Autonomous Procurement System (APS): Bidder Selection

Mazen A. Al-Sinan, Zainab Aljaroudi

Contracting Department
Saudi Aramco
Dhahran, Saudi Arabia
mazen.sinan@aramco.com, zainab.jaroudi@aramco.com

Abstract—**This is a follow-up paper that offers additional information about a pending patent that was filed with the United States Patent and Trademark Office (USPTO) in March 2020. The proposed patent provides an autonomous solution for conducting a procurement process for services and materials. This paper focuses only on one activity of the autonomous procurement system (APS), namely, bidder selection. The paper also provides a brief description of a typical procurement process for services as an introduction.**

Keywords: Procurement; Bidder selection; Artificial intelligence; Machine learning; Natural language processing

I. INTRODUCTION

Most previous studies that attempted to employ AI algorithms in the procurement process were more theoretical and academic in nature, and they were difficult to implement in industry [2-5]. In addition, attempts to develop friendly solutions for augmenting procurement based on AI have been fragmented. Recent advancements in algorithms, data availability, and affordable computational power (GPUs) have created new paradigms for employing AI in the procurement process. In fact, it has become possible to develop an AI solution that can conduct the procurement process autonomously.

In this paper, a description of the common procurement process is provided. Furthermore, a general description of the Autonomous Procurement System (APS) (patent pending) is presented. This paper focuses on one of the major procurement activities namely: bidder selection. Prior to this paper one paper was presented in conferences where Pro forma development and bidder selection was disclosed [1].

.

II. PROCUREMENT PROCESS

The procurement process, especially for services, consists of a number of activities that are governed by certain procedures and regulations to maintain the integrity of the process. The procurement process is typically initiated due to a need. The principles of the procurement process are generally the same, with minor differences based on procedures and rules that vary from one organization (buyer)

to another. Figure. 1 depicts the typical procurement process activities, where highlighted marks optional activities.
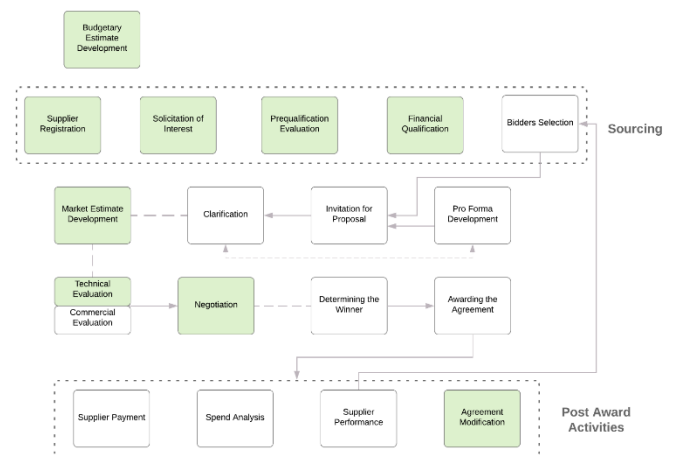

Figure 1. Traditional Procurement Process

The following 12 activities represent the typical core steps in the procurement process. There could be some variation from one organization to another:

1) *Supplier Registration*
2) *Solicitation of Interest*
3) *Prequalification Evaluation*
4) *Financial Qualification Evaluation*
5) *Bidder Selection*
6) *Pro Forma Development*
7) *Invitation for Proposals*
8) *Clarification*
9) *Commercial and Technical Evaluation*
10) *Negotiations*
11) *Estimate Development*.
12) *Agreement Award*

In addition, there are other essential processes related to contract administration, such as supplier payment processing,

supplier performance evaluation, and strategic processes, such as spend analysis.

During the execution of any agreement, it is always possible that some terms and conditions or requirements will need to be modified. The modification of the agreement could come in different formats, such as a change order or amendment.

III. DESCRIPTION OF APS

The invention is to execute the entire procurement process for services autonomously without any human intervention. The service requestor can create a procurement request in the system either verbally or in writing. The system will perform all the activities of the procurement process, including selecting bidders, issuing solicitations of interest, producing appropriate contracts pro forma, issuing invitations for proposals, receiving commercial and technical proposals, performing technical and commercial evaluations, selecting the winning supplier, and obtaining the signatures of both parties. The system is configured by assembling various applications and technologies, including blockchain, NLP, machine learning, and advanced analytics techniques. Figure. 2 depicts a general schematic of the APS.
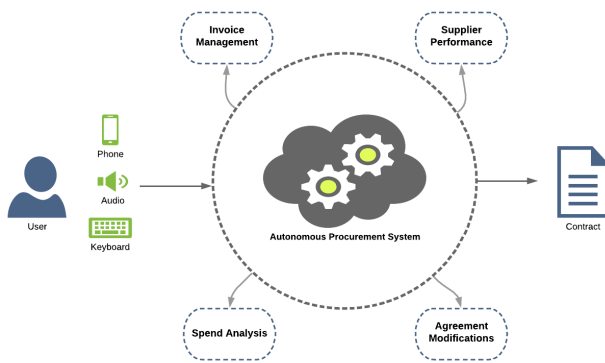

Figure 2. Autonomous Procurement System

A. System Configuration

The system has to be initially configured with some default policies to determine the underlying logic for certain modules. Table 1 shows some examples of the buyer polices. The user is able to make changes to the default settings to accommodate special cases or to reflect their own policies and procedures.

TABLE 1 BUYER POLICY MATRIX

Buyer Policy	Affected Module	Default Conditions
SOI	SOI	Mandatory for Selective Bidding and Ad Hoc Bidding

Bidding Strategy	Bidders' Selection	Open Bidding

The system can be unlocked using several recognition options, including traditional passwords and biometric identification methods such as fingerprint or facial, recognition. After the system is unlocked, the user can start feeding the request and required parameters to the system through vocal or written statements.

In order to initiate a procurement process, the user can instruct the system either verbally or in writing to begin the sourcing activities. If the request is verbal, the system will convert it to text using speech recognition algorithms. This information is fed to APS to fill a matrix with certain variables that are necessary to initiate the procurement process.

If the user fails to provide any of the mandatory variables, such as the commencement date of the contract, the system will ask the requestor to complete all mandatory fields. An example matrix is provided in the following table (Table 2):

TABLE 2. PROCUREMENT REQUEST VARIABLE MATRIX

Variable	Variable Type	Input
Commencement Date	Mandatory	The effective date of the contract
Solicitation of Interest	Optional	The user will be able to deactivate the SOI module based on his or her preference

B. Supplier Registration

Supplier registration is the process of creating supplier accounts. In these, record collection and procurement transactions can be carried out. To register, the supplier visits the buyer's webpage and initiates the registration process (Figure 3). Subsequently, the system will send invitations to identified potential suppliers (from the bidder selection module) with registration instructions to create a supplier account. Supplier databases will keep records of registered suppliers as well as invited ones. The database schema will be constructed with the supplier's general information, such as the commercial license number, list of owners, certificates, financial data, and any other requirements the organization needs (Figure 4). A suitable programming language (e.g., PHP or C#) will be used to develop the webpage, and Microsoft SQL Server or a similar database management system will be used to manage the supplier records.

During the registration process, the supplier will be mandated to fill out the minimum required fields to create their unique record and be assigned a supplier number in the system. After the supplier fills in the fields and submits their request, the system will generate a supplier number and send a one-time

password to the supplier to activate their account. This activity, as well as procurement communication with suppliers, could be configured using blockchain. The process will be autonomous, and the supplier number will be assigned to the supplier without human intervention.

After the supplier's account is created, the supplier will have a designated webpage through which all communications with the buyer will take place. This includes receiving solicitation of interest requests, invitations for proposals, and clarifications to queries.
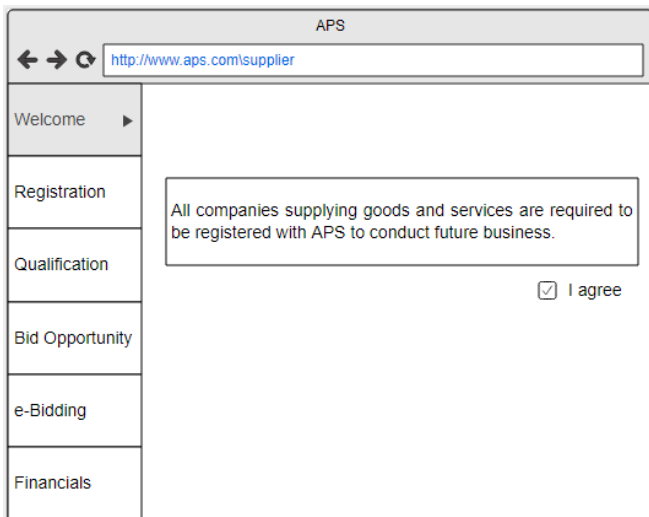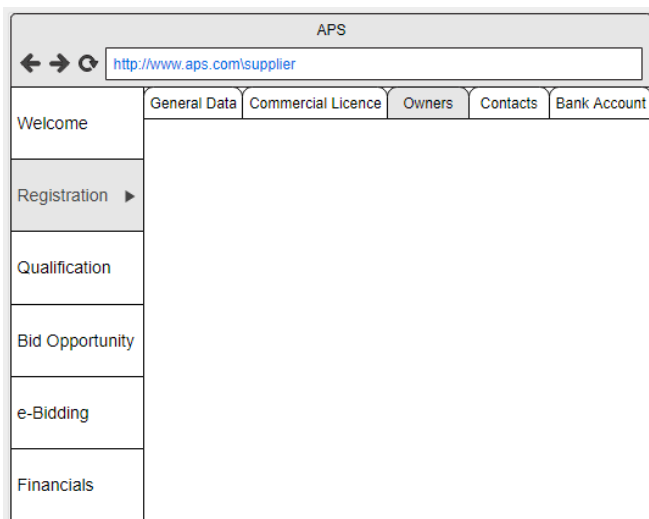

Figure 3 New Supplier Webpage

Figure 4 Supplier Registration Data

However, data verification is essential to ensure that the supplier's records are valid. Supplier data may contain inconsistencies, errors, and out-of-date information, which may ultimately result in exposing the organization to additional risk.

There are two schools of thought when it comes to securing the verification step of the process. The first option is to request the supplier to confirm the accuracy of their data and the legal consequences for submitting invalid information. With this option, verification occurs on the supplier's side rather than being performed by the system.

Where the concurrence of the supplier to bear the legal liability for submitting false information is insufficient, an alternative version of the system allows for supplier input to be verified by sending requests to the applicable government agency. A machine learning algorithm will extract and classify the data that need verification and send a request to the corresponding agency to verify this information (Figure 5).
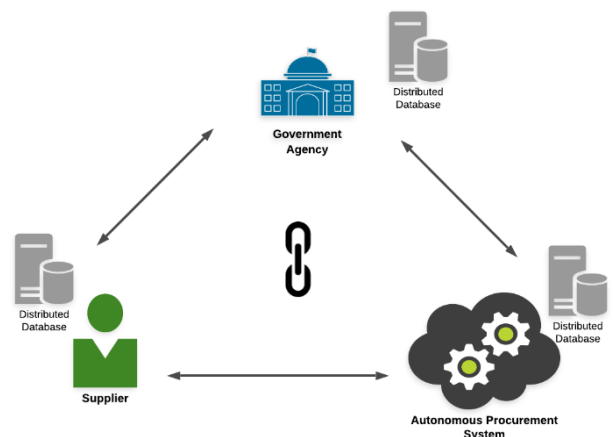

Figure 5 Supplier Registration and Blockchain

Ultimately, when the system is well established, a cloud solution will serve as a single hub between all participants, allowing for shared record-keeping between the registered parties. In the concept of the e-marketplace, verification of data is spontaneous, and alteration to the data requires the consensus of the other party. Blockchain network principles—using a Hyperledger algorithm, for example—will be deployed in this solution. The integration of all parties, including suppliers, accounting firms, registration agencies, and government entities, will streamline the accessibility and verification of the supplier data. The system would act as a single hub for all entities, ensuring compliance with continually changing regulations and policies. The APS could still be developed without the notion of the e-marketplace for the time being, however, since it entails that this solution be adopted by all stakeholders.

C. Bidder Selection

There are three basic strategies that can be used for determining bidders: open bidding, selective bidding, and ad hoc

bidding. Ad hoc bidding is when the potential bidders are determined by surveying the market. This occurs when there are no known bidders who are capable of delivering the requirements of the procurement. In this case, more bidding strategies could be configured. The bidding strategy shall be determined and triggered during the creation of the procurement request. One of the variables of the initial procurement request variable matrix is the procurement type, which is essentially the bidding strategy. For each strategy, a different scenario shall take place, as described in the following:

1)   Open Bidding:

If the procurement request specifies that the procurement should occur through open bidding, the system shall post an announcement on the buyer's webpage with a public invitation to those who are interested in participating in the bidding. The announcement will be generated by the system using a standard template into which certain variables will be exported from the procurement request, such as the location, effective date, and duration of the bidding. It is also important that a summary of the scope of work is visible to potential bidders. Therefore, the procurement pro forma development module will use AI Text Generator GPT—or a similar machine learning algorithm—to generate a summary of the scope of work. Another option is to upload the pro forma generated by the procurement pro forma development module in its entirety, unless there is a special concern, such as confidentiality. In addition, some general instructions, such as the registration of the supplier's requirements, will be published with the announcement on the web page. The website announcement and procurement system can be integrated with various applications, such as PHP and MySQL. For any supplier who is interested in the bidding, registration will be required. A supplier number and access account will be created. The supplier registration will provide the supplier with an access account. All communications between the system and the supplier would take place via the supplier account. The suppliers who are interested in participating in the bidding would go to their account, click on the "Bid Opportunity" button, and select the procurement that the supplier is interested in bidding on (Figure 6). The system will enter the supplier number in the bidder list. The bidder list is a list of suppliers who will subsequently be sent a formal invitation along with the pro forma and proposal forms. This task will take place after an automated due diligence check is conducted. The bidder risk analysis function described below will perform the due diligence process. There could be a need for prequalification, especially in the case of a critical procurement. The need for prequalification will be determined based on predefined criteria. The initial procurement request variables will be used to set up the intelligence to trigger the prequalification process, in which the suppliers who indicated their interest will be requested through a prequalification module to submit their prequalification. The criteria for conducting the technical prequalification could include the procurement value and type of services involved. Those who respond and pass the prequalification, if required, will be on the final bidder list.

Figure 6 Open Bidding, Supplier's View

2)   Selective Bidding:

In selective bidding, the bidders have to be identified by the system. The system will go to the registered suppliers list and select bidders whose registration reflects the services relevant to the scope of work. To automate this task, the system will review the scope of work and use a machine learning algorithm to identify the applicable field of services. The system will enhance this step for future procurements by refining the supplier list based on previous performance. A supplier performance module is essential for generating the bidder list. Other predefined filters could also be introduced, such as the maximum number of bidders or any other conditions that the buyer's contracting policies cater to.

3)   Ad Hoc Bidding:

The last strategy is used when no registered suppliers have been identified for a certain scope. In this case, the system will scrape the internet using scraping software to identify potential bidders. It will then make predictions based on its search and recommend potential bidders that could participate in tendering. A suitable machine learning tool, such as BERT or GPT, will be used to set up the internet-scraping process. Reinforcement machine learning will, by nature, improve module performance over time as it takes historical data into consideration. An invitation will be sent to potential bidders to complete their registration and obtain a supplier account.

For the selective and ad hoc bidder lists, SOIs will be sent to the bidders to confirm their interest.

D. Bidder Risk Analysis

Before finalizing the bidder list, a risk analysis will be conducted by the system. The module will perform a comprehensive search using internet scraping for negative phrases that could be associated with risks, such as bankruptcy, court orders, lost cases, debt, etc., to determine the supplier's overall risk status (Figure 7). Natural language processing and web scraping technologies will be applied for this task.
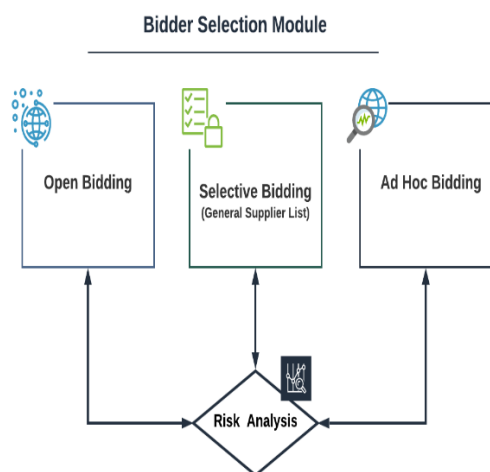

Figure 7 Bidder Selection Module

E. Financial Qualification Evaluation

This task will be triggered for certain procurements based on predefined criteria. For example, it might activate in the case of a lump sum construction procurement where the estimated value of the procurement is more than USD1MM. This activity could be skipped for certain procurements, especially when the financial risk is minimal. The criteria for mandating the financial qualification evaluation as a default requirement will depend on the buyer's procurement policies. In addition, the requestor could also trigger the financial qualification request at the time of initiating the procurement request, even if the company's predefined default criteria do not require financial qualification. In this case, the financial qualification evaluation variable in the procurement request variable matrix will be changed from "not applicable" to "required."

When a financial qualification evaluation is required, a message will be sent to the suppliers of the bidder list requesting them to fill out a financial evaluation form. The financial qualification evaluation form is a spreadsheet where the supplier will input various elements, such as assets, liabilities, operating earnings, and revenues. After submitting the financial numbers, the system will request the supplier to confirm the accuracy of the numbers and the legal implications for submitting false information. Once those variables are entered, the financial

qualification evaluation module will run calculations based on predefined financial ratios, such as profitability, liquidity, efficiency, and debt ratios. Predefined criteria will determine, based on the financial ratios, whether the supplier is financially qualified or not. The analysis will take into account the estimated procurement value and the procurement duration. If the supplier is not financially qualified, the supplier will be excluded from the bidder list. The bidder list will show all suppliers, and an indicator will determine whether the supplier is excluded. The reason for the exclusion will be documented in the bidder list table.

Where the concurrence of the supplier to bear the legal accountability for submitting false information is insufficient, an alternative version of the system permits suppliers to authenticate their financial inputs by submitting a PDF copy of their formal financial statement through their supplier account. However, this statement must have been authenticated by an authorized accounting firm. The submitted financial statement will be analyzed using a machine learning algorithm, such as BERT or a similar algorithm, to extract the essential variables and calculate the ratios. The same standard qualification evaluation form that is supposed to be filled out by the supplier will be filled out instead by the trained machine learning algorithm. The evaluation process and subsequent actions will proceed just as if the supplier filled out the form.

A third option for the module is to receive the input or the financial statement from the accounting firm directly. The system will support registering financial accounting firms to conduct this activity, and the supplier will be given the option to select from the available registered firms. Once selected, the accounting firm will be provided with the same smart form to input the various financial elements of the supplier. This option will work efficiently if the system is built in accordance with the notion of the e-marketplace, where accounting firms and governmental agencies are connected to a platform built on blockchain network principles. Such a blockchain network can be developed using Hyperledger Fabric or similar software. This module will be fully automated and will not require third-party input to determine the financial standing of a supplier, as it will be based on real-time data.

In some jurisdictions, the practice is to request that the awarded supplier submit a performance bond. In such cases, a financial evaluation will not be required. The system will capture the performance bond in the agreement record.

IV. CONCLUSION

This paper provided a brief description of APS (patent pending) with an emphasis on bidder selection. The paper demonstrated that the tools and algorithms for developing an autonomous procurement system are feasible. The authors believe that there could be some challenges in building APS, since AI may be immature in certain areas. Building a prototype

could be the first and correct step to having a fully reliable autonomous solution in procurement. This could also inspire others to find autonomous solutions in other fields that require cogitative capabilities.

REFERENCES

[1] M. A. Al-Sinan and Z. Aljaroudi, "Autonomous Procurement System (APS): Pro Forma Development," 2020 International Conference on Artificial Intelligence & Modern Assistive Technology (ICAIMAT), Riyadh, Saudi Arabia, 2020, pp. 1-6, doi: 10.1109/ICAIMAT51101.2020.9308015. Jan 1, 2021 IEEE Explore

[2] D. Kiefer, A. Ulmer, and C. V. Dinther, "Application of Artificial Intelligence to optimize forecasting capability in procurement," in *Wissenschaftliche Vertiefungskonferenz—Tagungsband*, Reutlingen University, 2019, pp. 69-80. [Online]. Available: ResearchGate, https://www.researchgate.net/publication/336879934_Application_of_Artificial_Intelligence_to_optimize_forecasting_capability_in_procurement.

[3] K. C. Lam, E. Palaneeswarn, and C. Yu, "A support vector machine for contractor prequalification," *Journal of Automation in Construction*, vol. 28, pp. 321-329, 2009. [Online]. Available: http://read.pudn.com/downloads150/ebook/651242/4.pdf.

[4] M. K. Trivedi, M. K. Pandey, and Bhadoria, "Prequalification of construction contractor using A FAHP," *International Journal of Computer Applications,* vol. 28, no. 10, 2011. [Online]. Available: https://www.ijcaonline.org/volume28/number10/pxc3874773.pdf

[5] J. Yang, H. Li, and M. Skitmore, "Expert systems in construction management: Is the hype over?," in *Proceedings of INCIT 96, International Construction Information Technology Conference*, 1996, pp. 131-136. [Online]. Available: https://eprints.qut.edu.au/4546/1/4546.pdf