidding contractor estimates his likely costs of carrying out the work detailed in the project schedules and adds a percentage markup to form the bid value. The value of the markup crucially influences the chances of a bidder winning the contract. Clearly, a low markup value should increases the chance of winning but decrease the profit, whilst a high markup should increase the profit but decrease the chance of winning the contract.

Strategic markup bidding assumes that the bidder applies a markup that happens to produce a balance between the probability of winning the contract and the profit generated as a result of winning the contract. A special case of strategic markup bidding id optimal bidding, defined as applying a markup that happens to maximize expected profit, i.e. the product of the

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probability of winning the contract and the profit generated as a result of winning the contract.

The literature on strategic markup bidding is quite extensive and several reviews have been published. All the work to date has been based on two bivariate models. The Friedman model compares the strategic bidder with the lowest bidders. However, the Friedman model has been frequently criticized as demanding unrealistic amounts of data to estimate the model parameters, especially for construction contract auction. The Hanssman and Rivett model partially solves this by reducing the number of parameters in the model and thus the data demands, but with a loss of predictive power.

Case-Based Reasoning(CBR) is a method of solving a current problem by analogizing the solution to previous similar problems. A CBR system draws its knowledge from a reasonably large set of cases contained in the case library of past problems rather than only from a set of rules. It solves new problems by adapting solutions that were used to solve new problems. Instead of relying solely on general knowledge of a problem domain, or making associations along generalized relationships between problem descriptors and conclusions, the CBR approach collects information about previous cases, and then retrieves this information for similar cases. By adopting this approach , it is able to utilize the specific knowledge of previously experienced, actual situations. Subsequently, the previous solutions may be adapted so that they more closely match the current problem and situation. Thus, such a reasoning method is very suitable for decision making in construction bidding—a complex, dynamically changing, and highly unstructured problem domain.

This paper presents a case-based reasoning decision support system (CBR-DSS) that assists contractors in solving markup estimation problem. The CRR-DSS uses successful cases of previous completed projects to derive solution to new project markup estimation problem. The principle of the CBR-DSS is to analogy new project with previous projects.

## 2. CBR SYSTEMS

Briefly, CBR is a problem-solving technique, which works by searching through a case base of previously-solved problems (called a case library) for one or more cases whose identifying features closely resemble the current problem. When found, the solution employed in the historical cases is retrieved and applied to the current problem. However, if the historical case most closely resembling the current problem is not sufficiently similar, then the CBR system undertakes a process of modifying the corresponding historical solution whenever possible, in order to better fit the current problem. This modification is referred to as adaptation, and is a function of the magnitude of the differences between the current problem and the historical solved case. Lastly, the current problem and the new solution can be post facto appended to the case library to increase its robustness. CBR is a simple technique with a lot of intuitive appeal but also with a cognitive basis.

While rule-based systems can be said to also make use of historical information, this experience is represented implicitly in the rules. Rules are used to represent the domain as seen through the eyes of human experts who typically acquire the knowledge from personal experience, and as further interpreted by knowledge engineers. CBR systems, on the other hand, make use of those experiences explicitly, without any subjective biases or interpretations introduced by the human expert and the knowledge engineer. The key to CBR systems, therefore, is a large and robust case library . This is in contrast to the multitude of rules experience-based expert systems, or the mathematical models involved with first principle approaches.

The CBR process includes three basic phases:

1st. Case Retrieval: In its most basic form, case retrieval consists of researching the case library to find the historical case that most closely resemble the current problem. The comparison consists of matching attributes of the current problem with those of each historical case, and computing for each case a composite similarity metric. This metric is domain-dependent, and provides an indication of how closely the historical case resembles the current problem.

2nd. Case Adaptation: It is possible that the most similar case in the case library is significantly different from the current problem. Or else, there may be a subtle but critical different between them that invalidates the application of the old solution to the current problem. In such cases, modification of the historical solution may be required in order fit the current problem. Adaptation scan take many forms, and their discussion is beyond the scope of the paper.

**3rd.** Case Library Update: Once the current problem has been solved through the retrieval and adoptions of a historical case, the current case can be integrated into the case library as a new historical case. This has the effect of continuously improving the CBR system. However, it is important that integration into the case library be delayed until it has been determined whether or not the new solution suggested by the CBR system works adequately.

## 3. DETERMINING FACTORS: EFFECTING MARKUP DECISION

Earlier work has identified some key factors relating to

the bid decision. A survey on top U. S. contractors conducted by Ahmad and Minkarah revealed 31 factors that were thought to influence the two steps of bidding decision process: bid/no-bid decision and the percentage of markup decision. Shash and Abdul-hadi and Shash in their study on some Saudi Arabian and U. K. contractors lists 35 and 55 factors, respectively. Although these factors were quite extensive , they were only dealt with in general, and no attempt was made to distinguish them according to the different reasoning subgoals that go into the bidding process. Nevertheless, Smith lists some factors pertaining to risk and uncertainty in estimating and tending, which contributes to "risk," one of the reasoning subgoals. Neufville and King presented some factors related to "need for work," another reasoning subgoal.

In the present study, a set of factors gathered from the literature is identified, which excludes those that are insignificant and includes other factors that may be important from the perspective of some reasoning subgoals. These factors are classified into two main categories: the internal factors and external factors, as depicted in Table 1.

The internal factors are those inherently related to the company, including its expertise, experience, financial ability, resource possession, current workload, etc. These factors reflect the company's ability and present status. They evolve with time, but independent of job. The contractor can exert this control over most of these factors. Most of the internal factors are not accessible to others, and they vary from one company to another.

External factors are those that are job-related or uncontrollable by the contractor. These include factors related to the nature of the work, bidding requirement, and the social and economic environment. Factors pertaining to the nature if work, such as size of project, degree of technological difficulty, resource requirements, public exposure and prestige of the project, etc. are the client's prerequisites for bidders' compliance rounding world, mainly relating to the social and economic conditions, including the current bidding market, resource mature of work depend on the specific project, whereas those client. However, the environmental factors evolve with time and are independent of the job. All external factors are independent of any specific contractor.

**Table 1 List of factors for bid markup decision**

| Category | Factors |
|---|---|
| External factors<br>Job related | Nature of work |
| | 1.Type of project<br>2.Size of project<br>3.Degree of technology difficulty<br>4.Cash flow requirement<br>5.Type and number of labor required<br>6.Degree of subcontracting<br>8.Identity of owner<br>9.Safety hazards<br>10.Delay or shortage on payment |
| | Bidding requirement |
| | 11.Required bond capacity<br>12.Prequalification requirement<br>13.Bidding method<br>14.Time allowed for bid preparation<br>15.Completeness of drawing and specification |
| Environment | Social and economic condition |
| | 16.Availability of other projects<br>17. Availability of qualified labor<br>18. Availability of qualified staffs<br>19. Availability of equipment<br>20.Government regulation<br>21.Degree of difficulty in obtaining bank loan<br>22.Resource price fluctuation |
| Internal factors | Firm-related factors<br>23.Similar experience<br>24.Familiarity with site condition<br>25.Current workload in bid preparation<br>26.Genersl office's overhead recovery<br>27.Relationship with owner<br>28.Share of market<br>29.Financial ability<br>30.Possession of qualified staffs<br>31. Possession of qualified labor |

## 4. CBR-DSS

CBR is based on psychological theories of human reasoning. It uses the fact that humans often solve new problems by comparing similar problems that they already know how to solve. CBR draws its knowledge from a large set of cases contained in a case library of past problems tather than from a set of rules. A CBR system must successfully addressed the following questions:

1st. How are cases organized in memory?

2nd. How are relevant cases retrieved from memory?

3rd. How can previous cases be adapted to new problem?

4th. How are cases originally acquired?

CBR-DSS focuses on the first two issues of case representation and retrieval process. The third issue of adaptation is handled by the engineer's judgment, which is used to determine what action needs to be taken based on the similar cases that were retrieved. Reasons for not automating adaptation are analyzed later under the heading "adaptation". The fourth issue of case acquisition is handled by using cases originally collected for the rule-based systems to contrast the CBR-DSS case library.

### 4.1 Case library

Over 100 cases were gathered from construction engineers in the development of the previous rule-based systems. The cases were taken from construction projects. Since each construction project has differing design, specification, and detailing requirements, it was decided to use only construction project so that the case base would match the target use.

Of the 120 cases used to develop the case-based reasoning system , the factors effecting markup decision are grouped into two categories: internal factors and external factors.

In most instances, the cases gathered for the CBR-DSS consisted of a problem description, and a suggested solution to the problem.

### 4.2 Programming environment

The choice of tools was based on availability as well as functionality and operation. The programming language CommonLISP and a case-based tool, MEM-1, that was developed to be used with the LISP language , were chosen. The research team was familiar with LISP. MEM-1 was developed and was readily available for use on this project. The combination of LISP and MEM-1 provided a satisfactory tool for implementing this case-based system.

The key concerns in developing the case-based program were how to represent the cases, determining the similarity if the cases, retrieving the similar cases, and finally tailoring the interface for functionality an d user friendliness.

### 4.3 Case representation

There are three important pieces of information that a case should include: (1)the description of the problem defining what was happening or the situation of the problem;(2)the solution that was used to remedy the problem;and(3)whether the solution proposed was a success or fai;ure. The cases were represented using the "defcase" function of MEM-1. Each project has its own set of descriptive features. Each case was described in the following standard manner:

(defcase(:name <name>

:purpose <ourpose>

:status <status>

:environment <environment>

<feature-list>

The first few lines give some general information about the case. They provide a name , purpose ,and status of the case . The information provided in the environment area describes the problem. The final part of the case is where additional features that are not defined for the specific project can be added.

### 4.4 Index

The most important aspect of case-based reasoning is the retrieval of similar cases. To do this the cases must be properly indexed. Indices or feature are descriptors that help in distinguishing one case from another. Indexing has two aspects, first assigning labels to cased at the time that they are entered into the case library to ensure that they can be retrieved at appropriate times; and second, organizing cases so that search through the case library can be done efficiently and accurately.

MEM-1 calculates the similarity of two cases using the feature values and feature importance as indicated by the feature weight. The degree of match is based on the value of the weight that the matched featured features carry versus the total weights of all the features.

### 4.5 Retrieval

The main part of any CBR system is its ability to retrieve similar and useful cases. In almost every instance it can be expected that the cases in the case-base are not exact matches with the new situation. Therefore there needs to be an efficient method for

determining partial matches and limiting the search space.

An option provided be MEM-1 tool is to define specific features as “important ” or necessary. Matching will then be restricted to cases that contain the defined important feature.

### 4.6 Adaptation

The case returned will almost always be slightly different than the new problem. Therefore the solution needs to be adapted to fit the new situation. In some CBR systems the adaptation process is automated. However the CBR-DSS was developed to retrieve the similar cases only and aloe the engineer to use engineering knowledge to adapt a solution to fit the new situation.

## 5. CONCLUSION

This paper presents the development of a markup estimate model using CBR. A CBR-DSS for construction bidding is developed using CBR for markup estimate. The CBR-DSS has several advantages. First, the contractor is not dependent on his experience only, which might not reflect a proper bidding process. Second, the CBR-DSS is adaptable to the users’ environment: novice contractors can utilize the provided model; more experienced contractors can adapt the model based on their experience. Using the present model in a new bid situation, the CBR-DSS not only provides an optimum markup value, but also provides the decision-maker with some indication about the implication of the markup decision.

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