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DESIGN OF TWO-STAGE BIDDING MODEL FOR SUPPLIER SELECTION

Nagabhushan S V[1] , Sindhu Swamy D[2]

Assistant Professor, Department of MCA, BMS Institute of Technology, Avalahalli, Bangalore, India[1]

Department of MCA, BMS Institute of Technology, Avalahalli, Bangalore, India[2]

Abstract: Electronic procurement is defined as the outsourcing of goods or services via internet. The decision processes surrounding are complicated by the uncertainty involved in the outsourcing process and by poor supplier management. A major process in the e-procurement decision making is that of supplier selection process. In this study, focus is on supplier selection for an auto-mobile organization by proposing a two-stage bidding framework. In two stage bidding model, suppliers first submit their technical proposals, in accordance with the specifications, but without price. The objective of this exercise is to ensure that all technical proposals conform to the same acceptable technical standards and meet the technical solution as required by the buyer, by using genetic algorithm. So suppliers are evaluated on the basis of their technical bid at the first stage. After the evaluation of technical proposals, the selected suppliers are allowed to bid in second stage. In the second stage suppliers are invited to submit price proposals. Here the supplier who offers lowest financial bid will be awarded a contract.

Keywords: E-procurements, Supplier selection, Supplier evaluation, Genetic algorithm, Two- Stage bidding model.

I. INTRODUCTION

Today all the processes of procurement are web enabled. Web service provides good communication among the people. In this paper focusing on the process called reverse auction which place an important role in E-Procurement. In reverse auction[3], many suppliers of goods and services compete amongst themselves for providing goods and services that a buyer request for. Since there is competition between the suppliers they can bid at lowest price for their products, there is no matter how the product quality is. So to overcome from this issue, two stage bidding model[5] is introduced. In this model the first stage is inviting the suppliers to submit their technical proposals and evaluating their bid, so that the particular bid is meeting the buyer's requirements or not. The suppliers who are selected from the first stage are invited in the second stage to submit financial bid.

Although two stage bidding model filters the suppliers regarding technical parameters, there are some other parameters which place an important role while making the decisions in supplier selection. So in this study, there is a preliminary step before allowing suppliers to participate in the two stage bidding competition. In this step the suppliers who are interested to participate in a particular bidding process, are first evaluated on their pre-qualification parameters. Pre-qualification[5] is based entirely upon the capability and resources of prospective eligible bidders to perform the particular contract satisfactorily. It also includes experience, past performance, successful completion of similar contracts over a given period, financial position etc. So the supplier who satisfies the pre-qualification criteria is allowed to participate in a particular bid. There is an intermediate stage between two stage bidding processes. In the intermediate stage suppliers selected from the first stage are evaluated based on the non-technical parameters like discount, warranty, delivery date, transportation etc. So with these stages suppliers can be filtered in the better way and award a contract for best supplier.

II. ANALYSIS

Several recent research works have analysed supplier selection process through different methodologies. This paper is focusing on supplier selection with two stage bidding model. The question why two stage bidding model for supplier selection? , need to be answered before one can implement the model. Many research scholars have focused, how reverse auction[3] brings about a high level of profitability, control and simplicity to procurement process. But here the buyer can be sure that the price is the most favourable that the market can offer. But also in all cases the decisions about suppliers can't be taken on the basis of price alone especially, when technical parameters place an important role in the evaluation of suppliers.

Consider an example of auto-mobile manufacturing organization, where the technical spare parts of a machine place an important role. If a minor damage/fault find in a machine parts then there will be loss for the organization to a greater extent. In these cases the suppliers who make the technical spare parts production for an auto-mobile manufacturing

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organization has to be evaluating their technical capability. In this paper to analyse the suppliers performance, efficiency, capability, resources, quality, two more evaluation criteria are involved. They are pre-qualification and non-technical parameters evaluation. The overall model analysis is done by using genetic algorithm. By this approach, an organization can obtain feasible solution in supplier selection process.
In this paper, an analysis of two stage bidding model is done by using single item with multiple attributes. By taking n number of technical and non-technical parameters into consideration other than price, supplier evaluation is analyzed.

III. METHODOLOGY

In this proposed work, the reverse auction by suppliers is evaluated by two stage bidding model by applying genetic algorithms. The supplier evaluation process flow will be as stated below

a. Evaluation of pre-qualification criteria
b. Evaluation on technical parameters
c. Evaluation on non-technical parameters
d. Evaluation on price bid

A. *Genetic Algorithm*

Genetic algorithms[1] are search and combinatory optimization methods based on the natural selection conceived by Charles Robert Darwin. The natural selection states that the most adopted generation remain while the less adapted disappear with time. Genetic algorithms are evolutionary algorithms[9], which initially consider an initial population and evolve through the genetic operators of selection, crossover and mutation.

B. *Motivation for using genetic algorithm for model evaluation*

Most of the researches use traditional techniques for solving vendor selection problem. Traditional techniques are not efficient when practical search space is large. Numerous constraints make the vendor selection problem more complicated. Genetic algorithm is different from traditional techniques in the following ways:

a. Genetic algorithm searches from one population of solution to another, rather than from individual to individual[2]. This gives genetic algorithms the power to search noisy space littered with local optimum.
b. Genetic algorithm use only objective function information to guide themselves through the solution space and not derivatives[2]. When compared to other techniques where it need variety of information to guide them. Genetic algorithm needs only the measure of fitness about a configuration in the space of solutions.

C. *Mathematical Model*

Here formulated a mathematical model to analyse two-stage bidding process for single item with multiple attributes using the following notations:

TABLE I
NOTATIONS

Notation	Description
i € 1…..n	Index of items
j € 1…..m	Index of suppliers
k € 1…..g	Index of attributes of item i
D_i	Demand for item i
C_{ij}	Capacity of supplier j to supply item i
l_{ij}	Delivery by supplier j when supplying item i
q_{ij}	Quality(defectives) of supplier j when supply item i
Q_{ij}	Acceptable quality for item i
L_i	Acceptable delivery for item i
S_{jik}	Suppliers parameters specification(technical)
B_{ik}	Buyer requirement specification(technical parameters
P_{ij}	Price of supplier j to supply item i

1) Decision variables

i. $y_j \rightarrow 1$, if supplier selected
ii. $y_j \rightarrow 0$, if supplier rejected
iii. $x_{ij} \rightarrow$ Quantity of item i ordered to supplier j

2) Objective

i. Is to find the winner supplier
ii. To minimize the total cost of price i.e., $\sum x_{ij}P_{ij}$

3) Constraints

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i. $\sum S_{jik}x_{ij}=B_{ik}D_i$; j=1…..m, i=1….n, k=1….g;
All the supplier's technical parameter specifications must exactly match with the buyer's attribute requirements for an item.

ii. $x_{ij} \geq C_{ij}$; j=1…..m, i=1….n; Supplier's capacity must be more than or equal to buyer's requirements

iii. $\sum x_{ij}l_{ij} \leq L_iD_i$; j=1…..m, i=1….n; Delivery date must be less than last date.

iv. $\sum x_{ij} \geq Q_iD_i$; j=1…..m, i=1….n; Aggregate quality must be acceptable

4) Algorithm

i. Buyer specifying the requirement i.e., technical parameters specifications

STEP 1: Buyer analyses the technical parameters of an item

STEP 2: Buyer specifies the attributes value i.e., B_{ik}, demand of item D_i and delivery Date L_i.

ii. Supplier evaluation at the first stage

STEP 1: Initialize P(t) : No of suppliers P(t) = $\{S_1, S_2, \ldots\ldots, S_m\}$

STEP 2: Each supplier specifies their specifications for technical parameters

STEP 3: Evaluate P(t) basis on the constraint that is $\sum P(t)\{S_{jik}\} = B_{ik}$; Supplier's technical specification is matching with the buyer technical requirements or not.

STEP 4: If there is exact match then S_{jik} in P(t) is represented as 1 i.e.,$y_j = 1$ otherwise, $y_j = 0$

STEP 5: By using the binary encoding[5] method from the genetic algorithm suppliers are evaluated.

→ After finishing the matching process, we get a binary format number like
11011…

→ Once get the binary format for all the supplier's specification or Decode it into string message selected if the value is 1 or else rejected if value is 0.

→ If b_k = "selected" for all attributes k, then supplier selected for second stage else, rejected.

iii. Supplier evaluation at intermediate stage

STEP 1: By first stage evaluation get new population called C(t) by applying genetic algorithm operator called mutation[4].

STEP 2: Supplier specifies the non-technical parameters; they are like x_{ij}, l_{ij}, q_{ij} etc

STEP 3: In intermediate stage, the supplier are evaluated on the basis of these constraints.

→ $x_{ij} \geq C_{ij}$; supplies capacity is more or less than Buyer Requirements.

→ $\sum x_{ij}l_{ij} \leq L_iD_i$; Delivery date is matching or there is delay.

→ $\sum x_{ij}q_{ij} \geq Q_iD_i$; Aggregate quality must be acceptable.

Here quality of item includes experience, Insurance, ISO certification, Discount, Warranty, Transportation, Annual revenue.

STEP 4: Supplier S_j selected if satisfied all above three constraints else rejected from intermediate stage.

iv. Final supplier selection from the second stage on the basis of Price bid

STEP 1: Again there is new population W(t) in which there will be suppliers who selected for second stage.

STEP 2: Each supplier from W(t) must participate in the bid on the price within given time T1 and are evaluated using selection technique in genetic algorithm called Rank selection method[4].

→ If the session given T1 is completed, the supplier cannot bid.

STEP 3: Each supplier is compared with their bid on price. If selected price is lowest among all bids then given supplier rank as r=1, next highest rank r=2 and so on…Repeat step 3 up to 'm' suppliers.

STEP 4: Selecting supplier who has ranked by number '1' is declared as the winner.

IV. NUMERIC ANALYSIS

It is assumed that there is an auto-mobile manufacturing company which needs to buy number of tires from supplier who provides the products. In the initial stage, buyer specifies the technical requirements. From the group of suppliers, 5 suppliers are selected from the pre-qualification criteria and allowed to specify the technical requirements and based on the further evaluation process winner will be selected. The process flow is analysed as shown below:

STEP 1: Buyer's Requirements are B(ij)

TABLE II
BUYER'S REQUIREMENTS

Attributes	Tyre category	Tyre type	Tyre width	Aspect ratio	Construction type
Requirements	Tubeless	Passenger	165mm	80%	Radial

STEP 2: Let, population of supplier is P(t)={S_1, S_2, S_3, S_4, S_5}. Supplier's technical proposals are (S_{jik})

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TABLE III
SUPPLIER'S TECHNICAL SPECIFICATIONS

Attributes	Tyre category	Tyre type	Tyre width	Aspect ratio	Construction type
Supplier 1	Tubeless	Passenger	165mm	80%	Radial
Supplier 2	Tube	Passenger	165mm	65%	Radial
Supplier 3	Tubeless	Passenger	165mm	80%	Radial
Supplier 4	Tubeless	Light truck	185mm	80%	Bias
Supplier 5	Tubeless	Passenger	165mm	80%	Radial

STEP 3: stage in the two stage bidding model, i.e., evaluation on technical parameters by applying binary encoding method of genetic algorithm.

→ Evaluation done by using constraint $\sum P(t)\{S_{jik}\} = B_{ik}$

→ If there is exact match then S_{jik} in P(t) is represented as 1

i.e.,$y_j = 1$ otherwise, $y_j = 0$

TABLE IV
SUPPLIER STATUS AFTER FIRST STAGE EVALUATION

Attributes	Tyre category	Tyre type	Tyre width	Aspect ratio	Construction type
Supplier 1	1	1	1	1	1
Supplier 2	0	1	1	0	1
Supplier 3	1	1	1	1	1
Supplier 4	1	0	0	1	0
Supplier 5	1	1	1	1	1

TABLE V
DECODED SUPPLIERS STATUS into STRING MESSAGE

Attributes	Tyre category	Tyre type	Tyre width	Aspect ratio	Construction type
Supplier 1	selected	selected	Selected	Selected	Selected
Supplier 2	rejected	selected	Selected	Rejected	Selected
Supplier 3	selected	selected	Selected	Selected	Selected
Supplier 4	selected	rejected	Rejected	Selected	Rejected
Supplier 5	selected	selected	Selected	Selected	Selected

By checking the constraint b_k="selected" for all attributes k of item i,

TABLE VI
FIRST-STAGE FINAL RESULT

Suppliers	Result
Supplier 1	Selected
Supplier 2	Rejected
Supplier 3	Selected
Supplier 4	Rejected
Supplier 5	Selected

STEP 4: In the intermediate stage applying mutation operator, i.e., changing the attributes means technical into non-technical attributes of population $C(t)=\{S_1, S_3, S_5\}$ obtained from the first stage

→ Here suppliers are submitting non-technical attributes specifications

→ The non-technical attributes are

- Production capacity
- Delivery date
- Experience
- Warranty
- Discount

Buyer demand D_i =1000, Limit for delivery days L_i =1 month,
Suppliers non-technical attributes specification who are selected for intermediate stage are

TABLE VII.
SUPPLIER'S NON-TECHNICAL SPECIFICATIONS

Attributes	Production Capacity	Delivery Days	Experience	Warranty	Discount
Supplier 1	1000 per month	30 days	10 years	6 years	10%
Supplier 3	500 per month	2 months	9 years	7 years	8%

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Supplier 5	1100 per month	1 month	15 years	7 years	9%

Evaluation of supplier in this stage is done by
→ Checking whether satisfying the constraints

$x_{ij} \geq C_{ij}$;

$\sum x_{ij} l_{ij} \leq L_i D_i$;

→ Comparison made on the constraint

$\sum x_{ij} q_{ij} \geq Q_i D_i$;

Suppliers who satisfy above constraints and give the best quality are selected for the second stage. Applying constraints and doing comparison among the supplier specification, result of intermediate stage is

TABLE VIII
RESULT OF INTERMEDIATE STAGE

Attributes	**Production capacity**	**Delivery Days**	**Experience**	**Warranty**	**Discount**
Supplier 1	Satisfied	Satisfied	$S_3<S_1<S_5$, good	$S_1<S_2<S_5$, poor	$S_3<S_5<S_1$, very good
Supplier 3	not satisfied	not satisfied	$S_3<S_1<S_5$, poor	$S_1<S_2<S_5$, good	$S_3<S_5<S_1$, poor
Supplier 5	Satisfied	Satisfied	$S_3<S_1<S_5$, very good	$S_1<S_2<S_5$, good	$S_3<S_5<S_1$, good

From Table. VIII, S_1 and S_5 are selected for the second stage.

STEP 5: Suppliers selected from the intermediate stage are asked to bid on price for single item including transport charges in second stage. Supplier price bid is

TABLE IX
SUPPLIERS BID ON PRICE

Suppliers	**Supplier 1**	**Supplier 5**
Price	5000	6000

Taking discount into consideration the final cost is analysed by using below stated formulae
→ totalcost=P_j*D_i
→ cost=totalcost*discount
→ finalcost=totalcost-cost

For supplier S_1,
→ totalcost = 5000*1000 = 5000000
→ cost = 5000000*(10/100) = 500000
→ finalcost = 5000000-500000 = 4500000

For supplier S_5,
→ totalcost = 6000*1000 = 6000000
→ cost = 6000000*(9/100) = 540000
→ finalcost = 6000000-540000 = 5460000

TABLE X
TOTAL COST OF PURCHASE

Suppliers	**Supplier 1**	**Supplier 5**
Final Price	4500000	5460000

STEP 6: supplier who offered least price is considered as the winner of the bidding competition. In this numeric analysis, supplier S_1 is offering least price so,

S_1 is the winner of competition

V. CONCLUSION

This study is more flexible approach to awarding contracts because it allows participation of prospective bidders in the definition of the technical specifications and scope of work. Two-stage bidding model with genetic algorithm is different from the traditional method used, because this approach provides a large search space, where this technique searches from one population of solution to another, rather than from individual to individual. The proposed model for supplier selection provides "fit and proper" potential supplier as an optimum solution.

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