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Cloud-based Auction Tower for Perishable Supply Chain Trading

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Abstract

Perishable supply chain trading (PSCT) involves typical activities that transfer perishable products among supply chain participants. Enhancing the traversal of perishable products through supply chains is essential for improving the standard of living and economic development. This study proposes a cloud-based auction tower to provide offline and online auction services for exchanging perishable products between suppliers and buyers. Product information service is designed to allow a huge kinds of perishable products to be represented and sold through the auction tower. The flexible auction server enables the deployment of many auction mechanisms. Dashboard-enabled information visibility and traceability facilitate operations and decisions of auction participants. The adoption of cloud computing achieves "pay-as-you-go" and "pervasive-to-access" implementation. The use of the auction tower leads to significant improvement in transaction capacity, market efficiency and effectiveness as well as supply and demand information visibility.

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1. Introduction

A perishable supply chain is a set of business entities (i.e. suppliers, manufacturers, distributors, and retailers) working together in production and delivery of perishable products. It covers the flow of perishable products from the source of supply to the point of consumption. Perishable products have been broadly characterized as products which have finite shelf-life, and/or undergo noticeable physical status worsening, and/or experience remarkable value decrease in the view of customers over time [1]. Typical examples include fruit, vegetables, meat, flowers, perfumes, alcohol, gasoline, photographic films, transportation tickets, hotel bookings, fashion apparel, and electronics products. Perishable products involve not only consumer goods but also industrial products, military ordnance and blood [2] and take up a large proportion of products produced worldwide [3]. Therefore, the performance of perishable supply chains has a significant impact on both the standard of living and the economic development.

Perishable supply chain trading (PSCT) is the process of buying, selling, transferring, or exchanging products, services, and/or information across a perishable supply chain. It can be regarded as a special type of supply chain trading. They share similarities. One is that both of them perform functions that match supply and demand, facilitate transactions and provide an institutional infrastructure [4, 5]. Another similarity is that both of them generally involve suppliers, buyers and a third-party trading service provider [6, 7]. On the other hand, PSCT differs from supply chain trading in a number of ways. Firstly, PSCT is specific to the exchange of perishable products, while supply chain trading concerns a large variety of products [8]. Moreover, besides the price, quality, quantity, time and location of the products, PSCT also considers the unique features of perishable products, such as high fluctuations in supply and demand, long lead time and a short shelf life [9, 10]. Such features, however, are not considered in the supply chain trading process. Furthermore, PSCT is responsible for reducing not only transaction costs but also transaction time, which means the time incurred in exchanging perishable products [11]. In contrast, supply chain

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trading adopts trading mechanisms for lowering transaction costs only.

PSCT, as the linkage between businesses partners, plays an indispensable role in matching supply and demand, facilitating the transfer of perishable products across the supply chain and enhancing the revenue of supply chain participants. Usually, the business relationships in a perishable supply chain are established through long-term contracts [12]. However, when suppliers and buyers make self-interested pricing and production decisions, the efficiency of perishable supply chain contracting suffers [13]. Driven by the prospect of better matches between suppliers and buyers, more flexible and dynamic practices are adopted to automate the PSCT process.

One typical example is using auctions for PSCT, especially for flowers, fresh fish and cattle. In auction markets, supply chain participants transact directly through a centralized intermediary [14]. The adoption of such practices could bring about several benefits. Firstly, the auction method eliminates problems of haggling and reduces bargaining costs in setting the price of perishable products [15]. Secondly, auction-based PSCT can not only reduce the time suppliers spend at markets but also reduce the time buyers spend in bidding or bargaining for products [11]. Hence, they can focus on their own business and perishable products can be exchanged quickly. Thirdly, with prices determined dynamically that reflect the supply and demand at a certain point of time, efficient matching of supply and demand can be realized [16].

Recently, with the advent of the internet and development of information technologies, Internet auctions (i.e., auctions carried out through the Internet) have permeated into perishable product marketplaces. Many Internet auction platforms have been proposed and utilized for exchanging perishable products to reap the benefit of transaction cost reduction and market efficiency improvement. In the literature, Rockoff and Groves [17] described a system for remote Dutch auction which is suitable for selling any type of perishable products. Rodriguez et al. [18] presented a java-based electronic auction house for the fish market. Cuni et al. [19] presented the Multi-Agent System for Fish Trading (MASFIT) for remote bidding in several fish markets simultaneously. In practice, four electronic auction initiatives, namely, the vidifleur auction, the sample based auction, the tele flower auction and the buying at distance auction, were adopted to transform the Dutch flower industry [20]. CALM (Computer Aided Livestock Marketing), an electronic auction system, was launched for livestock trading in Australia [6]. An increasing number of fish auction markets in France have set up their remote bidding system to expand markets since 2007 [21].

Despite significant progress achieved by research and practitioner communities, major challenges still exist in applying auctions/ Internet auctions to facilitate efficient PSCT. Several research questions should be solved before a breakthrough can be achieved in auction-based PSCT. They are summarized as follow.

- How to manage the information of multiple varieties of perishable products in a platform so that they can be represented and exchanged? There are multiple varieties of perishable products. The information needed to represent them in the trading process depends on their types and the trading models (e.g., onsite and remote). For instance, in Dutch flower auctions, the information about product characteristics, the producer, unit of currency, quality and minimum purchase quantity is usually of concern [22]. In fish auctions, the information about varieties, quality and weight should be provided. It is thus a challenge to manage the information of different types of perishable products to represent and sell them easily.
- How to decompose the auction design space into several processes and specify rules for each process in order to construct many auction mechanisms for PSCT? Due to the diversity of PSCT (e.g., different perishable products and different trading models), suitable auction mechanisms should be developed and implemented for each type of perishable product market to improve market efficiency and effectiveness. It is necessary to establish a scheme to create auctions so that they can be configured conveniently and reconfigured easily for different markets.
- How to visualize real-time transaction information to support the operation and decision making of auction participants so that they can maximize their own utilities in auctions? Auction participants (i.e., auctioneers, suppliers and buyers) generally need to make many decisions in the trading process. For example, in Dutch flower auctions, auctioneers must quickly decide on the value of three important variables (i.e., the clock speed, the initial standing price and the lot size) while consider many decision parameters (e.g., historical prices, quality measures, upcoming auctions, and market conditions) to manage the auction process [23]. The inability of obtaining complete and accurate information and processing the large amounts of information promptly will lead to non-optimal decisions.
- How to implement the platform with advanced information and communication technology to providing dependable auction services? Many requirements are placed upon the provisioning of electronic auctions which involve competitive bidding among suppliers and buyers [24]. The first requirement is scalability which enables a large number of suppliers and buyers on a global basis to participant auctions. The second requirement is security mechanisms which ensure the traders' private information to be concealed and reduce the possibility of misbehavior. The last requirement is fairness which guarantees that suppliers and buyers both have equal chance to sell or buy products.

In order to address above questions, this research proposes a cloud-based auction tower to provide offline and online auction services for PSCT, which involves suppliers, buyers and a third party trading service provider. It aims to standardize product descriptions, realize configurable auction creation and facilitate real-time decision making of auction participants. Firstly, three PSCT models involving two types of auctions are proposed to provide a guideline for auction participants. Moreover, an auction tower is developed to

25support these trading models. The auction tower contains three core components which answer the first three research questions one by one. Product information service is designed to make the auction tower suitable for the exchange of multiple varieties of perishable products. An auction server is established for the implementation of many auction mechanisms. A visualization system is proposed to support operations and decision making of auction participants. Finally, a reconfigurable and scalable architecture based on cloud computing is built to increase the flexibility of tower and fulfill the requirements of auctions. For simple, this paper focuses on the exchange of narrowly defined perishable products, the quality of which is highly related to time, temperature and humidity, such as flowers, vegetables and fruits.

The rest of the paper is organized as follow. Section 2 is about the overview of the auction tower. Section 3 presents the product information service for product information management. Section 4 shows the auction server to support multiple auction mechanisms. Section 5 describes the visualization system to facilitate operations and decision making of auction participants. Section 6 considers the system design and implementation issues. Conclusions and future works are given in section 7 to summarize this research.

2. Overview of Auction Tower

2.1. Configuration of auction-based Perishable Supply Chain Trading (PSCT)

PSCT involves typical activities that transfer perishable products among supply chain participants. A commonly-used market type for PSCT is the auction market, which consists of suppliers, buyers and a market intermediary. Suppliers are the providers of perishable products. Buyers have demands for perishable products. The market intermediary provides efficient centers for price discovery and the exchange of perishable products between suppliers and buyers. Auction mechanisms are adopted for perishable product allocation and price determination. The market clears by matching supply and demand, which creates economic value for suppliers, buyers and market intermediaries and for the whole society [4]. For simplicity of discussion, three PSCT models involving two types of auctions are considered in this study.

As shown in Figure 1, Dutch auctions and call auctions are used to automate the PSCT process. The Dutch auction was invented by a Dutch cauliflower grower in the 1870s to trade agricultural products [17]. It is a descending price auction. Central to the Dutch auction is an auction clock which displays current offer price. The dropping of the clock hand means the declining of the offer price. In the Dutch auction, the auctioneer sets an initial high price and then lowers the price continuously. When the buyer calls out and accepts the current price, the auctioneer asks the buyer how many units he or she will purchase. The buyer provides the bid. When the bid is accepted, the auctioneer reset the clock and the process is re-start to sell the remaining units. The call auction is one type of double auction which aggregate offers and bids over time and clear the market periodically. In the call auction, suppliers and buyers simultaneously submit offers and bids respectively which specify a price-quantity pair. The auctioneer determines the transaction price and matches the suppliers and buyers with a suitable matching algorithm. The matching algorithm is a main aspect of the call auction design and consists of a set of rules. Dutch auction is an online mechanism. Meanwhile call auction is an offline mechanism.

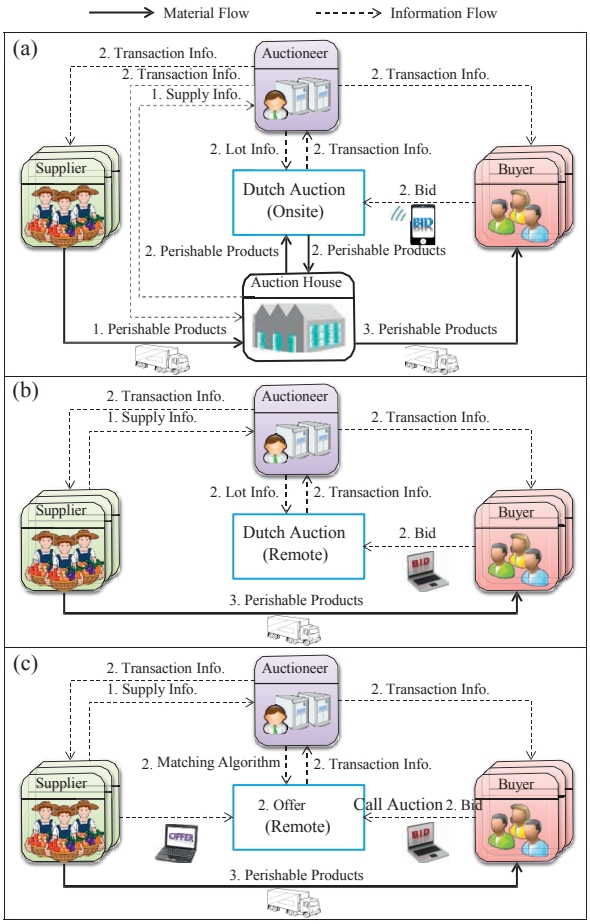

Fig. 1. Overall PSCT models.

As shown in Figure 1, three trading models are designed including one onsite auction market and two remote auction markets. The trading process can be divided into three stages [25]. They are information stage, auction stage and settlement stage. The material flow and information flow are marked with indices “1”, “2” and “3”, which signify these three stages in sequence. In the information stage, perishable products and the information about the products are prepared according to the predefined standards. The information and/or the physical commodities are available to buyers for searching and inspecting. Agreements which specify the conditions of business transactions are reached in the auction stage with proper auction mechanisms. In the settlement stage, the agreements reached are fulfilled.

The information and material flows in onsite Dutch auction market (see Figure 1(a)) is described below in order to

facilitate the understanding of the working process of PSCT in auction markets. In the information stage, well-packaged perishable products are delivered to the auction house firstly. Then they are sorted by category, assigned lot numbers and assembled onto uniform carts for transport into the trading floor. The supply information is prepared in the order of exchange by the auctioneer's staff, which constitutes the auction catalogue. Buyers can search the auction catalogue through the Internet and inspect the products physically. In the auction stage, perishable products are transported to the trading floor, shown to the buyers along with electronic information and sold lot by lot with Dutch auction. Buyers must be physically present on the trading floor to bid for a specific product. The transaction information is announced to all suppliers and buyers once an auction is complete. The auction will continue until all lots have been sold. In the settlement stage, perishable products are grouped by the transaction information and distributed from the auction house to the corresponding buyers.

In addition to the above, many hybrid trading models exist. One example is that onsite Dutch auction and remote Dutch auction are executed simultaneously with accurate product information collected in onsite Dutch auction. Another example is that remote call auction and remote Dutch auction are executed sequentially with products failed to be sold through remote call auction transferred through remote Dutch auction. An auction tower will be proposed to support all these trading models.

2.2. Overall infrastructure of Auction Tower

Auctions have three main constituting elements [26]. They are auction participants (i.e., auctioneer, supplier and buyer), tradable products, and auction rules. Figure 2 shows an overall infrastructure of the auction tower which covers these three aspects of auctions so as to support offline and online trading of perishable products. The overall infrastructure describes how perishable products are properly represented in electronic forms and how suppliers, buyers and auctioneers participate in several auction activities for the pricing and allocation of perishable products based on product information and/or products themselves. The auction tower consists of four layers. From bottom to top, the first layer is perishable products such as flowers, fruits and vegetables. They are the commodities for exchange. The second layer is product information service which is responsible for collecting and standardizing product information. In onsite auctions, perishable products are transported to the marketplace. Collecting basic product information such as the supplier, product name, quantity, broad quality grade, and relevant physical characteristics is enough because buyers can inspect the product quality physically. In remote auctions, perishable products remain at suppliers' locations and are not shipped until the transaction is completed. Accuracy product information which reflects the original products should be collected. Therefore, certain standards for product quality ratings and a trusted party to carry out products inspection are required [6]. The third layer is the auction server which provides auction services for the sale of perishable products. The auction mechanisms are implemented in this layer and specify the "rule of the game". Four core auction processes are identified. They are auction initiating, bidding, clearing and transaction notifying. The settlement of the transaction, such as product shipment and payment, is not considered in this study. The top layer is the visualization system which consists of auctioneer dashboard, supplier dashboard and buyer dashboard. These three sets of facilities are used by three distinct groups of auction participants respectively, namely, auctioneers, suppliers and buyers. Right information content in the right format can be provided to the right person in the right time through the visualization system for instructing operations and making decisions.

3. Product information service

PSCT involves multiple varieties of perishable products. Before auctions, the information of perishable products for sale should be registered into the Auction Tower. Therefore, product information service is built to manage the information of multiple varieties of perishable products, which allows almost all kinds of perishable products to be transferred through the Auction Tower. It consists of product definition stage and product information input stage. The first stage is responsible for standardizing the product information collected and displayed in auctions. The other stage is to collect product information according to the definition of product. The information that describes perishable products can be divided into common information and specific information. Common information includes the supplier, product name, and quantity. Specific information is defined in the product definition stage.

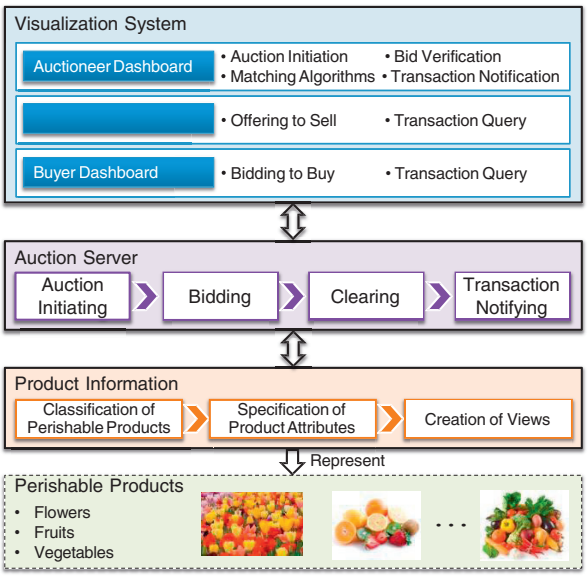

Fig. 2. Infrastructure of Auction Tower.

As shown in Figure 2, product definition stage includes three main modules. The first module is classification of perishable products. It is responsible for developing and

managing the classification structure. For perishable products, the structure is a product category hierarchy. For instance, different flowers are part of the "flower" category, which is part of the "agricultural produce" category. This allows products to be grouped by the species and managed by category.

The second module is specification of product attributes. It is used to specify all common attributes that characterize these categories of perishable products. The attributes of each category have the property of inheritance. That is to say, attributes belonging to a high-level category are part of the attributes of all its sub categories. For example, if the habitat is an attribute of the "agricultural produce" category, it is certainly an attribute of the "flowers" category. An attribute library is established to manage the product attributes. The attributes in the attribute library are classified, and new attributes can be added to enrich the attribute library. Therefore, attributes can be selected from the attribute library and appended to the attribute list of each category conveniently. The attributes of each category should be comprehensive and without duplication.

The last module is creation of views. This module is responsible for establishing views to control the product information required for the exchange of perishable products. Views are created based on the classification structure. Each product category has multiple views. Each view is generated by filtering the attributes of the category that the view belongs to. It is important to note that an attribute can only belong to one view in order to avoid information redundancy.

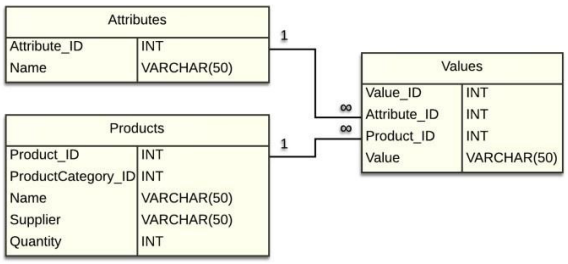

Fig. 3. Product data model.

After defining perishable products, the information of perishable products can be registered into the Auction Tower in the product information input stage. The inputs are the common information and the values of all attributes of that category. To store the product information in the database, two considerations are important. Firstly, although there are a number of attributes used to describe perishable products, only few attributes apply to each category. Secondly, the number of attributes that perishable products have is not fixed. It will increase with the evolution of the product category hierarchy. For these reasons, the EAV (Entity-Attribute-Value) data model is adopted, as shown in Figure 3. The Products table contains the common product information. The specific product information is stored in the Attributes and Values tables. This is the simplest implementation of EAV data model. In reality, the Attributes table is usually supplemented with many metadata tables which describe an attribute in further detail. Moreover, instead of storing all the values as varchar, values can be segregated based on data type to help support indexing and let the database perform type validation checks. Through this model, the number of product category can grow as the database evolves without schema redesign.

4. Auction server

Auction server is an important layer of the auction tower which is responsible for the creation of auctions. Most auctions consist of four core processes, namely, auction initiating, bidding, clearing and transaction notifying.

- Auction Initiating: This process determines the commencement of auctions. Sometimes auctions are started automatically at a scheduled time. Sometimes auctioneers initiate auctions.
- Bidding: The agents (referring to suppliers and buyers as "agents") who have passed the prequalification process are granted the authority to participate. They can submit their offers (submitted by suppliers) or bids (submitted by buyers) based on the initial information provided and their own situations. The offer (bid) will be accepted as long as it satisfies the offer (bid) rules.
- Clearing: In the clearing process, auctions are terminated and exchanges are computed. Matching algorithms are used to determine the resource allocation and the payments between suppliers and buyers.
- Transaction Notifying: Some brief information about transactions is published. In addition, the exchange details are sent to associated suppliers and buyers for transaction settlement.

These processes represent not only the way how auctions are conducted but also the way how auctions are designed. Different auction mechanisms can be implemented by applying different rules to these processes. In order to construct auctions for PSCT, opening rules, bidding rules, clearing rules and notifying rules need to be specified for the four processes respectively. The opening rules determine the conditions under which the auction will be started, such as a scheduled start time or by auctioneer activity. The bidding rules determine the authority to place certain types of bids, the bid content, and the acceptability criteria for submission and withdrawal of bids [27]. The clearing rules determine when to clear the market and which matching algorithm to be adopted for computing the exchange set and the transaction payments. The notifying rules determine what transaction information should be announced to the public and what information should be provided to associated agents.

Two types of auctions have been implemented in the auction server for the trading of perishable products. They are Dutch auctions and call auctions. The Dutch auction is initiated by the auctioneer and uses the single supplier restriction. In this multi-unit auction, the content of a bid consists of two parts, a price and a quantity indicating the units of the products that the buyer is willing to buy at that

price. With the price and quantity submitted sequentially, buyers can withdraw their willingness to buy by indicating fewer or more units than they originally intended to at the time they stop the clock [22]. If the quantity is an integer and greater than the minimum purchase quantity, it will be accepted. The auction is terminated when the auctioneer awarded the designated units of perishable products to the buyer who stops the clock at the price where the clock stops. The information about this transaction such as the price, quantity, and the identities of the traders is published. Moreover, in online Dutch auctions, the exchange details including packaging, transport, storage and insurance are sent to the associated supplier and buyer for executing the transaction.

The call auction is started at a scheduled time and allows multiple suppliers and buyers. Like the Dutch auction, the offer (bid) content is a price-quantity pair indicating the units of perishable products the supplier (buyer) intends to sell (buy) at that price. The suppliers (buyers) can submit and withdraw their offers (bids) at will before the closing of the auction. Only if the offer (bid) has a positive price and an integral quantity, it will be accepted. The time when the offer (bid) is accepted is recorded. The call auction ends at a scheduled time. A matching algorithm is utilized to set the auction price and determine the exchange relationships. The information about transactions such as the product type, price and trade quantity is published. Additionally, the exchange details including packaging, transport, storage and insurance are sent to the associated supplier and buyer for executing the transaction.

The matching algorithm is a main aspect of the call auction which includes the pricing rule, the tie-breaking rule and the allocation rule. The auction server currently supports four pricing rules, two tie-breaking rules and two allocation rules. In these matching algorithms, offers and bids are sorted in non-descending and non-ascending order respectively. The four multi-unit pricing rules are extended from the four single-unit double auction (DA) rules surveyed by Babaioff and Nisan [28]. They are the VCG DA, the k-DA, the trade reduction DA and McAfee's DA. The two tie-breaking rules are the arbitrary rule and the earliest-bid rule. The allocation rules for distributing over demand or oversupply in Huang et al. [29] and Huang and Xu [30] are adopted. All these rules are encapsulated as web services. In the clearing process, the selected rules are triggered to computing the exchanges. In this way, suitable auction mechanisms can be constructed for different PSCT markets.

The auction markets configuration process consists of three steps. The first step is to specify the product category. The second step is to decide the trading models. The last step is to determine the suitable auction mechanism. This step is of crucial importance for configuring auction markets. With auction mechanisms implemented based on auction type, the last step can be further partitioned into two sub steps. The first sub step is to determine the auction type which specifies the basic rules of auctions. The other sub step is to choose individual rules and set the values of corresponding arguments for each auction process. All these trading rules should be released before the opening of the market so that the suppliers and buyers know exactly how the market will operate ahead of time [29].

5. Visualization system

Three sets of facilities have been developed respectively for auctioneers, suppliers and buyers to realize information visibility and traceability. They are auctioneer dashboard, supplier dashboard and buyer dashboard. This visualization system provides auction participants an easy access to the auction market for conducting business. Moreover, information about suppliers and buyers, the supply and demand of perishable products, and past transactions can be found without much effort and shown in an easy-to-understand way for supporting decision making.

5.1. Auctioneer dashboard

Auctioneer dashboard facilities are typically implemented as web applications. Auctioneers are the main users. In a Dutch auction (onsite or remote), the auctioneer initiates the auction by resetting the speed of the clock, the initial price and the minimum purchase quantity. A set of values for these variables are provided for auctioneer to make adaptive decisions in a short time. In the bidding process, if the current offer price is too low to accept or reaches the reserve price, the auctioneer will announce the failure of the auction. If the buyer stops the clock and indicate the units of the lot to buy, the auctioneer will check whether the bid is valid in the clearing process. The auctioneer will award the specified units of products to the winner if the bid is valid. The sold amount is then subtracted from the quantity of the lot on offer. The auctioneer needs to initiate the auction again to clear the auction catalogue. In a call auction, the auctioneer publishes the auction start and closing time, the category of perishable product for trading, and the matching algorithm used. In the clearing process, the auctioneer can view the summary of the offers and bids which are grouped by the product type, and the detailed offer list and bid list. If all offers and bids are valid, the matching algorithm will be selected to computing exchanges. After checking the matching results, transaction information can be released to suppliers and buyers for transaction settlement.

5.2. Supplier dashboard

Supplier dashboard facilities are typically implemented as web applications. Suppliers are the main users. In an online Dutch auction, suppliers provide the common information and the specific information of perishable products for sale. The specific information is prepared according the attributes specified in the product information service. During the auction, suppliers are free to browse the transaction history. When an auction is complete, detailed transaction information necessary to execute the exchange will be sent to the product supplier. The supplier should package and deliver perishable products to the buyer according to the transaction information. In a call auction, the information of perishable products for sale should be provided by the suppliers in the information

stage. In the auction stage, each supplier can view his/her own supply information and determine the offer price of each lot. Suppliers can modify the offer prices during the bidding process. After the auctioneer clears the market, suppliers can view the matching results and prepare the perishable products sold for delivery. Products that are failed to be sold can be made available for offline or online Dutch auctions.

5.3. Buyer dashboard

Buyer dashboard facilities are implemented as mobile applications or web applications. Buyers are the main users. In a Dutch auction, buyers can browse the auction catalogue freely during the information and auction stages. In the auction stage, buyers need to consider current price, quality measures, transportation costs and time, upcoming auctions and market conditions when submit their bids [23]. Mobile devices are adopted for bidding in offline Dutch auctions and computers are used in online Dutch auctions. Buyers can change to any clock on the trading floor in offline Dutch auctions and change to any clock on any trading floor in online Dutch auctions. When the auction is over, buyers can view the detail information about their own transactions and the brief information about all transactions through computers. In a call auction, buyers can view the summary information of products on offer including the types of products and total available inventories. Sealed bids (i.e., price-quantity pairs) will be made for products they want in the bidding process. When the sealed offers and bids are matched, buyers can browse the matching results.

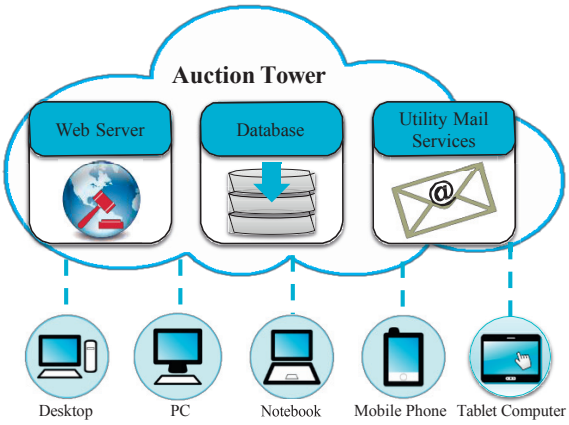

Fig. 4. Cloud-based implementation.

6. Cloud-based implementation

The Auction Tower is a web-based system supported by cloud computing. Figure 4 shows the cloud-based implementation with three categories of constructs. The first category is the web server which is responsible for provide auction services for suppliers and buyers. The second category is the database which manages all data related to the trading, such as product data, user data, and transaction data. The third category is the utility mail services which are in charge of informing auction participants of the progress of auctions. With auctions delivered through the SaaS model, auction participants can access them flexibly through a rich set of user terminals.

The three categories of constructs can be implemented through different service models and deployment models. Firstly, the web server and the database are built on the PaaS layer of cloud computing. The utility mail services are provided directly as services. Secondly, the web server and the database can be implemented in a private cloud or a public cloud. If a private cloud is adopted, the market intermediary is the cloud provider and the cloud user/ SaaS provider at the same time. If a public cloud is employed, the market intermediary is only the cloud user/ SaaS provider. PaaS providers are the cloud provider, such as Microsoft Azure, Google AppEngine and SalesForce Force.com. Auction participants are the SaaS users in both cases. The utility mail services are deployed in public clouds, like Gmail.

The Auction Tower is designed for market intermediaries to manage the PSCT process. With the adoption of cloud computing, the Auction Tower achieves “pay-as-you-go” and “pervasive-to-access” implementation. Several benefits are gained to cloud users and SaaS users respectively. On one hand, cloud users can subscribe the computing resources in a pay-as-you-go manner. In this way, the start-up investment on IT infrastructures to accommodate the auction services can be reduced. Meanwhile, there is no need to worry about over-provisioning for the services that may waste costly resources or under-provisioning for the services that will probably miss potential customers and revenue. Moreover, Quality of Service (QoS) is guaranteed by Service Level Agreement (SLA) between cloud providers and users. For auctions with competitive bidding among suppliers and buyers, high quality of computing environments are required, especially, hardware performance like CPU speed, I/O bandwidth and memory size. With QoS rendered, the responsiveness of the Auction Tower can be achieved which ensures that suppliers and buyers both have equal chance to sell or buy products. On the other hand, auction participants can access auctions which are encapsulated as services in a simple and pervasive way. Most services can be accessed through Internet browser. Although the cloud client software is required to be installed locally sometimes, it is lightweight. Therefore, auction participants can keep their working habits and environments while enjoy the benefit of cloud computing.

7. Conclusions

Perishable supply chain trading in auction market plays an indispensable role for the transfer of perishable products through the perishable supply chain. This study presents an auction tower to provide auction services for suppliers and buyers in perishable supply chain trading. Cloud-based implementation of the auction tower ensure the wide and QoS guaranteed availability of auctions in a cost-effective way. The use of the auction tower leads to significant improvement in transaction capacity, market efficiency and effectiveness as well as supply and demand information visibility.

The auction tower demonstrates several contributions. The first is that the infrastructure of auction tower covers all key elements of auctions and demonstrates their relationships clearly. Perishable products are exchanged between suppliers and buyers through auctioneer-intermediated auctions. The second contribution is the proposed product information service to standardize and manage the information of multiple varieties of perishable products. It allows a wide variety of perishable products to be sold through the auction tower. The third contribution is the design of the auction server. Process-based auction mechanism customization provides a flexible way to deploy many auction mechanisms in the auction tower. The fourth contribution is the dashboard-enabled visibility and traceability which supports operations and decisions of auction participants.

The current work provides a basic platform to support perishable supply chain trading in auction markets. The research will be further extended in several aspects. Firstly, the auction tower is yet to be tested in a real-life auction market. Secondly, the benefits of new auction mechanisms utilized will be analyzed by comparing them with existing auction mechanism. Thirdly, since the data involved in perishable supply chain trading are relatively sensitive, the technologies for enhancing data integrity, confidentiality, and security in the clouds should be in place.

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