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A Prototype System for the Prediction of Final Cost in Construction Projects

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Abstract
Civil engineering projects include several uncertainties and risks, due to the special characteristics of construction industry. Time and cost are two parameters that could potentially lead to successful and conforming to regulations production of projects. It is imperative to estimate correctly the development and the final outcome of these parameters. Various tools have been applied in order to create trustworthy estimations. In this paper, a prototype system will be presented, which aims at predicting the final cost, based on information available at the bidding stage. The methodology will be based on a combination of regression analysis and case based reasoning in order to produce models for the prediction of final cost. These models will incorporate a process view and will depend on activity based costing methodology to estimate the process cost.

Keywords
Construction Cost Prediction, Processes, Activity Based Costing (ABC), Case Based Reasoning (CBR), Statistical Analysis

1. Introduction

In construction project management, time, quality and cost are parameters which require special attention, due to the special characteristics of construction industry (Aretoulis et al., 2003). Variation in project costs usually results in exceeding the initial estimated cost (Ahmed, 2000). In general, projects that span over a long period of time tend to present time and cost overuns (Eyers, 2001). The goal is to achieve maximum construction quality, in minimum time and cost (Papathanasiou, 2003). Under the highly risky environment of the prevalent competitive bidding practice, preparation of realistic estimates pertaining to those management has been a complex task that is often performed in an ad hoc way and piecemeal manner. Conventional procedures and tools have proved inadequate in providing a structured decision aid that under

such environment, maximizes the contractor' s chances of winning a job with maximum potential profit (Hegazy, 1993).

Processes constitute a structured, measured sum of activities designed to produce a specific outcome for a specific customer or market (Angelides, 1999). The term process protocol, refers to the way in which processes related to project design and construction can be re-arranged in order to produce a more efficient and cost effective way of undertaking design and construction (Aouad et al., 1999). Project construction involves various processes and multiple organisations. It is an obvious need to develop a process model in various levels of detail, which could potentially describe the activities taking place in a professional process and sets them in a logical order (Cooper et al., 1998). A project' s duration and cost can be estimated through a detailed analysis of the activities that take place and available resources and more specifically through the creation of cost etimates for every single activity (Skitmore and Ng., 2003). In conclusion the deviation of final construction cost could be defined as the variation, increase or decrease in the cost of processes in relation to their original estimate.

There are three models for cost estimation of particular interest:

- MRA: Multiple Regression Analysis
- NNs: Neural Networks
- CBR: Case Based Reasoning (Kim et al., 2004)

Each of the abovementioned models produces a cost model based on a series of data which are available at the bidding stage. At the same time traditional estimation has been criticized for cost distortion and lack of relevance. A new method of costing based on activities (Activity Based Costing) has been developed and proposed as a mean to overcome the systematic distortion of traditional costing and to bring again relevance to management accounting. A traditional system reports the amount of money spent, where and by whom, but fails to provide the cost of activities and processes (Kim and Ballard, 2001).

Our aim is to produce a system that could predict the final cost for every process based on the original process estimation. The protype system will adopt prediction models. These models would be produced with regression analysis based on historical cost data. The choice of the best model will be based on a case based reasoning system.

The special economic characteristics of the construction sector will be presented in the second paragraph. The structure of the proposed system will be analyzed in section three. Finally the conclusions and future work will be presented in the last section.

2. Special Characteristics of the Construction Sector

The processes which are taking place during the design and construction of projects, and also the collaboration of project participants have many differences in comparison to corresponding economic sectors. This is mostly due to the long tradition of construction sector and the special characteristics of its product. Several of the main characteristics of the construction sector are the following:

- Every project is unique (Fotiadis, 1990).
- It is very difficult to standardise construction at the worksite, and even more difficult to automate it (Fotiadis, 1990).
- Successful engineers understand that technical work is merely part of a cost – driven business process (Westney, 1997).
- Cost determines which projects will go ahead. Once a project is approved, costs often determine the design approach to be used. And once the project is completed and operations begin, costs determine whether it will be a success (Westney, 1997).

3. System Presentation

3.1 System Structure

The proposed system produces a database constisting of models for the prediction of the processes' final cost. The models are based on historical cost data in process level. The cost of activities can be estimated by means of Activity Based Costing. The proper model can be determined using case based reasoning. The application of the proper model leads to the prediction of the process bidding price and as a result of the project' s bidding price. The structure of the system is presented in the following figures 1 and 2:

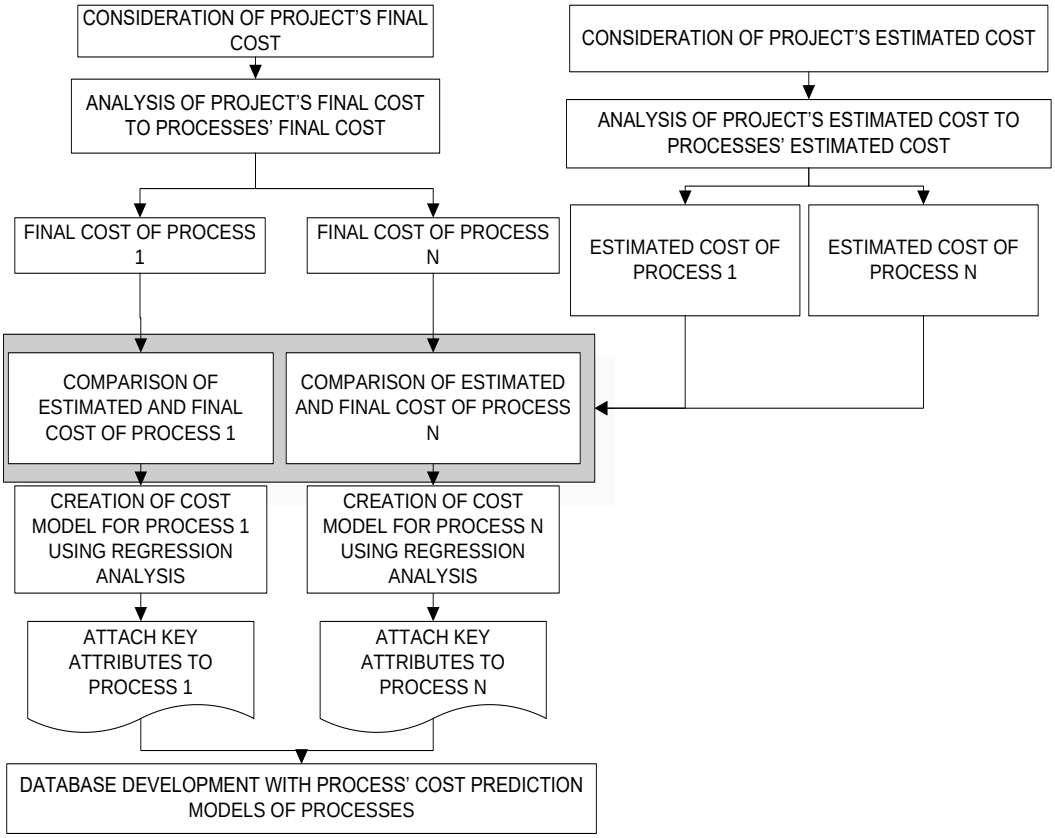

Figure 1: Production of database for the prediction cost models using regression analysis

In order to complete the proposed system a number of steps are required:

- Process Definition
- Process Modelling
- Creation of database with prediction models of the processes' final cost
- Estimation of the total project bidding price with the application of the models

3.1.1 Process Definition

The process definition of a construction project requires:

- Setting criteria for the process definition.
- Definition of the main – strategic processes.
- Definition of sub-processes.
- Mapping of the processes' relationships.

⇒ Setting criteria for the process definition

- Linking the processes with the construction product.
- Analysis of work methods for each process (Angelides and Kirkinezou, 2001).
- Linking processes with the required resources.

⇒ Definition of main processes

Main processes can be considered the ones that directly affect the project production.

⇒ Definition of sub-processes

The definition of sub-processes can be based on analysis of the main processes according to the suggestions of IAI organization for process analysis (Yu et al., 1999).

⇒ Mapping of the processes' relationships

In order to map processes and their relationships, it is required to discover their interactions as well as the order of execution based on the information that each process requires for its beginning and delivers with its completion.

3.1.2 Process Modeling

It is required to model the processes in a way that their cost would be directly estimated. Modelling of the processes can be achieved using the following:

- Process Protocol (Kagioglou et al., 1999).
- IDEF Methodology (Cooper et al., 1998).
- Aris Toolset software (Aris, 2004).

3.1.3 Creation of database with prediction models of the processes' final cost

The first part of the system is consisted by a database with prediction models of the process' final cost. Regression models can be produced using historical cost data. The production of the models can be based on a linear relationship between natural log of the process original estimation price and the natural log of the process final cost. This linear relationship can be described using the following equation:

$Y = C + b_1 X_1 + b_2 X_2 + \ldots\ldots + bn\ Xn.$

Where:

Y: is the natural log of the process' estimated final cost

$X_1, X_2, \ldots$, Xn: measures of distinguishable variables

C: is the estimated constant

$b_1, b_2, \ldots\ldots$,bn: are the coefficients estimated by regression analysis

SPSS package can be used to develop the regression model. The models would then be assigned key - attributes. These key - attributes would be selected accordingly to the distinguishable variables $X_1, X_2, \ldots$, Xn, which describe the processes and their cost. Finally, the models will be stored in a database, available for each new project.

3.1.4 Total Estimated Cost Using The Prediction Models

Each new project can be analyzed using the approach discussed earlier, into sub-processes. The original process cost would be estimated using activity based costing method. The proper prediction model can be chosen from the database considering the processes' key - attributes. Using case based reasoning techniques, the percentage similarity can be defined. The application of algorithms could provide the percentage similarity by comparing each key – attribute of the stored process to the corresponding one of the new process. The selected models would use as input the original process cost estimation and they would provide as output the final estimated process cost. The sum of the processes' final estimated cost would provide the project's total estimated cost.

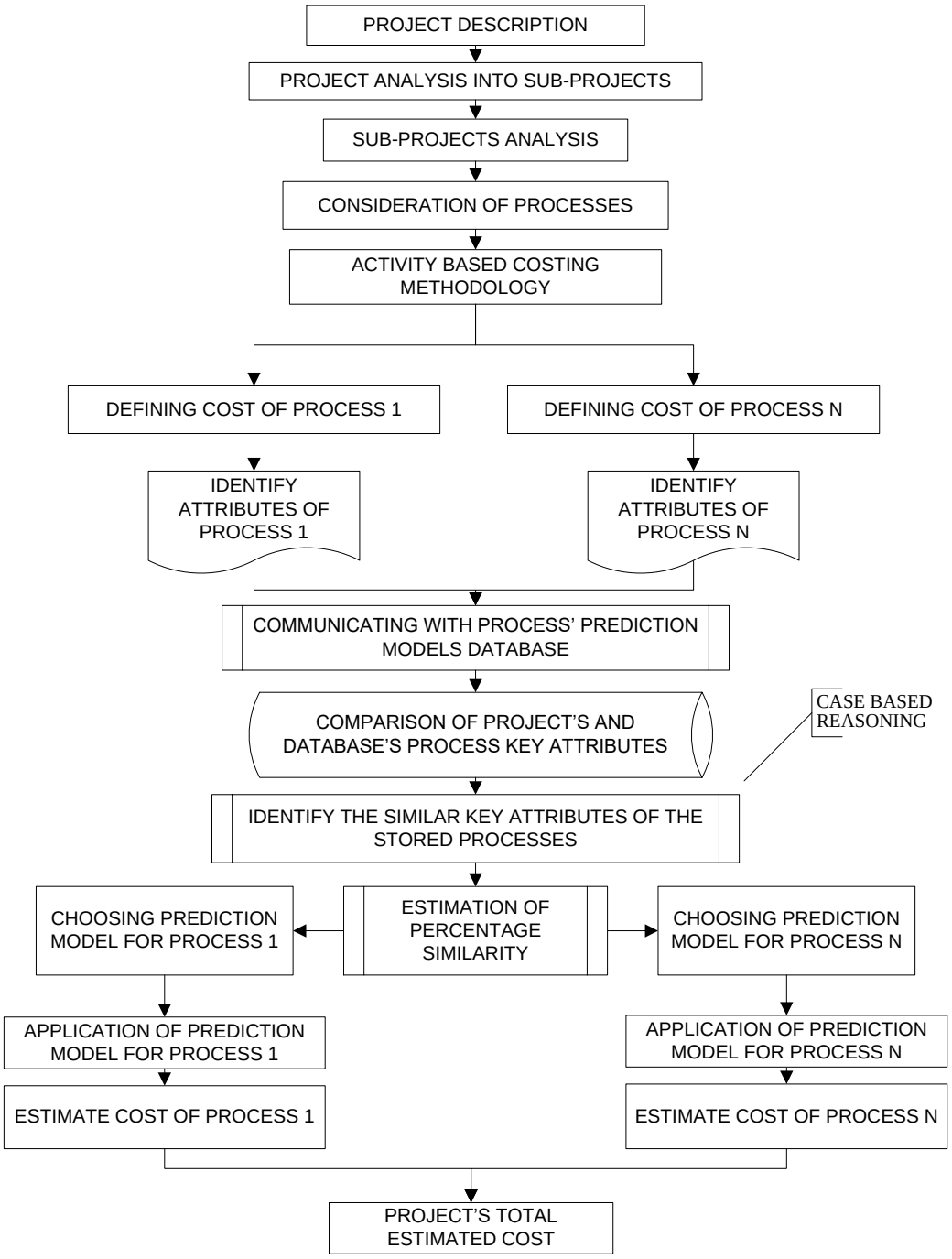

Figure 2: Total Estimated Project Cost

4. Conclusions And Future Work

The proposed approach can provide a number of advantages:

- Better estimation of the profits and general expenses, by defining them in a process level according to the process risk. The engineer using his experience can set the desired profit percentage to each process.

- The effort to produce regression models could potentially lead to useful conclusions concerning process overruns. It would be possible to discover the causes of cost overruns and the risk of each process.
- It would be easier to estimate the process performance.
- Non value added processes would be revealed and thus could be avoided in future projects.

The proposed approach will be completed as part of the future work with the aid of information technology. The prototype system will then be applied to the sum or to a number of processes of construction projects. Finally, the system will be evaluated and the aspects of the system that need further improvement would be noted.

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