Study on Workflow-Based Open Competitive Bidding E-Procurement Mechanism

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Abstract- **With the advent of the Internet in business world, buyers need at times to make use of competitive procurement strategies for certain purchases despite the move in recent years towards supplier partnerships. Within the realm of management, it is important for organizations to provide an open competitive bidding environment for suppliers. A new two stages E-procurement mechanism is designed. In the first stage, a contract is negotiated by a multiround multiattribute sealed-bid auction. The stage can be repeated until the non-price attributes are decided and announced. In the second stage, the lowest price is yielded through open competitive bidding in an online real-time dynamic auction. Workflow technology is also applied to define the purchasing process. Under the new mechanism, both buyer and the selected supplier will enhance their pay-off.**

Keywords: **E-procurement; Workflow; Competitive bidding; Electronic reverse auction (E-RA); E-negotiation; E-tender**

I. INTRODUCTION

With the advent of the Internet in our business world, various electronic service and its related technologies have been swiftly adopted and hot-issued in the real world. These technologies are promising buyers and their suppliers substantial transactional efficiencies in their procurement activities. However, these technologies also bring new dynamics to purchasing contexts and the impact of these new dynamics is not understood well. Buyers need at times to make use of competitive procurement strategies for certain purchases despite the move in recent years towards supplier partnerships. Within the realm of management, it is important for organizations to provide an open competitive bidding environment for suppliers considering the growing successful use of electronic reverse auctions (E-RAs) in E-procurement activities. These auctions have been dubbed "reverse" to reflect the fact that sellers bid instead of buyers, and the prices are bid down instead of up. A reverse auction is "an online, real-time dynamic auction between a buying organization and a group of pre-qualified suppliers who compete against each other to win the business to supply goods or services that have clearly defined specifications for design, quantity, quality, delivery, and related terms and conditions"[1]. These auctions have become a standard component in the E-commerce toolkits of companies such as Ariba, Commerce One, Oracle, B2E Markets, FreeMarkets, and a variety of vertical hubs. Many of the top Fortune firms regularly employ E-auctions in their E-procurement activities. Furthermore, in procurement practice, it's a tendency that government contracts are awarded by E-procurement system.

In this paper, we focus on one-sided open competitive bidding E-procurement mechanism. "One-sided" refers to the fact that there exists a single buyer and multiple sellers. In the open competitive bidding E-procurement condition, suppliers are able to view the price bids of every competitor and have the opportunity to bid against their competitors in real time.

The procurement is in practice a result of a bargaining game with the suppliers. However, it may obtain specific rents from contract. This trade-off determines the optimal choice of contract. In this paper, a new E-procurement mechanism is designed. We design a two stages procurement mechanism. In the first stage, a contract is negotiated by a multiround multiattribute sealed-bid auction following the buyer's gradually disclosed preference. The stage can be repeated until the configurable attributes except price are decided and announced. In the second stage, the lowest price is yielded through an open competitive bidding in an online real-time dynamic reverse auction as the mechanism as electronic reverse auction (E-RA).

In the last 20 years or so we finely have developed tools to not only do the work, but to manage the work process. The accelerating adoption of new technologies such as the Internet, is causing shifts in the way people work and their working environment. The increasing flexibility has pushed the concept of business process technology to the forefront of an organization's consciousness. More than just procedural documents, the workflow process is defined formally in the workflow computer system. With the workflow system, information is easy to access, time and cost can be saved, and the tasks can be performed concurrently. The business conducted more effectively, and the users can focus on business issues. One of the advantages of a workflow system is the control of process [2]. We apply workflow technology to define the procurement process under the new mechanism.

To the best of our knowledge, the trade-off mechanism described above has not been founded in the existed literature.

The paper is organized as follows: We first characterize the E-auction in the next section. Then the characteristics of different E-procurement mechanism are compared. Following, the new E-procurement mechanism is proposed in section 4, and mechanism model is described in section 5. After process based on workflow technology is defined in section 6, conclusions are given in section 7 finally.

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II. CHARACTERISTICS OF E-AUCTION

The E-auctions work according to the general auction principles, i.e. bids concerning defined criteria placed on a goods to be purchased or sold before a predefined end when the best bid is computed according to a transparent algorithm. E-auction has an important role as a price revealing mechanism that stimulates price competition (in varying degrees) and clearly and quickly delineates all suppliers on the basis of price. The electronic reverse auctions (E-RAs) occurring in the marketplace is a fundamentally new phenomenon in procurement. E-RAs offer the unique opportunity for buyers to gain insight into price levels, market prices, price elasticity (as related to various volumes), and price rigidity (from powerful oligopolies) from suppliers that participate in the event. This knowledge of markets and prices can result in some cases, in a "power shift" from strong suppliers to weaker buyers not previously attainable until information is revealed through an E-RA event [1]. For a growing number of buying firms, E-RAs have found an appropriate niche in their sourcing toolkit, allowing them to efficiently source goods and services that are highly standardized, have sufficient spend volume, can be replicated by a reasonable number of qualified competitors, and have insignificant switching costs. The major benefit from the use of E-RAs is the potential for measurable direct cost reductions of purchased goods and services. The major benefit of E-RA is the potential to buy goods and services at a lower price. Some firms are reporting an average price savings of 10 percent to 20 percent [3]. E-RAs can create markets for goods or services where none previously existed. They can also increase the reach of buyers to allow them to find potential suppliers worldwide in a cost effective way. Many organizations also report a significant cycle-time reduction of as much as 40 percent over traditional sourcing processes [1]. Because most E-RAs are hosted through standard (secure) Internet connections, the reach to include qualified suppliers worldwide is increased substantially. E-RAs are a very efficient method of getting to a final best price from a group of suppliers [1].

It is important to recognize that the E-auction phenomenon is a fundamentally different phenomenon both substantively and theoretically, than anything we've seen in the past. The economics literature considers auctions from both a theoretical and empirical perspective, with a focus on the process by which individual actions translate into prices. Hence, this literature considers differences among the valuations that bidders may have for auction objects, characteristics of the bidder (e.g. risk averseness), psychological mistakes (e.g., the winner's curse) and how these factors affect the prices in a variety of auction formats (e.g., sealed, open, English, Dutch, etc.) that vary in their allocation rules. For an overview of this literature, see McAfee and McMillan (1987) and Milgrom (1989) [4], [5]. E-auctions differ from manual auctions in several ways. First, the speed of information in E-auctions is rapid, with instant communication and feedback. Second, the cost of contract among bidders is greatly reduced. Also, geographic and temporal convenience is increased, as asynchronous bidding is possible and bidders are able to participate from all over the world. Third, E-auctions represent a significant compression in negotiation time and preparation. Finally, the E-auction preserves bidder anonymity, by not allowing the bidders to know the identity or number of other bidders in the auction process [6].

Whereas the products auctioned are differentiable on attributes other than price. Aspects such as product quality, supplier reliability, and value added services are important in the purchase decision. The auction models are partial equilibrium models. The role of the price system in coordinating the actions of different people cannot be understood except within a general equilibrium system [4] such as negotiation.

Particularly, level of price competition is significantly greater and more explicit in open bidding auctions than in the sealed bidding auction. The fast-paced, dynamic nature of the bidding process, along with the need to quickly respond to the bids of competitive suppliers creates a tense environment that pressures suppliers to vigorously cut prices. It is the compressed time frame of open bidding auctions that creates a stressful context for the supplier. Conversely, in sealed bidding auctions, suppliers are more likely to make relationship-specific investments. Trikia et al. have presented a multistage mixed-integer stochastic optimization model under a multiauction competitive market [7].

In case of a progressive multistage E-purchasing event, two-party negotiations should be concluded in the process, and the different stages could consist of different procurement type. In the next section, the characteristics of other E-procurement mechanism are compared.

III. E-PROCUREMENT MECHANISM

Electronic–negotiation (E-negotiation). Negotiation is the key decision-making approach used to reach consensus. It is a complex, illstructured process, and requires sophisticated decision support. Global communication networks and advances in information technology enable the design of information systems facilitating effective formulation and efficient resolution of negotiation problems. The impact of information technologies on negotiations is not limited to the use of electronic communication. Information technology changes the way that a negotiation problem can be represented and a negotiation process structured. The use of Internet-based information systems allows for many more activities undertaken in negotiations, including, efficient matching of potential negotiators; exchange, comparison and categorization of rich data; and the use of tools for data collection, problem structuring and analysis, and interpretation of offers [8]. The main models of E-negotiations are negotiation support system (NSS) and automated negotiation system. Initiated by the commercial

exploration of the Internet as a global communication and "negotiation" infrastructure [9], electronic varieties of negotiations have started to gain momentum in manifold shapes—from web-based NSS [10], to automated agent-based negotiations [11], and in both research studies and business applications [12]. The computerization of negotiation processes increasingly affects the way organizations (and individuals) interact with each other. E-negotiations promise higher levels of process efficiency and effectiveness, and most importantly, a higher quality and faster emergence of agreements. The potential monetary impact leads to an increased demand for appropriate E-negotiations for specific negotiation situations (e. g. for E-procurement).

Yet, both the design of suitable E-negotiation and the implementation of germane E-negotiation media largely lack systematic, traceable and reproducible approaches and thus they remain more an art than a science. Currently designing and implementing E-negotiation systems remains a laborious trial-and-error process. The design and implementation of E-negotiation system requires the consideration of insights from multiple relevant research areas in order to fulfill its promises and represent the richness and complexity of real negotiation scenarios in E-commerce. Recent developments created an opportunity for mutual fertilization of research studies and approaches, and for integration of different perspectives on negotiations into an interdisciplinary research effort to develop an engineering approach to E-negotiation, similar to, for example, system or process engineering which brings together the findings about negotiators and negotiation processes from the different research areas.

Electronic-tender (E-tender). Tender is a term that a legal person or any other organization that, in accordance with the provisions of this law, puts forth a project subject to tender and carries out the tender [13]. Tender and bid activities shall conform to the principles of openness, fairness, impartiality and good faith. Tenders include public tenders and invitational tenders. A tenderer shall prepare the tender documents containing all substantial requirements and terms as technical requirements, standards on examination of bidders' qualifications, requirements on bid price quotation and bid assessment standards as well as main clauses of the contract to be signed. A bidder shall deliver his bid documents to the place of submission prior to the deadline for submission set in the tender documents. The tenderer shall sign and keep the bid documents when receiving and may not open them. Bids shall be opened at the same time of the deadline for submission of bid documents set in the tender documents. E-tender provides decision support for tenderer or bidder, and enhances the efficiency and reduces the time by finishing tender process with the help of computer and the network [14]. With the implementation of the "open-door" policy from the beginning of the 1980s, competitive bidding was introduced to China, the number of reported corruption cases has begun to decline. The history of development of competitive bidding systems in China is reviewed by Lai *et al.* [15]. Whereas, the tender document preparation, bid strategy and supplier selection are still main problems. Considering the probability of collusion and winner curse, it needs to be discussed that tender only remains to be the mechanism with seal-bid and one round bid.

We argue that there should be an integrative approach which increases the communicative quality of information exchanges, enables cooperative management to configure business contracts, specifies the content of the negotiation exchanges in a structured yet flexible way, and finally supplier competitive in an open environment. The next section will present our approach.

IV. NEW E-PROCUREMENT MECHANISM

The new E-procurement mechanism proposed is combined of two stages:

In the first stage, the buyer needs to staff a purchasing request. After evaluating the requirements and generating a first work plan, the buyer estimates the task to be performed. Some contents are quite structured and others require specific qualifications. There are some attributes that the buyer either is not aware of private knowledgeable enough to perform or for which dedicated resources are not available in the restricted time frame. The contract needs negotiattion that a multiattribute sealed-bid auction. The buyer now submits requests for these attributes to E-procurement system. Upon receipt of this request, the system authority notifies potential providers for this request, the candidate providers can then bid to perform this contract. Offers should include the demanded contents about the configurable multiattributes such as estimated time to complete the contract, the price, or the quality of service attributes. On the basis of buyer's preferences being gradually disclosed and known, the suppliers provide their offers considering their private information round by round. The bidding process can be repeated until the attributes except price are decided and announced. After the buyer determining the final contract configuration that is the best satisfied, the process gets into the second stage.

In the second stage, the lowest price is yielded through open competitive bidding in an online real-time dynamic auction. In the open competitive bidding E-procurement condition, suppliers are able to view the price bids of every competitor and have the opportunity to bid against their competitors in real time. In this process, the auctioneer sends an invitation to participate along with the buyer's request for purchase (RFP) to the prequalified suppliers. The price is revealed and the bidding begins. Bids are submitted from the suppliers to the buyer and all suppliers view the price falling successively until only one bidder remains. A scheduled and actual closing time is indicated as well. The open bid format utilizes a moving end-time (a soft close) for each lot; this means that if there is a bid within the last minute of the closing time for the lot, the close time

will automatically extend for 2-5 minutes more to allow other bidders to respond. This will continue until the close time is reached with no bidding activity in the minute prior. Hence, while open competitive bidding involves a dynamic competition on price, it is an important signaling mechanism whereby all suppliers can make decisions regarding price concessions in real time. The buyer will be pleased with the results as the process has been shown to lower procurement costs.

V. MECHANISM MODELS

In this section, we propose new mechanism models presenting the buyer making decision in the purchasing process.

Stage 1:

With general information of problematic event (I_G), solution (I_S), and the primary expert knowledge (K_e), purchasing request knowledge (K_r) is first generated. Then, with suppliers' knowledge including their private information (K_s), buyer (B), suppliers (S), purchasing knowledge (K_r), and offer (O), feedback knowledge ($K_{f,n}$) is continuously generating and correcting after suppliers n round bidding. Finally, with general information of problematic event (I_G), solution (I_S), expert knowledge (K_e), and transformed feedback of case-based knowledge ($K_{f,n}$) compose the final knowledge (K) and contract configuration (C) is determined by the buyer.

Model 1:

$$K_r=f_{Ke}(I_G,I_S, K_e ,B) \quad (1)$$

Where f_{Ke}: knowledge process function Formula (1) corresponds to the purchasing request knowledge resulted from a buyer using a particular solution approach.

Model 2:

$$K_{f,n}=f_{Kf}(K_e, K_r , K_s ,O_{i,n} , K_{f,n-1} ,B,S) \qquad n\geq 2 \quad (2)$$

Where $K_{f,n}$: the nth round feedback knowledge $K_{f,1}=K_r$ f_{Kf}: knowledge transformation function $O_{i,n}$: the offer provided by the ith supplier in the nth round

Model 3:

$$K=f_{Ks}(I_G,I_S,K_e,K_r,K_{f,nmax}, S, B)\ n_{max}=\max(n) \quad (3)$$

Where f_{Ks}: solution approach function Formula (3) corresponds to the final knowledge. Different types of information in the generation process are derived from different subjects and solution approaches.

$$C= f_{Kc}(I_G,I_S, K_e, K, S, B) \quad (4)$$

Where f_{Kc}: contract configuration approach function Formula (4) corresponds to the final contract configuration.

Stage 2:

In this stage, the suppliers open competitive bid price offers in an online real-time dynamic auction.

$$S_w=f_{Kw} (I_G,I_S, K_e, K, C, P_{i,n} , S, B) \quad (5)$$

Where S_w: the selected winner supplier f_{Kw}: the winner supplier select function $P_{i,n}$: the price offer bid by the ith supplier in the nth round Formula (5) corresponds to the final winner supplier selection.

VI. WORKFLOW-BASED PROCESS MODEL

Purchasing is a dynamic business process with a set of one or more linked procedures or activities that collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles and relationships [16]. According to Workflow Management Coalition (WfMC) [17], a workflow model is the formal representation of a business process in a form that supports automated manipulation. It includes five relevant perspectives [16]–[19], i.e., process, resource, organization, information, and function perspectives, which are necessary for a workflow that can be automated by workflow management system (WfMS). Workflow management aims to help business goals to be achieved with high efficiency by means of sequencing work activities and invoking appropriate human and/or information resources associated with these activities. Being a key technology in supporting business process reengineering and an effective means realizing full or partial automation of a business process, many workflow systems have been developed for different types of workflow based on different paradigms [20], [21]. Recently it has been employed as a framework for implementing E-business (B2B) process enactment over the Internet. This typically requires collaborative enactment of workflows across multiple organizations [22]-[26].

A process model, in general, represents activities, their relations, and attributes describing the process and activities, such as activity ID, due date, task performer, and so on [27]. Next, We will present process models representing precedence relations among activities to show how interactions can be systematically managed with the workflow system presented in Fig.1. At run-time, once a purchasing process is launched, the system controls the execution of the process and continually checks the states of the component activities until process completion.

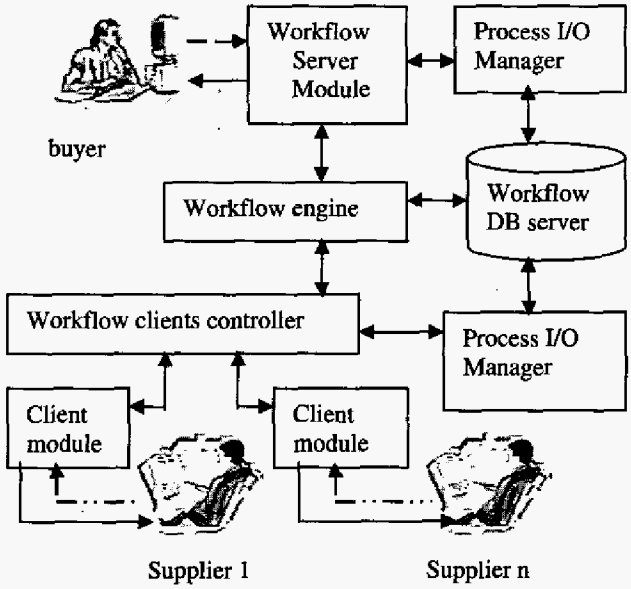

Fig. 1. workflow system architecture

Process structure model definition: A workflow is defined as a direct graph G={(S, A)}, where there are two types of nodes named coordinator state nodes S (ellipse) and activity nodes A (rectangle), such that:

$S=\{s_i | i=1, p\}$ is the set of coordinator states, where s_i is the ith state and p is the total number of states in G.

$A=\{a_i | i=1, q\}$ is the set of activities, where a_i is the ith activity and q is the total number of activities in G.

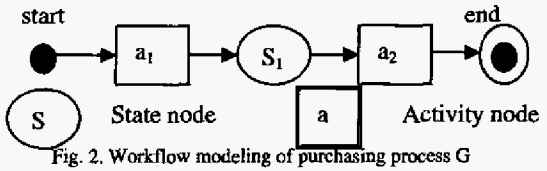

Fig. 2. Workflow modeling of purchasing process G

The graphical representation of purchasing process is given in Fig. 2. Here, node start denotes start state, node a_1 denotes activity in stage 1, s_1 denotes stage 1 completed state that contract finished configuration and stage 2 can be started, a_2 denotes activity in stage 2, and node end denotes stage 2 completed state that price competitive bidding process closed, winner supplier selected and all the purchasing process terminates. We will use the above notation to draw detailed graphs under the process description in section 4 following the rule of the process structure model definition.

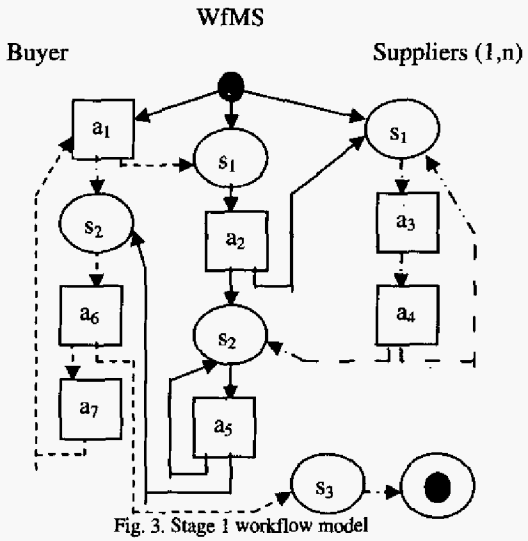

Fig. 3. Stage 1 workflow model

The workflow in stage 1 is drawn in Fig. 3, and the workflow in stage 2 is drawn in Fig. 4. All the states and control flow are listed in Tab. 1 and Tab. 2. All the activities and data flow are listed in Tab. 3 and Tab. 4.

TAB. 1. COORDINATOR STATES S

Number	Description
s_1	suspend
s_2	waiting for offer
s_3	prepare stage 2
s_4	waiting for new bid until stage 2 time out

TAB. 2. CONTROL FLOW

State transaction	trigger
start- s_1	Buyer propose request
s_1- s_2	WfMS announce new request
s_2- s_3	Buyer finish contract configuration
s_3- s_4	WfMS announce contract
s_4- end	Buyer select winner supplier

TAB. 3. ACTIVITIES A

Number	Description
a_1	Buyer propose request
a_2	WfMS store and announce new request
a_3	Suppliers study request and prepare offer
a_4	Suppliers send offer
a_5	WfMS store and send offer
a_6	Buyer study new offer
a_7	Buyer revise request
a_8	Buyer propose contract
a_9	WfMS store and announce contract
a_{10}	Suppliers study contract and prepare bid
a_{11}	Suppliers send new bid
a_{12}	WfMS store and send new bid
a_{13}	Buyer analyze all the bids
a_{14}	Buyer winner supplier selection
a_{15}	Buyer send winner supplier information
a_{16}	WfMS store and send winner supplier information
a_{17}	Suppliers confirm winner supplier information received

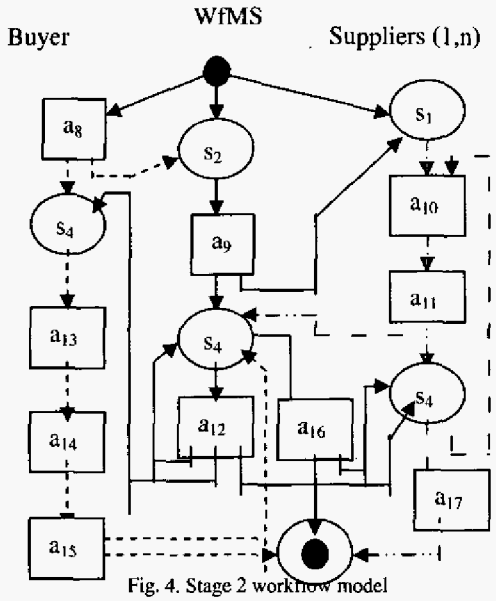

Fig. 4. Stage 2 workflow model

TAB. 4. DATA FLOW

Activity	Transferred information
a_1, a_2	Buyer's request
a_4	Supplier's offer
a_8, a_9	Buyer's contract
a_{11}, a_{12}	Supplier's bid
a_{15}, a_{16}	Buyer's selection about winner supplier information
a_{17}	Supplier's confirmation of winner supplier information received

VII. CONCLUSION

This paper has taken a view of an emerging phenomenon—the E-procurement. A new mechanism is designed combining E-auction with other E-procurement mechanism such as E-negotiation and E-tender. It's obvious that buyers can benefit from the new mechanism not only cost advantages and cycle-time saves but also others. Buyers need to consider that what is appropriate candidate for the open competitive bidding procurement mechanism. Collectively, further studies are required to understand which areas of procurement are most suited, what additional, new success criteria will emerge and how, if at all, organizations are employing this mechanism to adapt to the use of competitive purchasing strategies.

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