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Context-aware auction solution of cooperative fish market monitoring system for intelligent user

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Abstract

This study proposes a context-aware auction solution suitable for the intelligent user. The solution informs the most reasonable prices for brokers after considering the size of each species of the catch along with other information and their effects on the fish price. This solution is expected to improve the safety of the catch and increase the competitiveness of auction sites by introducing a digitalized auction system to replace the traditional analog system which could be unsanitary sometimes. The solution's Unified Modeling Language has been developed with Java Android and the data obtained from the proposed solution is useful in simplifying the bidding process, avoiding overheated bidding, or stabilizing the fish prices for consumers in the distribution process starting from a broker, distributor and then to consumers. Such a simplified procedure will be able to maintain the freshness of the catch and strengthen the food safety as well as the competitiveness of auction sites, assisting brokers who often experience some difficulties in making a decision on the bidding price due to many variables. This study has focused on the new paradigms, software, middleware and systems for intelligent user. Thus, cost reduction was considered mainly in terms of software engineering. The proposed system is to be supplied with a price 30% less than the existing systems.

Keywords: Context-aware, Auction solution, UML, Java Android, App, Solution, Software engineering, Intelligent user

Introduction

Despite the continuous downsizing, the primary industries have an indispensable relationship with the survival of mankind and recognized as ones that have to be sustained. Yet, these relatively neglected industries including agriculture and fisheries are required to respond to the paradigm shift actively in order to avoid the errors they have made in the past.

Various types of elements involved in the application of information technologies to improve the quality of human lives are required to consider the issues in a varied computing/information processing environment and technology and such a concept pervades human-centric computing. Our context-aware auction system proposed to Busan

Table 1 The current auction system used at BCFM

1. Port entry (fishing boats)	Docking: Assign each docking location
	Reporting: Determine the catch of each species
2. Unloading and arranging	Unloading and arranging
3. Collect all the products at an auction site	Collect all the products at an auction site
4. Auction	Starting time: 06:00 AM
	Method: Finger-based bidding
	Number of bidding: unlimited (simultaneously for each type of business)
	Successful bidder: One with the highest bidding price
	No. of auction dealers: 7 (taking a turn every day)
5. Payment (BCFM to consignor)	Calculation: Computer-processed
	Payment method: Direct (approx. 30 min. after the completion of the auction)
6. Payment collection (wholesaler → BCFM)	Calculation: Computer-processed
	Billing: After the completion of the day's auction)
	Collection: Before starting next day's auction
7. Shipping	Shipping destinations: All parts of the country

Cooperative Fish Market will be able to manage time and costs efficiently to make successful bidding rapidly, which allows the products to be maintained in a good condition and not to be discarded or downgraded.

As the individual solutions for those issues, a variety of algorithmic and computational frameworks supporting cloud/cluster/mobile computing are available for developing a more efficient algorithm for the methodology focusing on solving optimization, machine learning, prediction and control, decision support, meta-heuristics, or security problem. Although the scale of the primary industries is being continuously downsized, they are imperative to human survival and should be sustained in good condition. Especially, the fisheries products distribution sector is required to actively respond to the ever-changing paradigms in the market for not to repeat some of their mistakes made in the past [1, 2].

As a typical labor-intensive industry, the fisheries industry is expected to be largely influenced by the 4th Industrial Revolution where technological polarization could determine its success or failure. In the Republic of Korea (ROK), fishes are being sold on a commission at each regional cooperative fish market operated by regional Fisheries Cooperatives for distribution [3–5]. The Busan Cooperative Fish Market (BCFM) is the largest marine products auction site in the ROK jointly operated by five different cooperatives including Busan Fisheries Cooperative and approx. 2800 to 3200 Mt of marine products are brokered daily, occupying about 30% of entire domestic auction sales [6–10]. However, this market has been losing its competitiveness due to deterioration during over 45 years of analog operation processes in unloading, bidding, and payment systems.

Also, the issues pertaining to food safety focusing on maintaining the products' freshness has become one of the major problems for this market while it endeavors to strengthen its competitiveness. The auction procedure of the BCFM is shown in Table 1. Meanwhile, Fig. 1 shows original fish display at Busan Cooperative Fish Market.

Also, the auction is conducted by auction dealers and 100 brokers who bid prices with their fingers (traditional auction) which should be changed following the modernization

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Fig. 1 Original fish display at Busan Cooperative Fish Market

project led by the government. Thus, it is necessary to data the catch classified by species and sizes before the auction is held to offer more convenience to both brokers and consumers.

That is, sending the information about the elements that affect production and consignment sales rate [e.g., number of fishing boats, Catch per Unit Effort (CPUE), production, production amount, etc.] to the server along with their substitutes (i.e., the production and prices of farmed marine products) and present the approximate values that can be helpful for the auction.

The proposed solution provides a reasonable bidding price to the brokers based on the information about the catch (e.g., size, weight, etc.) and other factors that may affect the price. Also, by introducing a digitalized auction procedure, the current unsanitary analog method can be avoided, improving the food safety level as well as the competitiveness of the consignment sales houses.

The context-aware auction solution proposed to Busan Cooperative Fish Market is an improved system from the existing ones and it has been implemented with a Java Android-based UML. The big data generated from this system is expected to stabilize the prices by simplifying the auction procedure or reducing excessive competition. Such a simplified process will contribute to maintaining the catch in fresh condition or enhancing the competitiveness of the auction houses around the nation while assisting brokers or wholesalers who are having difficulty in deciding their bidding prices. Figure 2 shows functional system diagram.

Related research

The term 'Context' used in a context-aware service refers to all the information available to the user at the time of interaction, including the information associated with a person, location of an object, identification, activities, conditions, etc. context-aware-based service is a service that collects and exchanges such information to recognize a situation and provide an appropriate service after subjecting it to the process of analysis or inference. The types of situations can be classified into the situation of a user, physical environment, computing system, user–computer interaction information, etc. [11–13].

Context-aware technology is an indispensable technology when creating an IoT environment its early type was 'The Active Badge System' developed in the UK as part of office automation. This technology tracks an employee's location through his/her badge [14]. A domestic research on this technology led to the development of 'Context-Aware

Fig. 2 Functional system diagram: proposed system
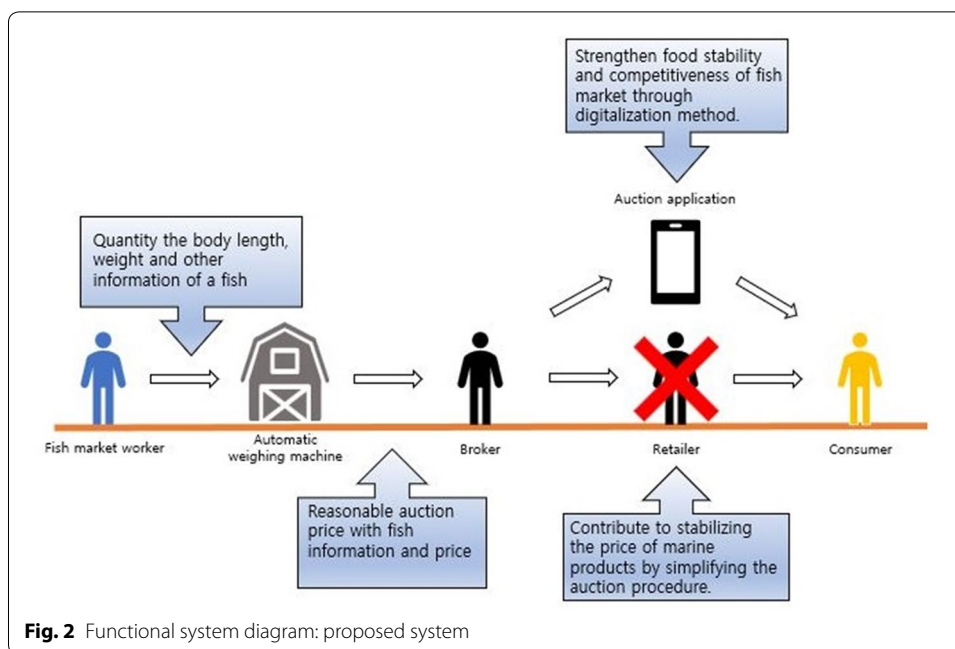
Middleware for URC System (CAMUS)' by the Electronics and Telecommunications Research Institute (ETRI) of the Republic of Korea for the 'Ubiquitous Robot Companion' project [15]. As a standard platform supporting a network-based u-Robot to recognize the situation, CAMUS assumes the role of an engine that analyzes and stores the information obtained through a sensor to notify events. Most of the modern context-aware technologies use next-generation mobile devices like smartphones. In 2003, the US's CMU developed 'Sensay' which was able to automatically adjust the status of a portable device after detecting the user status through its sensor [16]. That is, the cell phone was blocked from ringing or switched to auto answer function when a meeting started. JCAF [17] is a Java-based context-aware programming framework that provides an infrastructure and API for the development of context-aware programs and has been supporting the context-awareness function effectively since 2005. Meanwhile, a context-aware resource management middleware 'CARMEN' re-organizes the altered environment in a wireless environment based on the contents of a metadata. Currently, the studies on modeling or inferring the a situation with a more meaning context instead of applying the data obtained from the sensor directly are in progress. For example, MOnCa [18] and Wang [19] proposed an ontology-based context model and a low/high context inference technology using an inference approach based on descriptive logic or rules [12, 20].

Busan Cooperative Fish Market (target market)

Busan Cooperative Fish Market was opened in 1963 and has been handling about 30% of entire consignment sales over a half-century, having a long history and tradition as a local market. They are still largely contributing to national economy and Korean fishing industry by maintaining high-quality products and seamless distribution system.

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Seas are the infinite-dimensional repository of natural resources the eternal home of Korean dreams and hope. Busan Cooperative Fish Market starts when the fishing boats return to the port with the boatful of fish. The construction plan for this modern market was decided on Oct. 21th, 1959 at the Cabinet meeting and opened on Nov. 1st, 1961 with the name Busan General Fish Market, aiming to increase fishermen's income and protect consumers [21].

Also, following the revision of the Fishery Cooperatives Law (2017), they are in the midst of changing themselves into a corporative joint business corporation after receiving a government fund [22].

Following the revision of Fishery Cooperative law, the name was changed to Busan Cooperative Fish Market and moved to Namhang, the current position, due to the renovation of Busan port. It is now operating jointly with its affiliated company Busan Joint Fish Market which was constructed in 2008 [21].

Busan Cooperative Fish Market has a characteristic of a joint business and some of their five major members are Busan City Fisheries Cooperative, Gyeongsannamdo Stationary Net Fishery Cooperative, Large Surrounding Net Fishery Cooperative, Large Trawlnet Fishery Cooperative, and Seonamgu Trawlnet Fishery Cooperative.

Also, their related groups include Busan Cooperative Fish Market Brokers' Association, Busan Port Labor Union Fishery Branch, and Retailers' Cooperative consisting of retailers operating next to the fish market annex.

Busan Cooperative Fish Market size is approx. 64,247 m^2 where the building areas are totaling to 66,195 m^2. They carry out fishery product consignment sales along with a fish processing business by fully operating a 1016 m-long pier to which twenty-three 150-ton ships can come alongside simultaneously, consignment sales house with the sales capacity of 160,000 cases per day, 130-ton live fish tank, and a refrigeration factory with the size of 6629 m^2. To operate their businesses smoothly, they have three main departments (i.e., General Affairs, Sales, and Engineering) [21].

The main task of Busan Cooperative Fish Market's consignment sales is to receive the information regarding the daily catch by species when ships enter the port and rapidly transfer fishes to the land by using a conveyor belt or other means and array them at the consignment house by species and their grades. Then, the producer and the market sides check the quantity together to complete the listing process. Auction starts after this process by ringing the bell and the finger-based signs are exchanged, among which the highest price is chosen as a successful bidding price.

Depending on situations or species, only the samples are displayed for the auction and those fishes which have received a winning bid will be delivered to the consumer markets or processing factories directly by road, increasing the efficiency in the distribution process as well as in utilization of the consignment sales area.

Also, this market is putting its best efforts to further modernize the distribution system by complying with Hazard Analysis Critical Control Points (HACCP) by automatically classifying the grades of a single fish species while they are being bred [23].

Once the auction is completed, the fishes are packed separately to transport them to every corner of the country. The packing materials used for this work include the paper boxes that can maintain the fish in a frozen state, plastic boxes for close-range delivery, or the Styrofoam boxes used for long-distance/overseas transportation. The Styrofoam

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boxes are excellent for keeping the low temperatures and quite sanitary so that they are suitable for packing fishes for long-distance delivery and strongly recommended by the fish markets to maintain freshness and quality.

The money from the sales is checked by comparing it with the winning bid recorded by the auctioneer and the account record drawn up by the auction secretary. If the calculation is correct, it is entered into the computer for a quick settlement to allow the broker to check all the details of his/her transaction and make a payment that will be paid to the producer after deducting the commission. The computer inputs are widely used by related institutions or organizations as statistical data.

About 60+ fish species including a variety of mackerels, squids, cutlassfishes, blackthroat seaperches are listed at the Busan Cooperative Market and approx. 90% of mackerels are distributed through it. Also, this market is handling about 25% of entire consignment sales of fresh fishes within the ROK placing itself as the top fish market.

To this day (2019), the consignment sales commission (3.4%) imposed by Busan Cooperative Market is the lowest rate among the entire fish markets in the ROK, about 37% of which is returned to the fisheries cooperatives or affiliated organizations to improve the welfare of fishermen.

The refrigeration factory is operating fish processing, refrigerating, and cold storage business as well as ice-sales business with its ice-manufacturing facility.

In addition, to improve the accessibility of users, a homepage was opened to allow visitors to check the current state and statistics of Busan Cooperative Fish Market conveniently. The market's automatic answering system provides a variety of information to the callers as well and the proposed system can do the same with its smartphone application.

The conceptual diagram of clean fishery products consignment auction center
A fishery products auction center for consignment sales is the core facility in every marine product producing area and handles approx. 87% of the total fishery products taken at the Korean (South) coastal waters. However, most of 222 auction centers located nationwide are becoming decrepit increasingly, making the product quality worse. To deal with this problem, the ROK government is to proceed with the project 'Construction of Clean Auction Center Model' under their 'Primary General Plan for Development of Fishery Products Distribution (2018–2022)' and 'Fisheries Innovation Plan 2030 (2019–2022)' to establish a pilot model for the purpose of achieving an innovative sanitary control all across these centers. As shown in Fig. 3, the project starts from this year until 2020 for a period of 2 years with a budget of six billion won. In the model, the consignment auction and unloading spaces will be separated while establishing a low-temperature auction facility and the purified seawater will be available for use. This clean consignment auction center is expected to be further equipped with the other advanced systems in the future" [24].

4th Industrial Revolution
The 4th Industrial Revolution refers to a new form of the industrial revolution through intellectualization of systems based on big data and AI. As shown in Fig. 4, the 1st Industrial Revolution was a starting point of the machine-based production systems such as hydraulic or steam-powered manufacturing systems. The 2nd Industrial Revolution

Fig. 3 The conceptual diagram of clean fishery products consignment auction center

Fig. 4 Phased changes of industrial revolutions
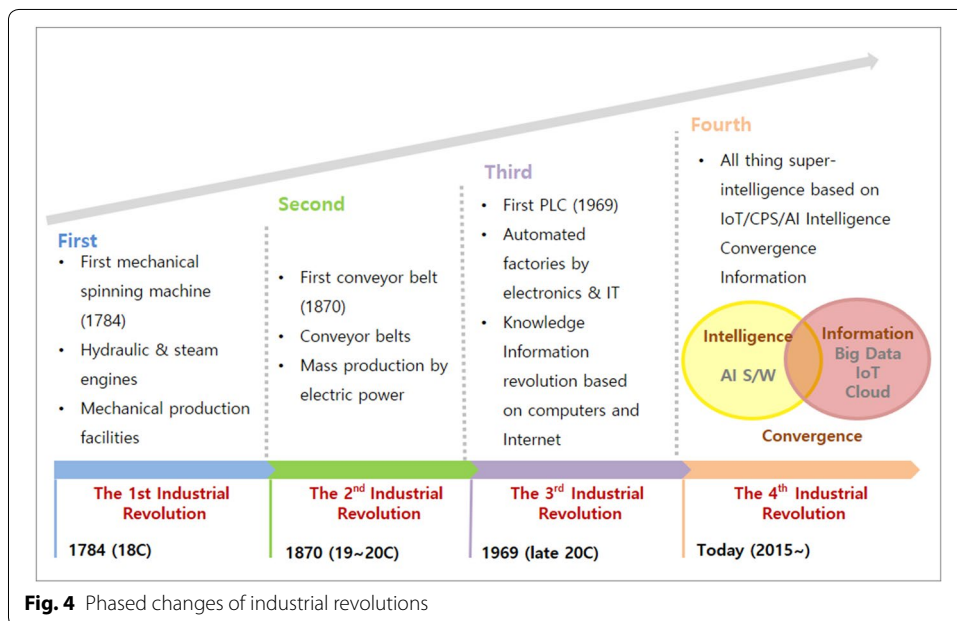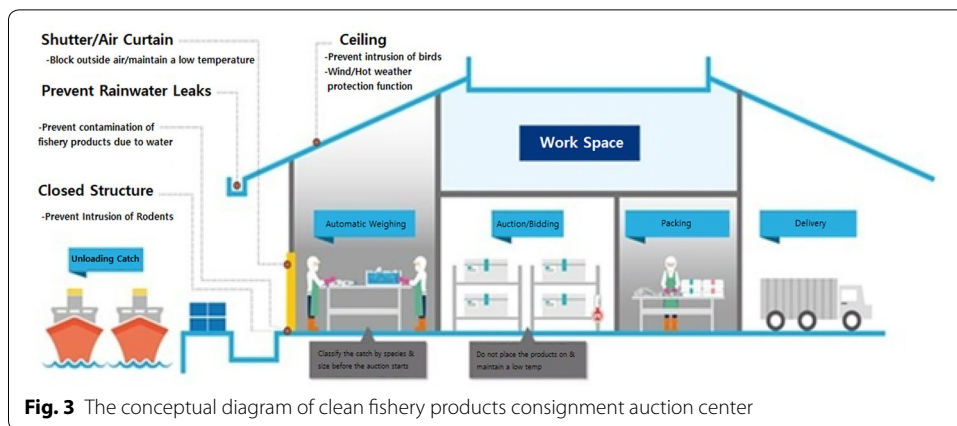
achieved a mass-production system by using conveyor belts and electric power whereas the 3rd Industrial Revolution focused on the factory automation based on the electronics and Information Technology (IT). The 4th Industrial Revolution further added advanced Information & Communication Technology (ICT) to such a factory automation system.

In the 4th Industrial Revolution, the machines and the products have some sort of intellect and data is shared through networks. This brings a new paradigm between consumers and suppliers.

Also, the 4th Industrial Revolution changes the existing mass-production method to achieve a customized small-quantity production with which production and delivery can be processed flexibly and rapidly. To meet the requirements of the 4th Industrial Revolution, the accurate market demands and customer orders should be estimated first by using IT systems, perform a smart production based on the automated system, and

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establish an AI-based production system which can deliver goods to the places where there is a shortage in stock timely and efficiently. Especially, it is important that a smart production system should establish a rapid supply system to optimize the efficiency of resources such as production materials [25].

Solution

Until quite recently, most of the software was developed by the institutions or firms due to their respective necessities. The flow is that an IT consultant informs the necessity of a certain system to his/her customer who would then secure a required budget to proceed with a System Integration (SI) project. However, the requirement of additional investment to an ICT system constructed almost completely to some degree has been reduced quite a lot and as a variety of new ICT technologies such as open platform, cloud, etc. have emerged recently, the number of cases pursuing SI is becoming rarer than before [26, 27].

On the contrary to this, the number of solution software used by the public increasing as more and more personal mobile devices are being released on the market almost every day [26].

Since the customers for a certain solution are not usually fixed in advance, the process or method of developing a solution is a little different from the SI project: much time is often spent for understanding/analyzing the customer requirements when proceeding with an SI project but a lot time is required for developing, delivering, or upgrading a solution as it is essential to develop a software which can be used by many users for all long period of time by providing necessary services or periodical upgrading.

The fishery product distribution law in the Republic of Korea

The enactment of a fishery product distribution law in the Republic of Korea (ROK) has been one of the fishing industry's long-cherished businesses as the current Farm Safety Law and the other laws associated with the distribution of fishery products do not properly reflect its actual characteristics. In fact, the Farm Safety Law was made mainly for fruits and vegetables but they are fundamentally different from fishery products. The former is associated with distributing 'living and breathing products' whereas the fishery product distribution deals with 'dead products' except live fishes or shellfishes. Thus, there are many differences in their transaction methods, distribution systems, low-temperature distribution systems, or quality/sanitary control standards. The livestock distribution is more similar to the latter. There have been many problems in the ROK's fishery distribution system and its development is rather slow even after experiencing many changes. The fishery market had once changed into a retailer-oriented market but the current consumer trend is forcing it to make another change. With all the past changes, the Korean fishery distribution system is still not making much progress and the fishermen are going through difficult times [28].

There are several ways of setting prices through transactions at the wholesale market but one of the typical ones is the auction system for the listed products. Actually, listing and auction are clearly separate processes but many see them as one [28, 29].

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Listing is a sort of a sales method consigned to the wholesale corporations entrusted by the producer. As it is an act of a shipper/producer to ship the products to the wholesale markets, such an act is carried out prior to the auction. That is, as the auction can be performed after the products are listed, listing process must come first. Auctioning is the typical way of determining prices but there are other methods available (e.g., optional sales, fixed-price sales, etc.) [30].

Smart agriculture and fisheries

The difference between the ROK and some of the advanced countries' distribution systems is that the former's distribution process is relatively complex forming a multi-level market: The catch by the Korean fisheries company is usually gathered, auctioned, and distributed at the affiliated local fish market while it is still fresh or cold. The size and species of the catch can be of a wide variety depending on a season of the fishing operation. In the case of the advanced countries, many fishing companies have their own unloading, sorting, packing, and processing factories equipped with cold storages, a One-Step distribution system which enables the systematic fishing operation as well as planned or controlled production, distribution, and logistics.

It is quite difficult to plan production for a particular size due to the fluctuation in the values of marine products: the price can be changed depending on the freshness. Also, the consumption and distribution of marine products are quite complex and carried out on a small scale by many participants who specialize in collection or distribution of some particular product categories and have their own distribution channels [31]. The association between distributors is very tight so that the volume, price, and financing from the point of production to the consumers are often determined by them. The normal distribution step of marine products is that the first auction is held at the port market where individual fishing boat anchors whereas the second and the third auction are performed at the wholesale market after going through several distribution channels before reaching the consumers [32–34]. The current distribution system and auction system is described in Fig. 5.
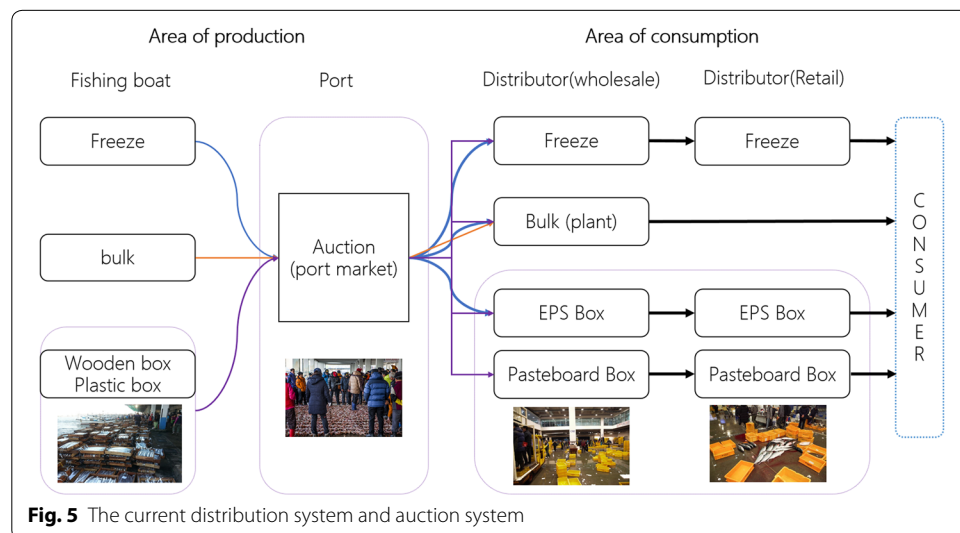

Fig. 5 The current distribution system and auction system

Meanwhile, Japan has been utilizing unmanned helicopters or drones for farming since about 20 years ago. The perform crop-dusting or pest-control with a special multi-spectrum camera which can take the images of various types of wavelength including infrared and UV rays. Also, farmers can plant seeds over a wide area if the drones are mounted with a sowing machine and such a method is more effective for the large-scale farms often seen in the US, for example [35–37].

The multinational companies such as Monsanto, Dupont, John deere, etc. have introduced a big data-based 'Prescriptive Planting' to the farmers they are contracted with for the cultivation of corns or soybeans: Monsanto has offered a big data-based information network named 'FieldScript' which includes the condition of the soil, status of crop growth, weather information along with a chart describing the weather changes for the past decades and the opinions of agriculturists. They expected that the annual increase in production worth about 20 billion dollars (approx. 21 trillion won). Dupont developed and distributed unmanned planting machines and the field-plowing tractors which operate on a Global Positioning System (GPS) information, in addition to their weather information solution 'The Progressive Farmer' [38–42].

There are several other innovative examples such as a weeding robot with a machine-learning engine 'Lettuce-Bot' (Blue River Technology) or a GNSS-based automatic soil-analyzing robot which was developed by Bosch and a certain university jointly. These kinds of intelligent farming systems converged with some of the cutting-edge technologies such as the robot, big data, artificial intelligence, or Internet of Things (IoT) minimize human intervention and perform their own control to maximize efficiency [43–45].

The 4th Industrial Revolution has brought innovation not only to the agriculture industry but also to the fishing industry. Some of the Northern Europe countries including Norway and Iceland have systemized their marine products management systems by introducing the IoT, robot, and big data-based core technologies for the sensing, network, security, and service interface purposes [46, 47]. Especially, the smart aquaculture system and its platform developed by Norway's leading marine technology company AKVA Group allow efficient automated underwater feeding, production management as well as remote monitoring/controlling. This system has strengthened the company's competitiveness with its automated management system used for hatching or shipping process based on the datafied growth and development information of each species, the farm operating information, and big data analysis [48].

Agent and multi-agent

It has been understood since 1990 that the research on an individual agent is a special and independent task when dealing with artificial intelligence (AI) as its course of behavior is determined by the knowledge and information acquired through learning. This kind of characteristic distinguishes an agent from an object who tends to carry out predefined interactions. There is no universal agreement on the definition of agent yet but there are some concepts that are being supported by the majority of researchers and one of them is by Russell and Norvig [49] who defined an agent as a system that utilizes a sensor to understand its current environment and responds in concordance with it through effectors. At the same time, it is a common view that agents can be largely divided into a physical agent (i.e., robot, vehicle, etc.) or a virtual agent (software,

computing module, etc.). Meanwhile, Distributed Artificial Intelligence (DAI) is a subfield of AI providing distributed solutions for a specific problem by applying an AI algorithm or a multi-class problem solving technique. The definition by David [50] was that DAI could be distributed in a multi-agent system (MAS) and can be classified into space, time, means, resource, and comprehension [51].

Rosenschein [52] argued that a DAI system needs to have at least two or more autonomous agents with a certain knowledge in addition to some degree of inference and planning abilities. DAI is further divided into distributed problem solving (DPS) and multi-agent system (MAS) [51].

In DPS, a specific complex problem is divided into a set of subproblems to allow the distributed agents to provide their respective solutions. The ultimate solution is then obtained by minimizing the inconsistencies among them. Meanwhile, MAS arrives to the final solution based on a comprehensive solution deduced by computing individual solutions. In such a method, it becomes necessary to coordinate the knowledge, capacities, objectives, and schedules of individual agents involved as they are unable to deal with the complex problem independently without collaborating with each other by making necessary adjustments. In this regard, MAS can be regarded as a goal-directed system that promotes system efficiency to deduce a reasonable solution in a collaborative and autonomous manner. To be specific, the overall system status is analyzed and evaluated by the agents distributed in a multi-agent system based on the available data collected to deal with the problem through collaboration [51].

Being an autonomous computing system, MAS is composed of a distributed environment where a series of interactive agents exist to provide a solution that cannot or difficult to be deduced by a single agent or system. In many cases, a unit program is utilized in a multi-agent system to make an independent judgment or decision while the user and agents interact together in a collaborative manner. Such a framework can therefore be useful as an expert support system operating on a real-time basis.

The MAS introduced in this research work is for the Android operating system and consists of a series of agents interacting together intelligently to provide a solution to a complex problem. Such a problem is often difficult or impossible to solve without collaborating with each other and also, a unit program is required to form an independent judgment or a decision. One successful example of this is the context-aware auction solution developed especially for the cooperative fish market monitoring system, which is an efficient real-time expert support context-aware system enabling the human agent collaborative interactions.

Proposed system architecture: context-aware auction

A broker enters the information regarding the condition of fish he/she intends to purchase, buyer, species, body size (1–6), use, and the variables involving the current economic situation through a mobile device based on his/her subjective judgment and transmits them to the main computer where the data which could affect fish price are collected and delivered to the DB by Module_1 and 2. At this time, the development of each element that might affect fish price is calculated and formulated by the former. The user can turn on or off either module. The closet data to the received data is then traced from the past record and the unit price entered by the user for a specific species will
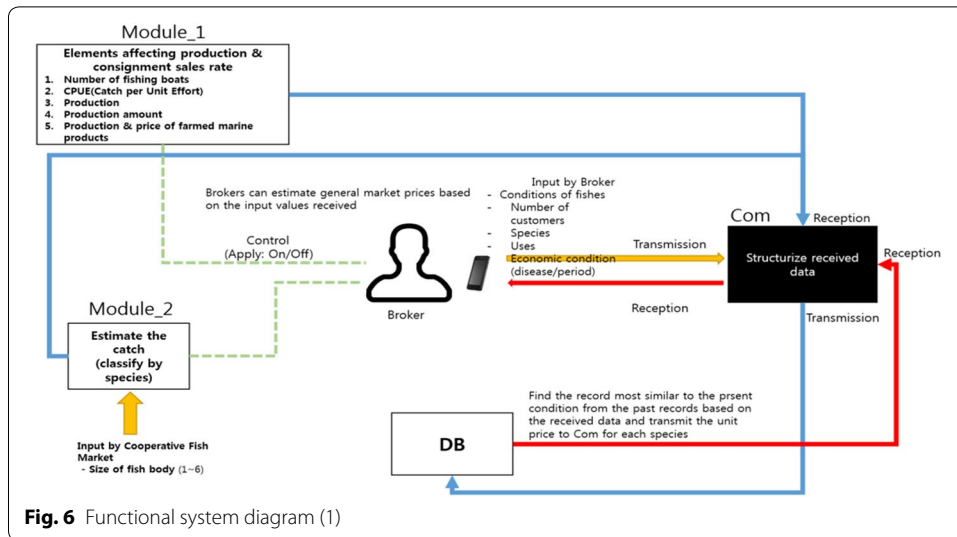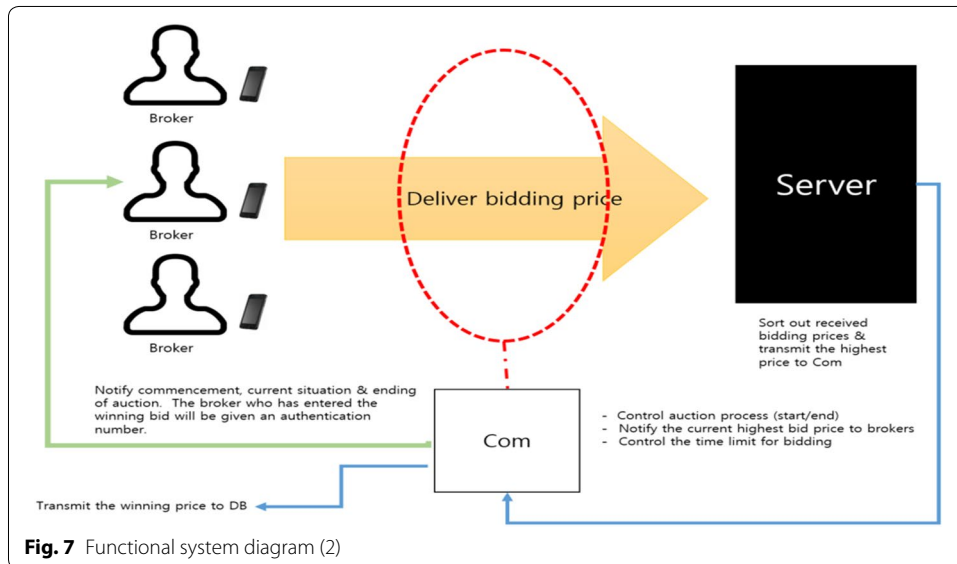
Fig. 6 Functional system diagram (1)

Fig. 7 Functional system diagram (2)

be delivered to the broker's mobile device through the main computer. After receiving the unit price, the user can check the expected market price on his/her mobile device whereas the broker can apply a more subjective change based on that price, modifying the resulting value.

After determining the predicted value, the broker participates the auction and transmits his bidding price to the server through his/her mobile device. The server lists up the bidding prices entered within the auction time limit and then selects the winning price which is transmitted to the auction-control computer. The user who has entered the winning price is provided with an authentication number authorizing him/her for the payment. The purchase is finalized when the broker settles the payment. Figure 6 shows functional system diagram 1. Also, Fig. 7 shows functional system diagram 2.

The system flowchart includes the process proposed to Busan city. Its basic flow was implemented with Jave Android, as well as UML for the application for simulations. After finalizing the application design, a patent will be applied for both domestic and foreign registrations. Also, if our proposal is accepted, it is expected to be used at the new context-aware auction house in Busan.

Flowchart and Pseudo code of Cooperative Fish market monitoring system

The application of context-aware auction solution of the Cooperative Fish market monitoring system uses the solution's Unified Modeling Language (UML). The application has been developed with Java Android, and the data obtained from the proposed solution is useful in simplifying the bidding process, avoiding over-heated bidding, or stabilizing the fish prices for consumers in the distribution process starting from the broker, distributor, and finally to consumers. Such simplified procedure will be able to maintain the freshness of the catch and strengthen food safety as well as the competitiveness of auction sites, assisting brokers who often experience some difficulties in making a decision on the bidding price due to many variables. To explain the details and flow of this application, this report will show the create Pseudo code and flowchart of the application process.

The flowchart shows the steps as boxes of various kinds and their order by connecting the boxes with arrows. It is used in analyzing, designing, documenting, or managing a process or a program in various fields.

The flowchart for the Unified Modeling Language (UML) of application of context-aware auction solution of the Cooperative Fish market monitoring system is shown in Fig. 8.

The items and flows included in the flowchart are as follows: First, Broker will log into the application with his/her ID and password. Broker will choose whether to Make a bid or not. If it is a yes, User will Search Fish species. Broker enters the information regarding the condition of fish he/she intends to purchase, buyer, species, body size (1–6), use, and variables involving the current economic situation through a mobile device based on his/her subjective judgment and transmits them to the main computer where the data that could affect the fish price are collected and delivered to the DB. At this time, the development of each element that might affect the fish price is calculated and formulated by the former. The closest data to the received data is then traced from the past record and the unit price entered by the user for a specific species and will be delivered to the broker's mobile device through the main computer. After receiving the unit price, the user can check the expected market price on his/her mobile device, whereas the broker can apply a more subjective change based on that price; thus modifying the resulting value. User will be shown Auction information, and he/she will choose Bidding or not. If it is a Yes to bidding, User will input the bidding price based on the conditions and recommend prices of application. If it is a No, the user will return to Fish Specie Search and go to the return menu. If it is a no to Make a bid, My ongoing auction, the user will see the List Auction. User will choose whether to Re-bid or not. If it is a yes, the user will move to the Auction information. User can add the information regarding the condition of fish he/she intends to purchase, buyer, species, body size (1–6), use, and variables

Fig. 8 Flowchart of Cooperative Fish market monitoring system
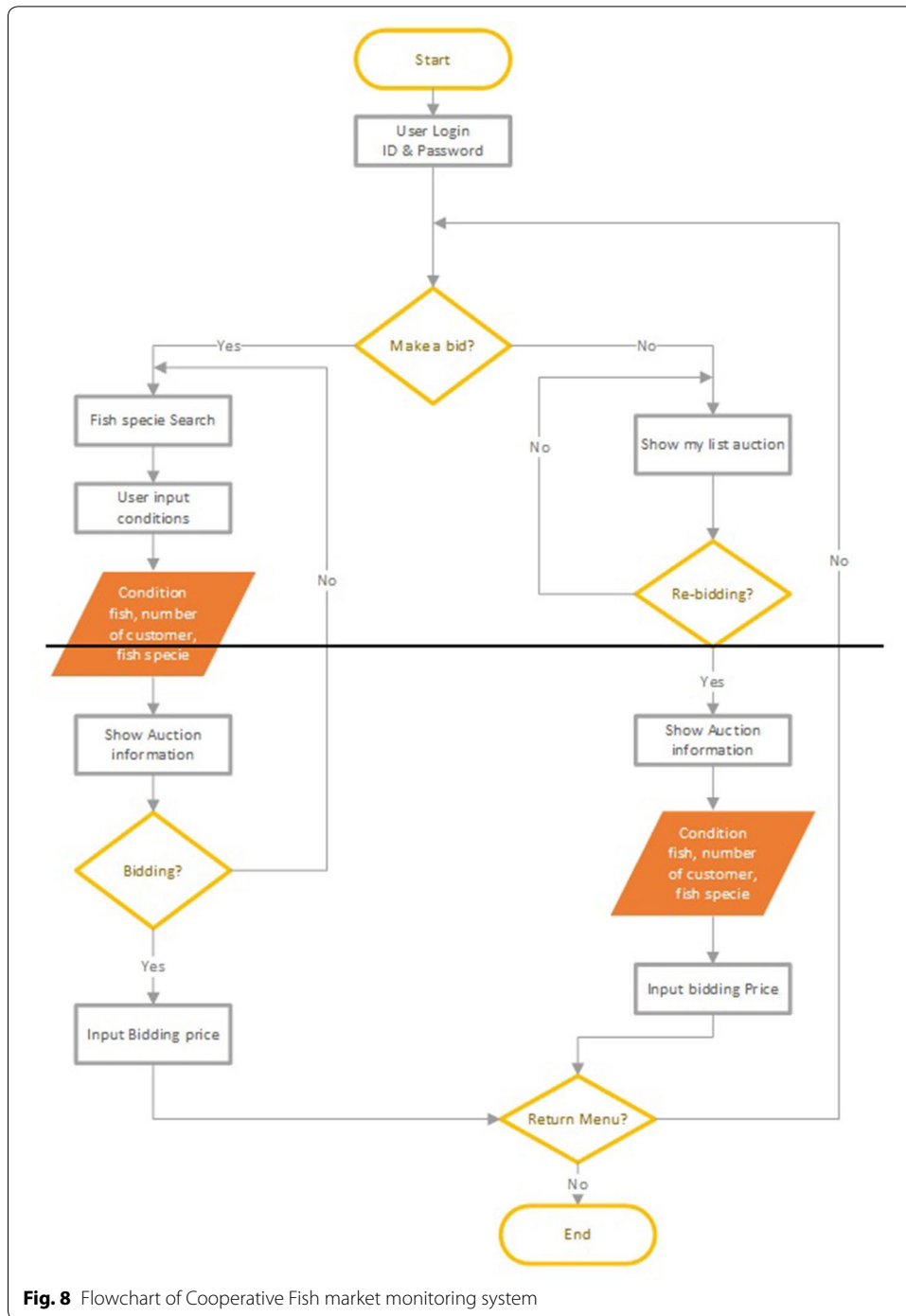
involving the current economic situation through a mobile device. He/She will input the bidding price based on the conditions, recommend prices of application, and go to the Return menu. If there is no re-bidding, the user will go back to show my list auction. Finally, User selects the Return menu. If it is a yes, the user will return and choose to make a bid. Otherwise, if it is a no, the user will end and exit the application.

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    Function collectConditions
        print("Please input conditions of fish")
        Shape = input("Shape")
        Oar = input("Oar")
        Color = input("Color")
        Specie = input("Please input specie of fish")
        NumberOfCustomer = input("Please input number of customers")
        EconomicCondition = input("Please input use economic conditions")
        conditionsDataSet="[<Shape>,<Oar>,<Color>,<Specie>,<NumberOfCustomer>,<EconomicCondition>]"
        return conditionsDataSet
    Function ShowMyAuctionList
        myAuctionList = [<my Auction List>]
        return myAuctionlist
        Endfunction
    Function ShowAuctionInformation
        AuctionInformation = [<Auction Information List>]
        return myAuctionlist
        Endfunction


Print ("Do you want to make a bid? (0.No 1.Yes)")
Return answer
If (answer =='0'
        print("Show My Auction List")
        myAuctionList = showMyAuctionList()
        print(myAuctionList)
        Print ("Do you want to Re-bidding? (0.No 1.Yes)")
        Return answer
        If (anwer =='1'
                AuctionInformation = ShowAuctionInformation
                Call function collectConditions
                Input bidding price
        Else
                print("Show My Auction List")
                myAuctionList = showMyAuctionList()
                print(myAuctionList)
Else
        Call function collectConditions
        AuctionInformation = ShowAuctionInformation
        print("Do you want to bidding? (0.No 1.Yes)")
        If (anwer =='1'
                Input bidding price
        Else
                Call Fish Specie search
```
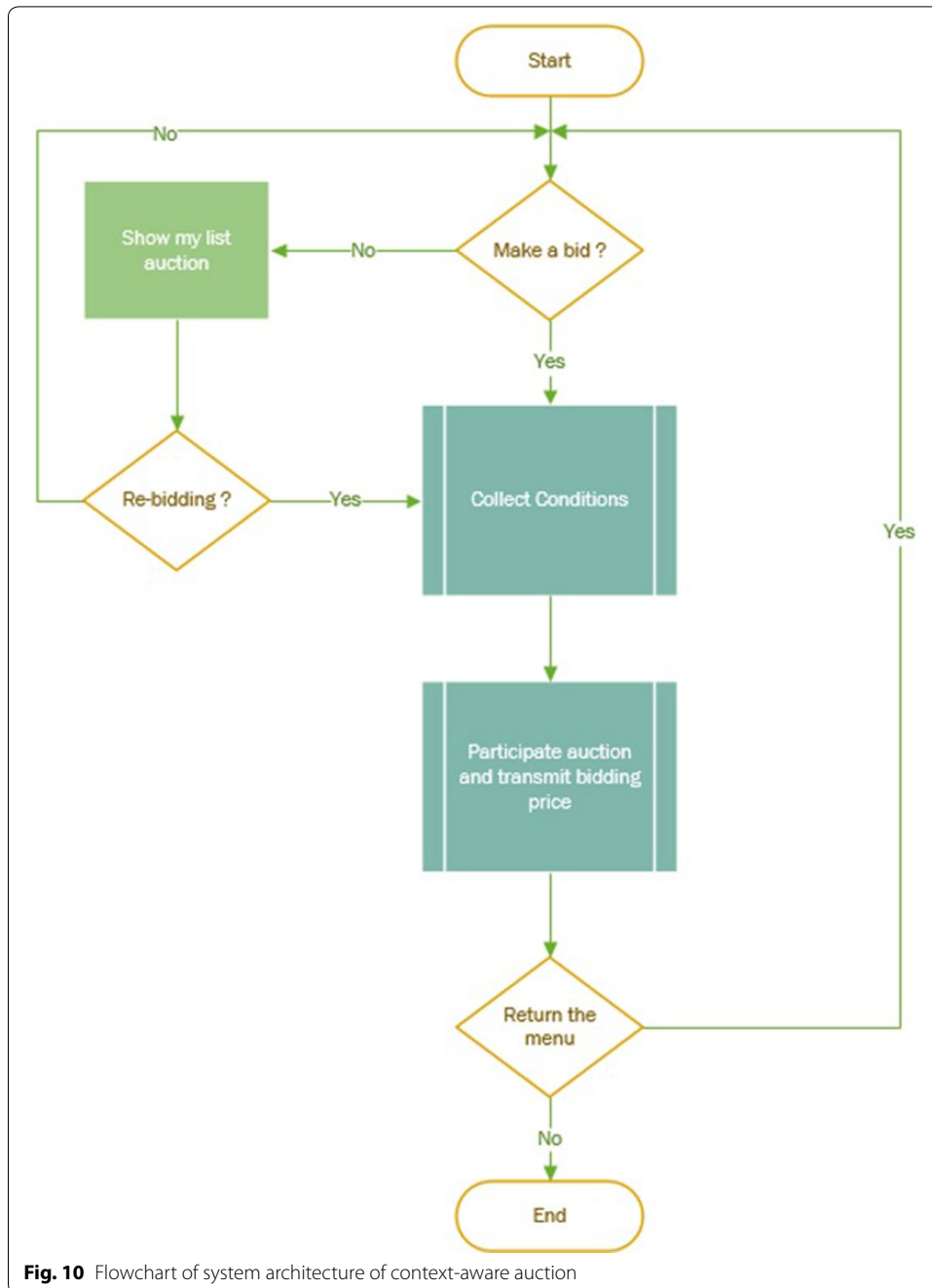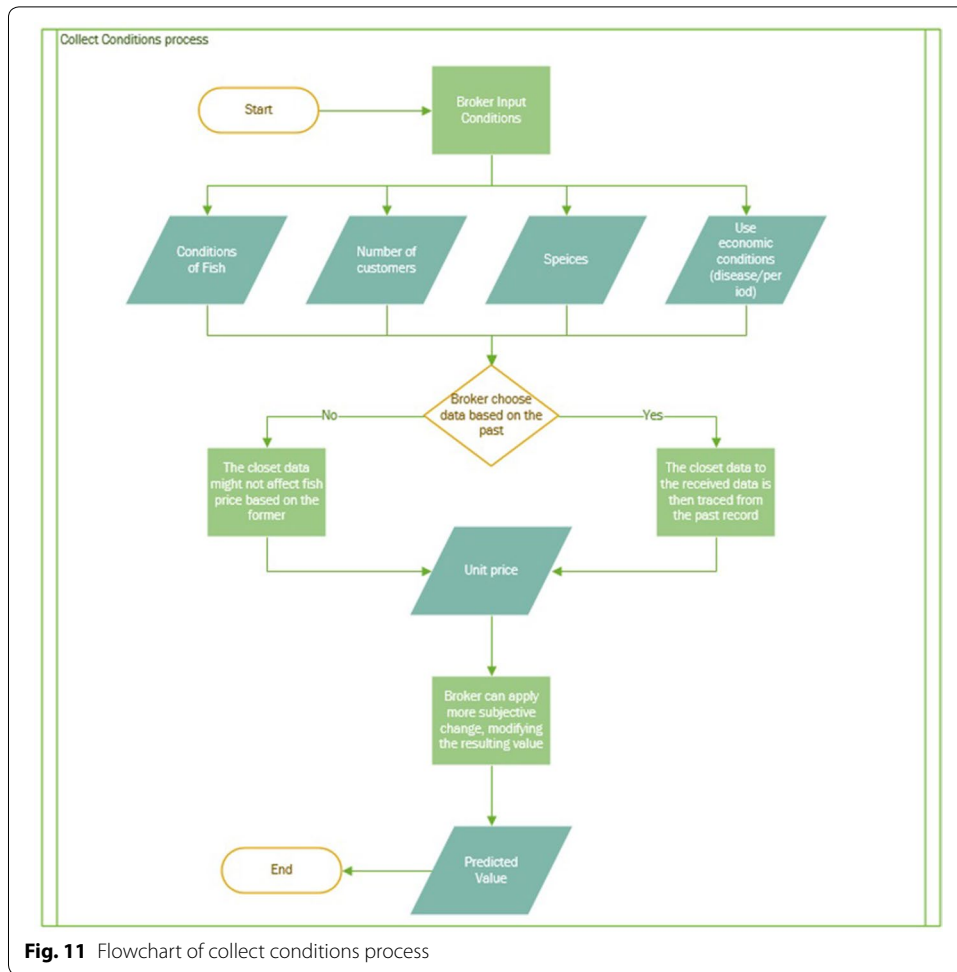
Fig. 9 Pseudo code of Cooperative Fish market monitoring system

Pseudo code is simply an implementation of an algorithm in the form of annotations and informative text written in plain English. It has no syntax like any of the programming languages, so it cannot be compiled or interpreted by the computer. In this report, Pseudo code is used to explain the details of the flowchart and the process to execute the program for the application of context-aware auction solution of the Cooperative Fish market monitoring system in Fig. 9.

When Starting the Program, there are three functions. The function collect Condition collects the information regarding the condition of fish that the user intends to purchase, buyer, species, body size (1–6), use, and variables involving the current economic situation. This function returns conditionDataset. The function ShowMyAuctionList returns my Auction List. The function ShowAuctionInformation returns Auction Information. The main program provides two options: choose Make a Bid or My ongoing auction. In case User chooses 1. Make a Bid, he/she will be shown the Auction information. User will then choose Bidding or not. If he/she chooses Yes to bidding, he/she will input the bidding price based on the conditions and recommend prices of application. If No, the user will return to Fish Specie Search and go to the return menu. In 2 My going on auction, the user will see the List Auction. User will choose Re-bidding or not. If it is a yes, the user will move to Auction information. User can add the information regarding the

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Fig. 10 Flowchart of system architecture of context-aware auction

condition of fish he/she intends to purchase, buyer, species, body size (1–6), use, and variables involving the current economic situation through a mobile device. He/She will input the bidding price based on the conditions and recommend prices of application and go to the Return menu. If there is no re-bidding, the user will go back to show my list auction.

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Fig. 11 Flowchart of collect conditions process

Big data process flow and Pseudo code

First of all, when the broker logs into the application, he/she will choose whether to make a bid or not. If the broker chooses not to bid, the current broker's auction will be listed, and he/she decides whether or not to bid again. The re-bidding option will be the same as Make a Bid at the beginning. Figure 10 shows the flowchart of the system architecture of context-aware auction.

After the broker decides whether to make a bid or re-bid, the system will collect the conditions and the choice based on the broker's history data or not. At this time, the server will select a suitable auction matching the criteria of fish species and types, number of customers, and use economic conditions. Moreover, the former data will affect the fish price if the broker chooses based on history. After the unit price is assessed and calculated by the system, the broker can apply more subjective change, modifying the resulting value before deciding on the final predicted value. Figure 11 shows the flowchart of the collect conditions process.

Finally, the broker participates in the auction and transmits his/her bidding price based on the predicted value. The server will list the auctions matching the bid prices and its time limits. If the bid is the winning one, the broker will be provided with an authentication number authorized for payment. Eventually, the broker will pay for the

Fig. 12 Flowchart of participate auction and transmit bidding price process
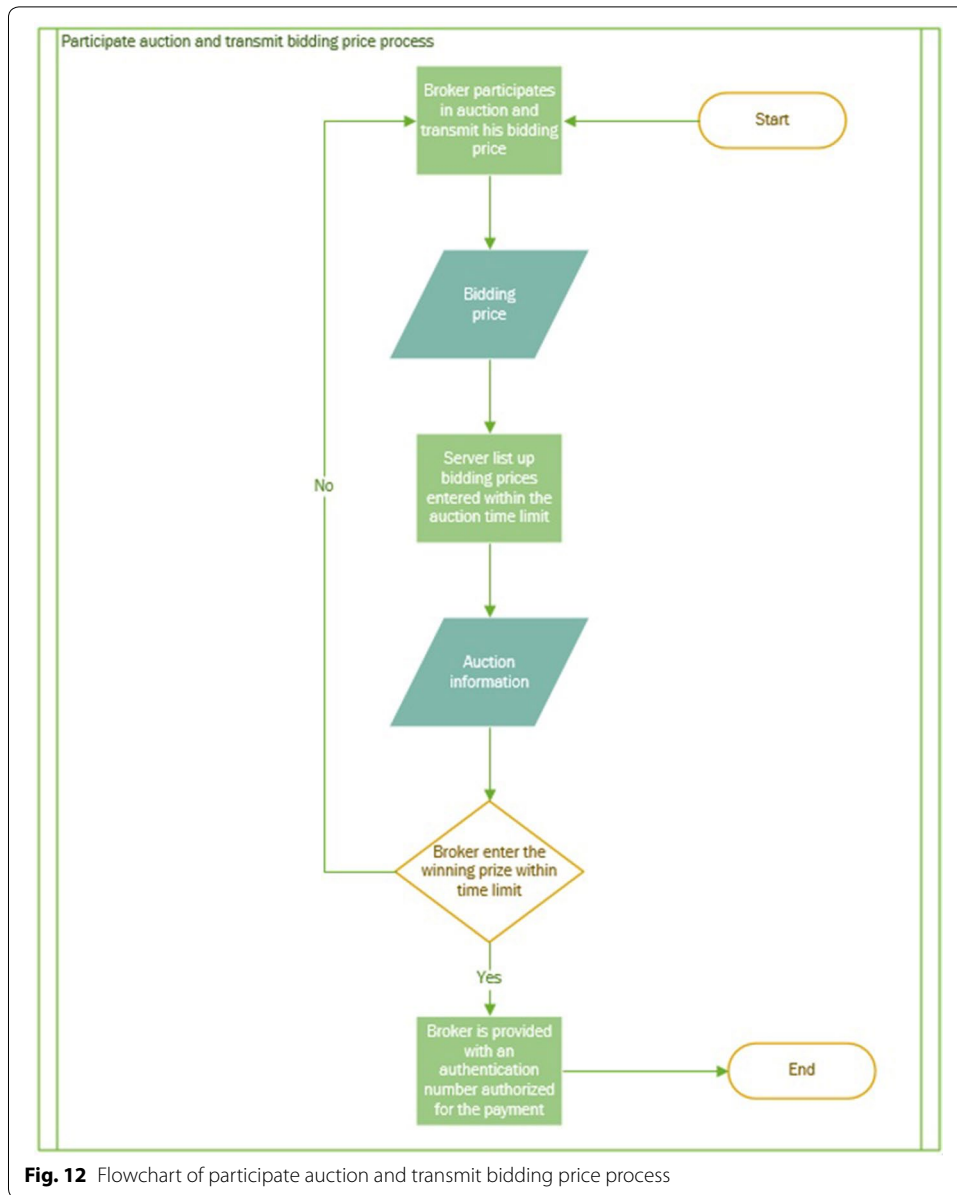
items he/she bid for successfully and receive the items. Figure 12 shows the flowchart of the participate auction and transmit bidding price process.

First of all, the broker has to choose whether to make a bid or not (Yes or No); if it is a No, the system will show his/her auction list. Otherwise, he/she will input the conditions of fish (shape, oar, color...), species, number of customers, and use economic conditions, including whether the data is based on the past data or not. Figure 13 shows the define Make a Bid and collect condition process.

After the system collects the conditions, the server calculates and formulates information on auctions that appropriate the indicators in advance, thereby offering a reasonable unit price. The broker can apply more subjective change to the aggregate predicted

```
In [1]: def MakeABid():
            answer = input("Do you want to make a bid ? (0.No 1.Yes)")
            return answer

In [2]: def showMyAuctionList():
            myAuctionList = ["<my Auction List>"]
            return myAuctionList

In [3]: def collectConditions():
            print("Please input conditions of fish")
            Shape = input("Shape (0.Slim 1.Round 2.Elongated) : ")
            Oar = input("Oar (0.Sleek 1.Slipy) :")
            Color = input("Color (0.White 1.Black 2.Light pink) : ")
            Specie = input("Please input specie of fish (0.Coastal 1.Sea 2.Deep Sea 3.Reef) :")
            NumberOfCustomer = input("Please input number of customers (0.1-100 1.100-2000 2.over 2000) : ")
            EconomicCondition = input("Please input use economic conditions (0.Restaurant 1.Bistro 2.Canteen) :")
            conditionsDataSet="[<Shape>,<Oar>,<Color>,<Specie>,<NumberOfCustomer>,<EconomicCondition>]"
            return conditionsDataSet
```

Fig. 13 Define Make a Bid and collect condition process

```
In [4]: def UnitPriceProcess(BaseOnPast):
            if(BaseOnPast == '0'):
                UnitPrice = ['<Closet Data not affect fish price based on the former>']
                return UnitPrice
            elif(BaseOnPast =='1'):
                UnitPrice = ['<Closet data to the received data is then traced from the past record>']
                return UnitPrice

In [5]: def BrokerAdjustResultValue(UnitPrice):
            print("Broker can apply more subjective change, modifying the resulting value")
            PredictedValue = "[<Predicted value after broker modify>]"
            return PredictedValue

In [6]: def BrokerParticipateInAuction(PredictedValue):
            BiddingPrice = "[<Broker transmit bidding Price base on predicted Value>]"
            return BiddingPrice

In [7]: def ServerListAuctionBidding(BiddingPrice):
            ListAuctionInformation = "[<Find and match suitable auction base on broker's bidding price>]"
            return ListAuctionInformation

In [8]: def BrokerWinningPrize(BiddingPrice,ListAuctionInformation):
            WinningPrize = "[<Bidding price win the auction>]"
            if (WinningPrize == "[<Bidding price win the auction>]"):
                return True

In [9]: def AuthenticationNumberAuthorizedPayment(isWinningPrize):
            if(isWinningPrize):
                Authentication = "[<Provide Authentication Number Authorized Payment>]"
                return Authentication
```

Fig. 14 Define participate auction and transmit bidding price process

value. Figure 14 shows the define participate auction and transmit bidding price process. Finally, the broker participates in the auction and transmits his/her bidding price based on the predicted value. If the bid is the winning one, the broker will be provided with an authentication number authorized for payment. Eventually, the broker will pay for the items he/she bid for successfully and receive the items. Figure 15 shows the main process and result.

Main auction UML

The Java Android UML developed for the context-aware auction solution suitable for the BCFM has been designed to allow the user to participate in the auction through Make_bid_Activity or My_on_going_auction_Activity. These two parts exchange data through the server.

The main UML in Fig. 16 represents the entire application process briefly along with the respective designs of Make_bid_Activity and My_on_going_auction_Activity.

```
In [10]: if __name__ == "__main__":
    answer = MakeABid()
    if (answer == '0'):
        print("Show My Auction List")
        myAuctionList = showMyAuctionList()
        print(myAuctionList)
    elif (answer == '1'):
        print("Input Conditions")
        conditionsDataSet = collectConditions()
        print(conditionsDataSet)
        BaseOnPast = input("Please choose data based on the past ? (0.No 1.Yes) :")
        UnitPrice = UnitPriceProcess(BaseOnPast)
        print(UnitPrice)
        PredictedValue = BrokerAdjustResultValue(UnitPrice)
        print("Broker Participate in Auction and Transmit Bidding Price")
        BiddingPrice = BrokerParticipateInAuction(PredictedValue)
        print(BiddingPrice)
        ListAuctionInformation = ServerListAuctionBidding(BiddingPrice)
        print(ListAuctionInformation)
        isWinningPrize = BrokerWinningPrize(BiddingPrice,ListAuctionInformation)
        print("[<Bidding price win the auction>]")
        print(isWinningPrize)
        Authentication = AuthenticationNumberAuthorizedPayment(isWinningPrize)
        print(Authentication)


Do you want to make a bid ? (0.No 1.Yes)1
Input Conditions
Please input conditions of fish
Shape (0.Slim 1.Round 2.Elongated) : 0
Oar (0.Sleek 1.Slipy) :0
Color (0.White 1.Black 2.Light pink) : 0
Please input specie of fish (0.Coastal 1.Sea 2.Deep Sea 3.Reef) :0
Please input number of customers (0.1-100 1.100-2000 2.over 2000) : 0
Please input use economic conditions (0.Restaurant 1.Bistro 2.Canteen) :0
[<Shape>,<Oar>,<Color>,<Specie>,<NumberOfCustomer>,<EconomicCondition>]
Please choose data based on the past ? (0.No 1.Yes) :1
['<Closet data to the received data is then traced from the past record>']
Broker can apply more subjective change, modifying the resulting value
Broker Participate in Auction and Transmit Bidding Price
[<Broker transmit bidding Price base on predicted Value>]
[<Find and match suitable auction base on broker's bidding price>]
[<Bidding price win the auction>]
True
[<Provide Authentication Number Authorized Payment>]
```

Fig. 15 Main process and result

Fig. 16 Main auction UML

Make bidding activity UML

The auction bidding UML in Fig. 17 starts from the initial activity to the search activity where all the information is received by the server and delivered to 'information_fishmarket activity'. After completing the search, an activity allowing bidding is initiated by shifting to a detailed information page.

Fig. 17 Make bidding activity UML

Fig. 18 My on going auction activity UML
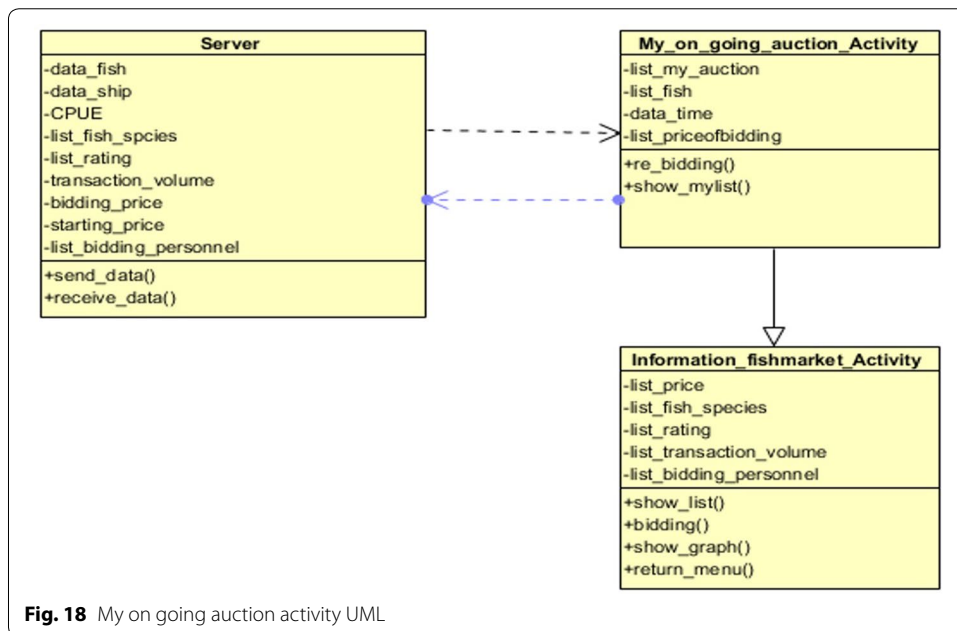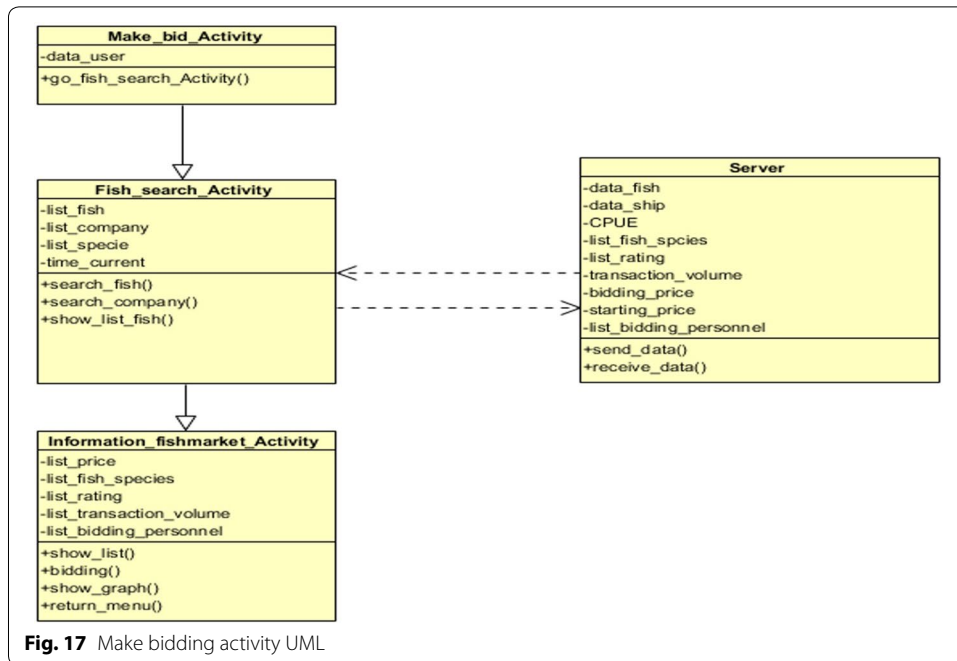
My on going auction activity UML

The My_on_going_auction_Activity UML in Fig. 18 shows the bidding list after its completion and all the data is brought from the server. The user's bidding information in the first activity is shown and the user can participate in re-bidding by shifting the detailed information page, if so desired.
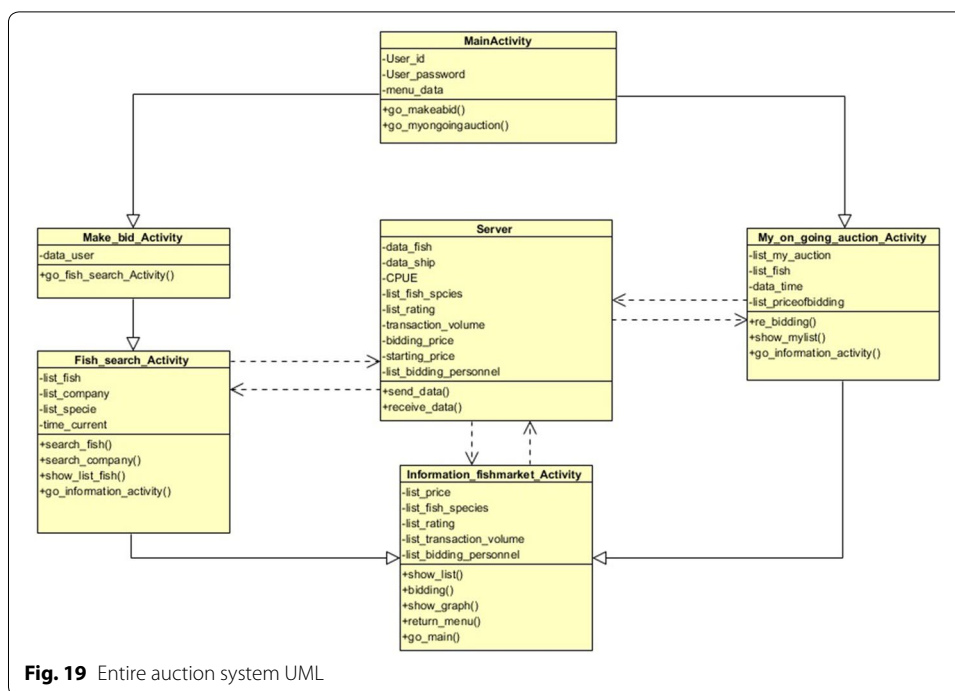
Fig. 19 Entire auction system UML

Entire auction system UML

The three UMLs described above has been integrated as a whole auction system UML. The entire operation is represented by the UML and each function is the same as the individual UML. There are two functions and which can check the list of both activities. In the Make_bid_Activity, user can make a bid after receiving his/her own data and sort out the species he/she desires from the species-search page. The data is exchanged at the server. The information about the search and its function are included in 'fish_search_activity'. The actual auction and bidding are performed in 'information_fishmarket_activity'. The My_on_going_auction_Activity list on the right is also the same. If re-bidding is desired, it can be executed by shifting to information_fishmarket_activity. Figure 19 shows entire auction system UML.

Figure 20a shows flow chart 1 shows bidding. The target species search is initiated from the start. Once the desired search information is entered, the relevant auction information will be shown and after asking whether the user wishes to participate in bidding and if the answer is yes, he/she can enter his/her bidding price, or return to 'Start' otherwise. Also, Fig. 20b, flow chart 2 shows My ongoing auction. In this process, the details of one's ongoing bidding are shown to the user and if re-bidding is desired, the user will be guided to the auction information details or returned to 'Start' otherwise. The process will be completed after entering the new price.

In Fig. 21 shows flow chart 3, the user will be shifted to the menu for the auction when he/she replied Yes or moved to the menu for showing his/her auction details if the answer is No. The flow chart on the left shows the auction process and the one on the right shows the user's auction information. He/she can either return to the start menu or end the application.
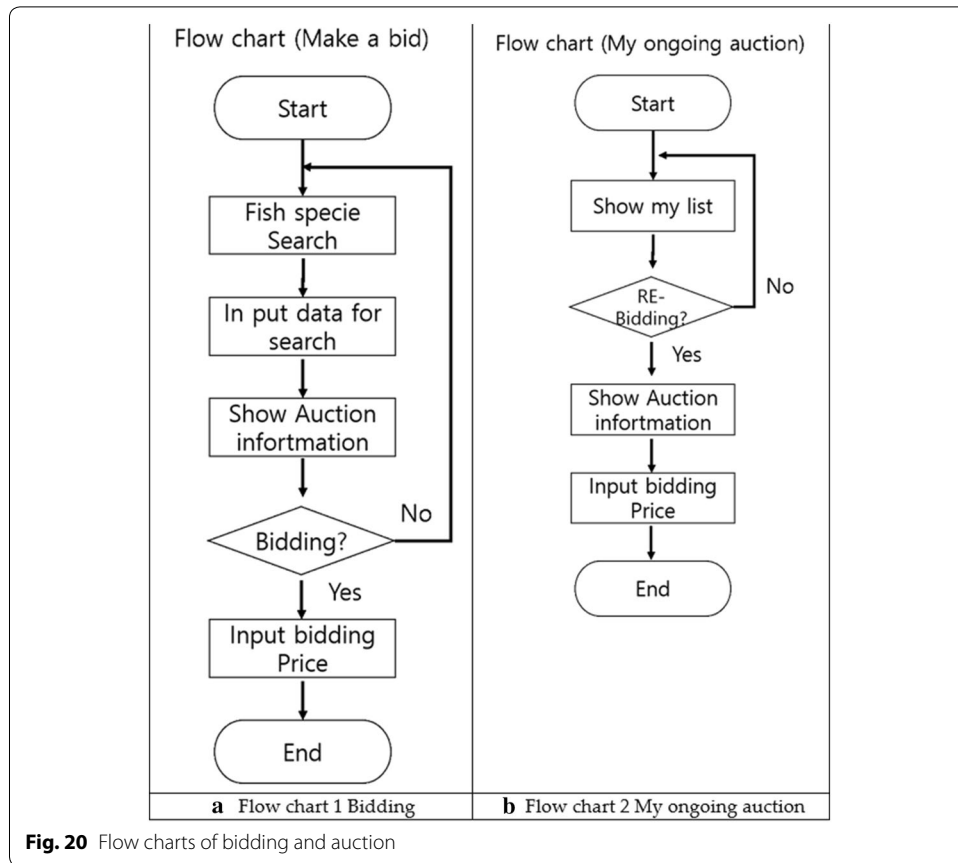
Fig. 20 Flow charts of bidding and auction

Application UML

This is the main screen. In this case, 'Common fish market' refers to a cooperative fish market. Figure 22 shows application main screen. The functions are divided into 'Make a bid' and 'My ongoing auction' to either make a bid or check one's own auction information. Since the fishes to be sold through the auction will be registered by the cooperative fish market administration themselves, the registration page was not designed. First, the bidding function.

This page has a search function with which the user can search species or fishing companies he/she wants to search. By pressing the desired species, the picture is activated and perform a filtering function. Since the Back and Setting buttons at the upper-right corner are the basic ones, all the pages have them. When Back is pressed, the screen shows the previous page whereas when Setting is pressed the user can set login, logout, or application details. Once the target species is pressed, it will be shown on the screen after performing the filtering function based on the information provided. Figure 23 shows application species search.

The search result appears in the form of a table. Figure 24 shows application search result list. After searching the target species on the previous page, the result will be shown as such a table. For example, a search was performed in the order of mackerel, flatfish, king crab, and red sea-bream. The items in the list are Species, Rating, Transaction Volume, Starting Price, Bidding Price, and Bidding personal, the number of

Fig. 21 Main flow chart 3 main auction
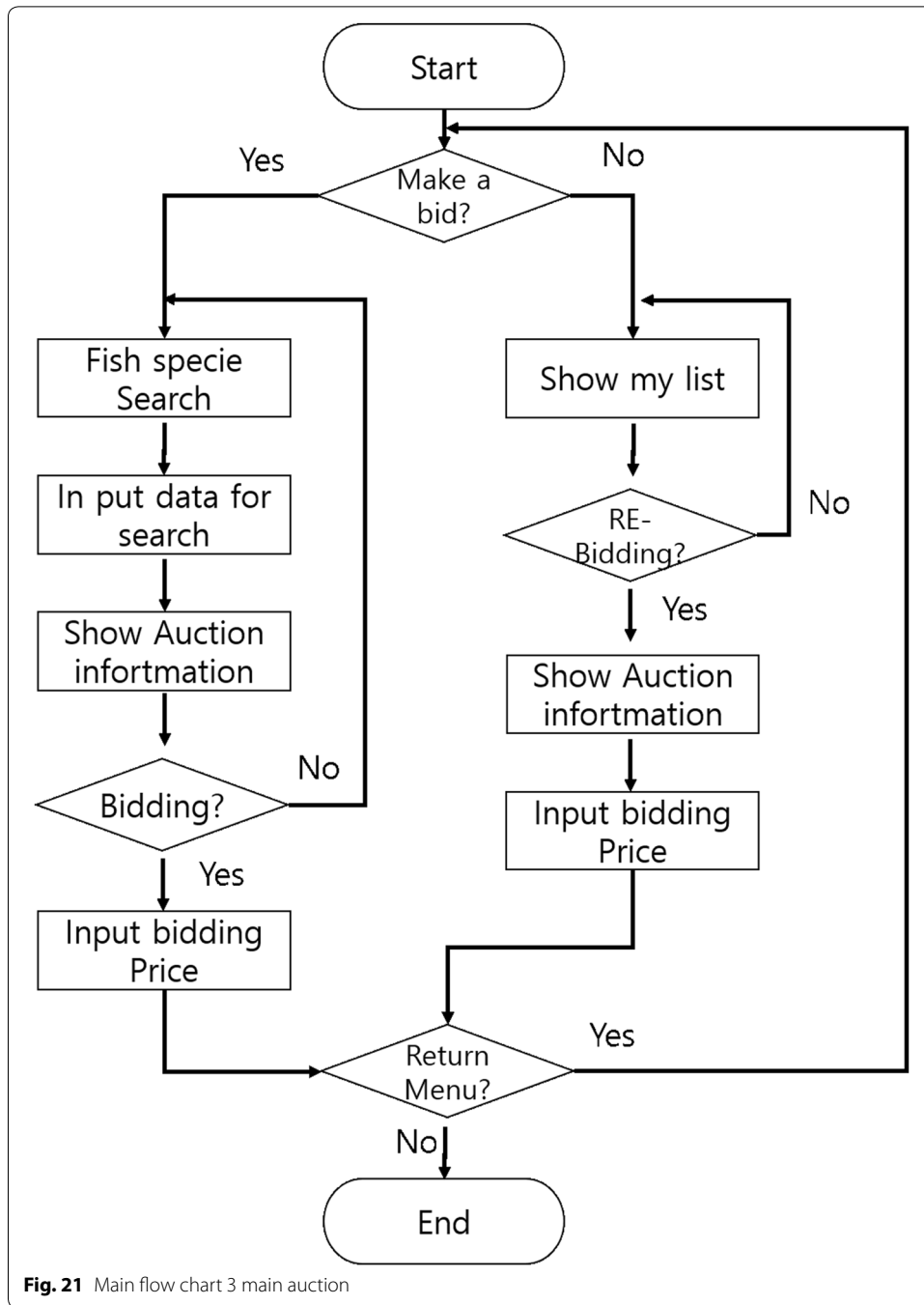
participating bidders. The 'Rating' indicates the condition of the target species. Best refers to the best quality and Top means the superior quality. Transaction volume represents the volume of a catch available for sales. The starting price literally means the first starting price whereas the Bidding price indicates the current bidding price. The item Bidding personal shows the number of participating bidders. The values of individual items will be shown for each species. When the desired species is pressed from the searched table, the screen shifts to the next page. As there is a date at the

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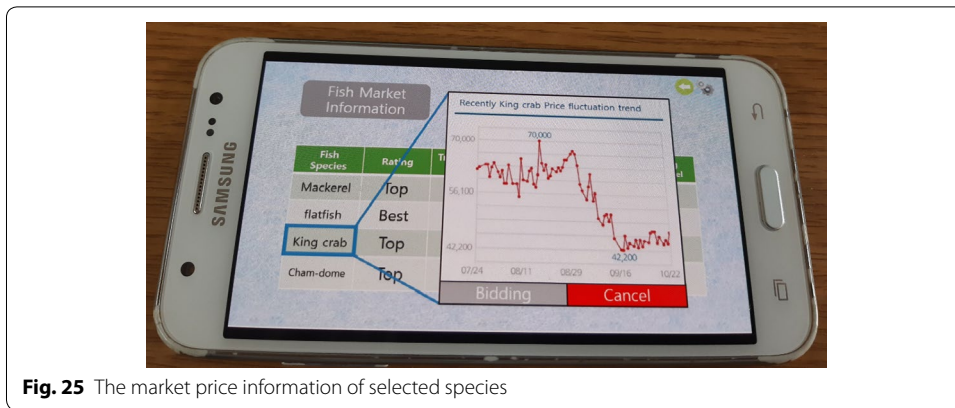

Fig. 22 Application main screen
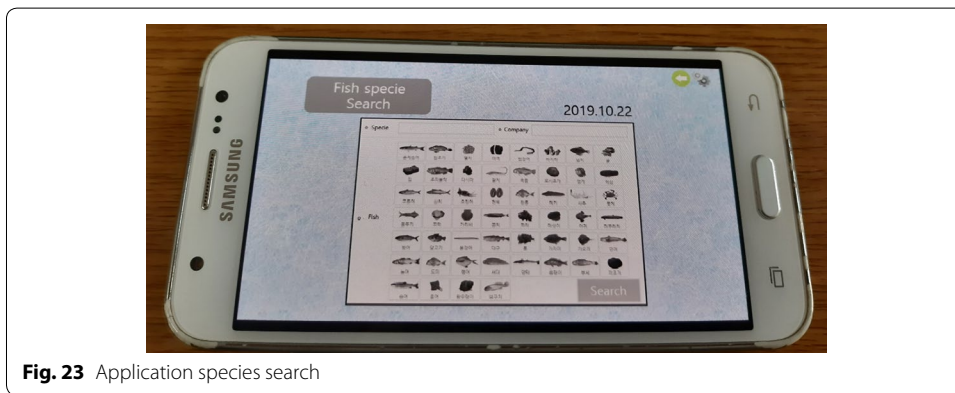
Fig. 23 Application species search

Fig. 24 Application search result list

upper-right corner of the table, one can check the market price of the day or search for the previous records. The screen for bidding is shown below.

Figure 25 shows the market price information of selected species. The user can check the market price of the species he/she has selected as it was considered that the information about the current species should be provided to assist him/her in making decisions. A graph appears once the target species has been pressed from the table searched to decide whether to make a bid or not. Bid and Cancel buttons were added

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Fig. 25 The market price information of selected species

Fig. 26 Auction status application screen

Fig. 27 My ongoing auction list
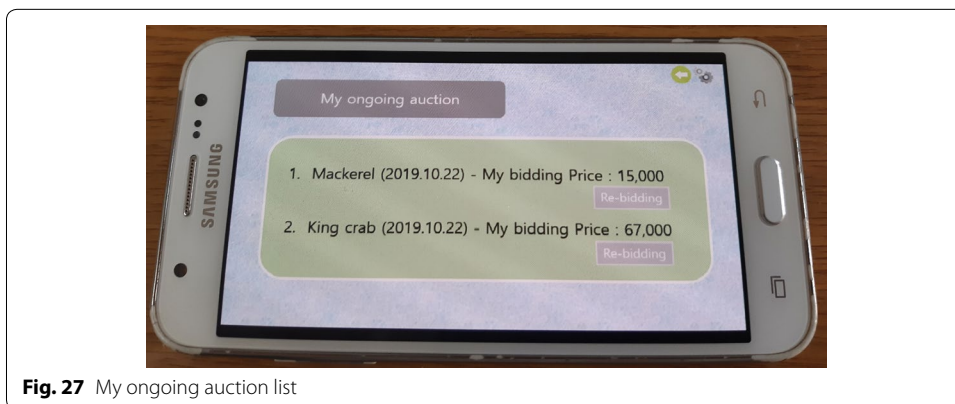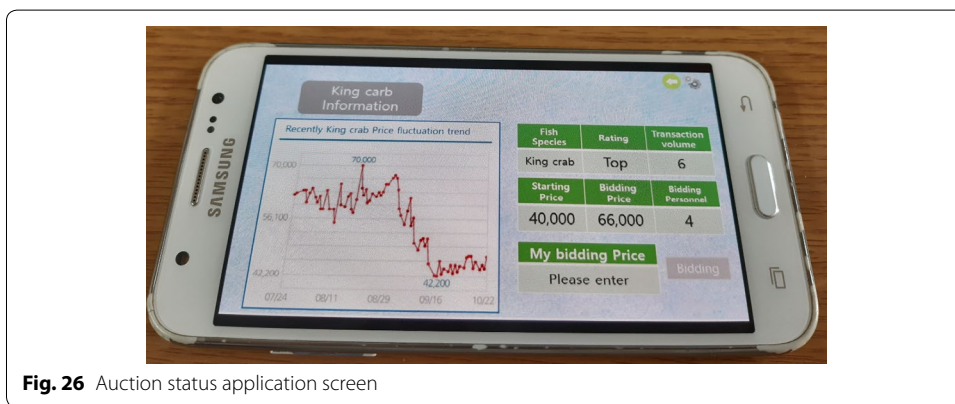
for the user's choice. If the user wishes to make a bid, he will be guided to the next page after pressing the Bid button.

The market price and relevant information can be found on this page. The market price and other information that had been shown on the previous page will be shown again to make a decision on bidding. When the user enters his/her bidding price based on this information, it is considered that he/she has actually completed the bidding and the details of which will be stored in the My ongoing auction list. The next

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picture shows the My ongoing auction page. Figure 26 shows auction status application screen.

This page shows the list of auctions the user participated. The bidding price each target species will be shown along with the auction date and price. A function allowing the user to re-bid is included and he/she will be guided to the next page after bidding again. Figure 27 shows my ongoing auction list.

Comparison with other system

The term 'Blue Revolution', which refers to the revolution of the Aquaculture industry, was first introduced in an UK economic Journal 'The Economist [53–55]' in 2003 and derived from the original term 'Green Revolution' that had led to a dramatic increase in the output of agricultural produce. Although The Economist has forecasted that the mankind would obtain marine products through aquaculture industry fulfilling the Blue Revolution by 2030, the current aquaculture industry of the ROK is still at the early stage of such a revolution [55, 56].
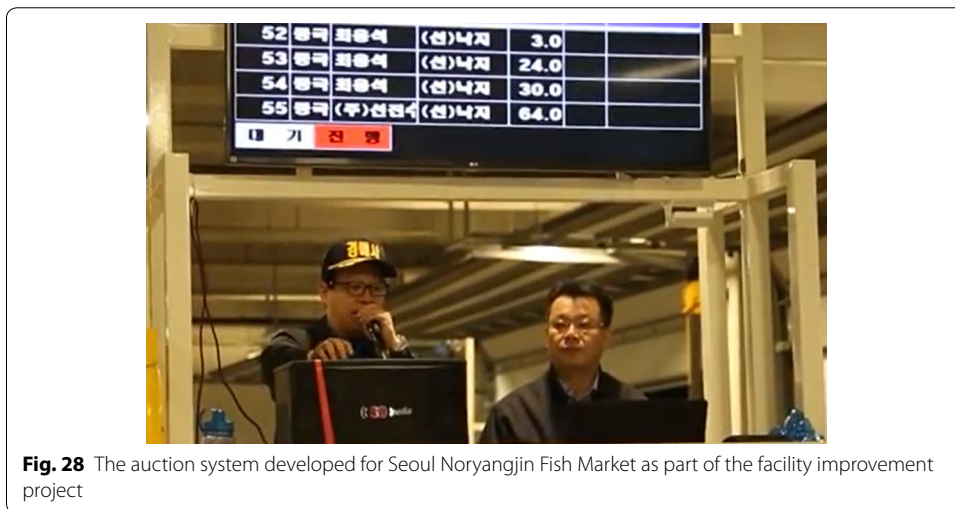
Currently, Busan International Fish Market (BIFM) is aggressively attempting to break away from the inefficient and unsanitary auction/consignment sales style of the past by introducing an automatic fishery product grader into their auction system and adopting a kg-based sales practice [56–59]. The current auction and distribution processes have become speedier due to the introduction of a 'sample auction system' where only the partial catch is being graded by the automatic grader for auction sales. This can save much time compared to the existing bulk sales and maintain the freshness. For example, for the catch (mackerel), the actual auction time spent was about 1 h which was a couple of hours faster than before when the existing auction method had been used. In the past, many workers had to place fishes in the wooden boxes one by one before starting the auction after they were unloaded so that their freshness was not maintained adequately. The distribution process after the auction was completed quickly as well. The mackerels were placed in the wholesaler's/broker's boxes immediately after the sample auction ended.

The members of the auction centers are now agreeing that such a method is much more efficient than the previous way of placing the entire box-packed fishes on the auction center floor and re-packing them later. One of the most notable changes is the automatic grader which classifies the size of fish automatically. This machine can save labor cost and maintain a sanitary auction environment as it is not necessary to place fishes on the floor. It is also noteworthy that a kg-based auction is being carried out on a trial basis to secure transparency in the auction process. In the past, it was difficult to determine exact number of fishes or their weight as all the auction prices were set by the box. The dealers and buyers often experienced difficulties as the weight of individual boxes were different even though the price was the same.

On the other hand, if the kg-based auction system is introduced formally, everyone will be able to know about the size, and weight of the product they desire, guaranteeing transparency and accuracy during the auction process. Meanwhile, the BIFM is also prohibiting the cargo trucks to enter the auction center, which is different from the current practice of the Busan Cooperative Fish Market (BCFM). Reflecting this, the management office of BCFM is implementing their own consignment policy complying with

Table 2 Cost comparison with the existing system (Unit: Korean Won)

The development cost of the system used by the Seoul Noryangjin Market (without the application)		Proposed system	
1. Hardware			
Server and operating equip.	100,000,000	Server and operating equip.	206,700,000
Receiver	87,800,000		
Transmitter	13,780,000		
Antenna	89,570,000	Switch	68,900,000
Access unit	53,350,000	–	–
Motion detector	41,340,000	–	–
2. Software			
Customized software development	275,600,000	Hybrid web/app software development (Java)	551,200,000
Package software license Operating System (OS)	275,600,000 55,120,000	Data management system	68,900,000
Other middleware	227,370,000	–	–
Data management system	254,930,000	–	
◎ **Integrated service**			
Standardization adjustment of standards	6,890,000	Integration and adjustment with application	34,450,000
–	–	Development/integration of application (hybrid web/app)	34,450,000
Total	1,378,000,000		946,600,000

Fig. 28 The auction system developed for Seoul Noryangjin Fish Market as part of the facility improvement project

Hazard Analysis and Critical Control Points (HACCP) to strengthen the sanitary environment of the market.

This study presents a further improved auction management system than one that is being adopted by the BIFM and offers a more variety of functions. Especially, the user convenience has been increased by developing it with an Android application.

This study focuses on software engineering in the field of computer engineering/science where speed and cost are deemed essential. Thus, cost reduction was considered

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Fig. 29 A broker/wholesaler entering his desired price (1)

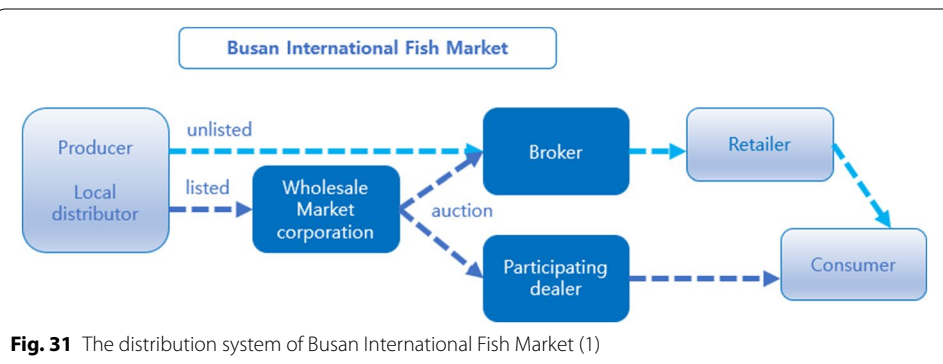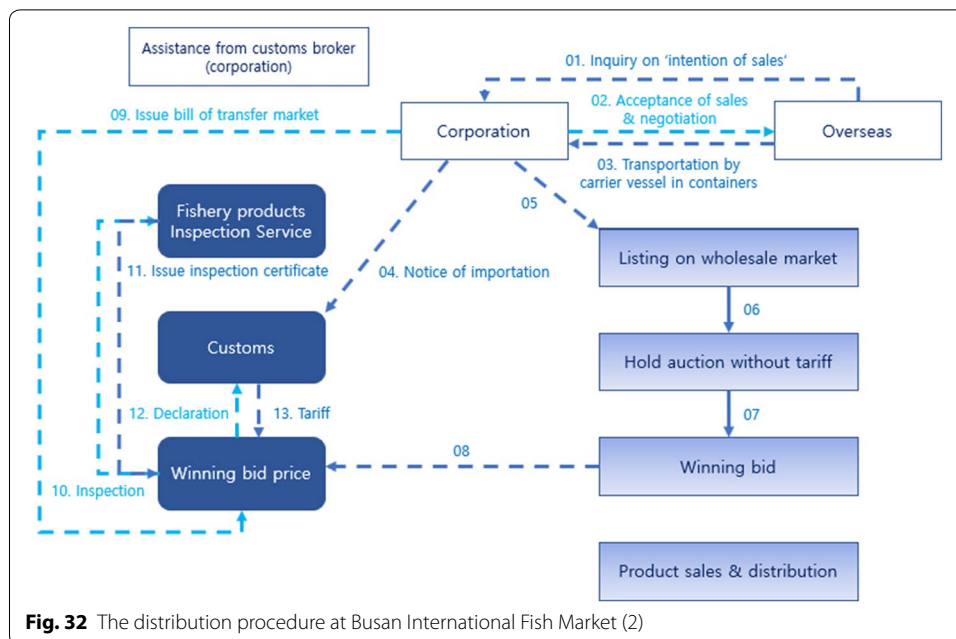**Fig. 30** A broker/wholesaler entering his desired price (2)

Fig. 31 The distribution system of Busan International Fish Market (1)

mainly in terms of software engineering. The proposed system is to be supplied with a price 30% less than the existing systems.

As shown in Table 2, the proposed system is expected to be sold at a price of 946,600,000 Korean won whereas the development cost for the existing auction system

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Fig. 32 The distribution procedure at Busan International Fish Market (2)

used by Seoul Noryangjin Market was 1,378,000,000 korean won (as of Oct. 2019 considering depreciation). This system even has an application compatible with Android smartphones or tablet products.

Seoul Noryangjin Fish Market in 2016

Figure 28 describes the electronic auction system developed for Seoul Noryangjin Fish Market in 2016 and Figs. 29, 30 shows a broker/wholesaler who inputs the desired price on his/her device. The comparison is being shown in Table 2.

Busan International Fish Market in 2019

The distribution process of Busan International Fish Market is shown in Fig. 31 where the distribution process for the products listed by their producer goes through a wholesale market corporation, auction, broker, retailer, and consumer or a wholesale market corporation, auction, dealers, and consumer. However, if the products have not been listed, the process starts from a broker to retailer and then to consumer.

The wholesale market corporation in such a case is the central operating body of the wholesale market who sells the consigned fishery products to the brokers or participating dealers through auction. The brokers participate in the auction after receiving approval from the main agent holding the auction and buy the listed products to sell/broker them to retailers or big consumers. The participating dealers can be considered as a business operator (e.g., department, supermarket, etc.) who purchases products in bulk by participating in the auction with brokers. Finally, auctioneers belonging to a wholesale market corporation take the lead in every auction process

such as placing the priority in the sales products, pricing each product, or determining the successful bidder.

Figure 32 is showing the distribution procedure of Busan International Fish Market where the seller's 'intention of sales' is inquired first from overseas to the corporation followed by the second procedure—'acceptance of sales' or negotiation between the involved parties. Third, the products are transported on a carrier vessel in containers (overseas market to the corporation). Fourth, a notice of importation is submitted to the customs by the corporation. Fifth, the products are listed on the wholesale market. Sixth, auction starts without considering the tariff. Seventh and eighth, the successful bidder and bidding price are determined. Ninth, a bill of transfer is issued from the corporation to the bidder. Tenth and eleventh, the products are inspected and an inspection certificate is issued. Twelfth, an import declaration is submitted to the customs and the tariff is paid by the successful bidder.

When the importer lists fishery products on a wholesale market in a BWT form, the procedure is the same as the corporation's case. However, the importer has to be registered in the Busan International Fish Market first as a local distributor in advance. Second, when the importer lists the products on a wholesale market after clearing the customs, he/she needs to register in Busan International Fish Market as a local distributor prior to listing and negotiate with the corporation or a consignor presents his/her 'lowest bidding price' before the listing.

Meanwhile, when dealing with the coastal fishery products, their listing will be completed through price checking by the chief fisherman before leaving the fishing ground. Additionally, considering the size of the Busan International Fish Market facility and other elements, it is expected that only the large purse seiners or trawl vessels belong to the National Federation of Fisheries Cooperatives will be allowed. Also, with the safety assessment result for the offshore fishing boats entering/departing the Gamcheon port, the number of vessels allowed into the port is limited to nine vessels due to the possible risk of collision between a large vessel and a fishing boat. Such a restriction is observed by the joint-fishery boat control center.

The exceptional listing products are the ones that are not suitable for listing by the corporation or equivalent to it and such a product can be traded by the brokers after receiving permission from the auction holder. Also, they are designated by the "Market" itself and if any brokers want to handle them, they are required to make a request by submitting an application form. Additionally, they need to operate a window for making/settling a deposit for proving their net asset amount and the shipper.

For the fixed price or optional transactions, the sales are carried out by auction or bidding at a wholesale market but the transactions taking place with a price already set by the other wholesale/joint market can be subjected to an optional transaction when the wholesale corporation is selling the products to a party other than the broker or participating dealer after receiving permission from the auction holder; it is almost impossible to hold auction or bidding due to natural disasters or other unavoidable situations; or product quantity and the number of brokers handling it is quite small so that its transaction was passed after deliberation by the market operating committee. In this case, the market corporation trades the product by listing it to the brokers or designating one of

Fig. 33 Busan International Fish Market Data Flow Diagram
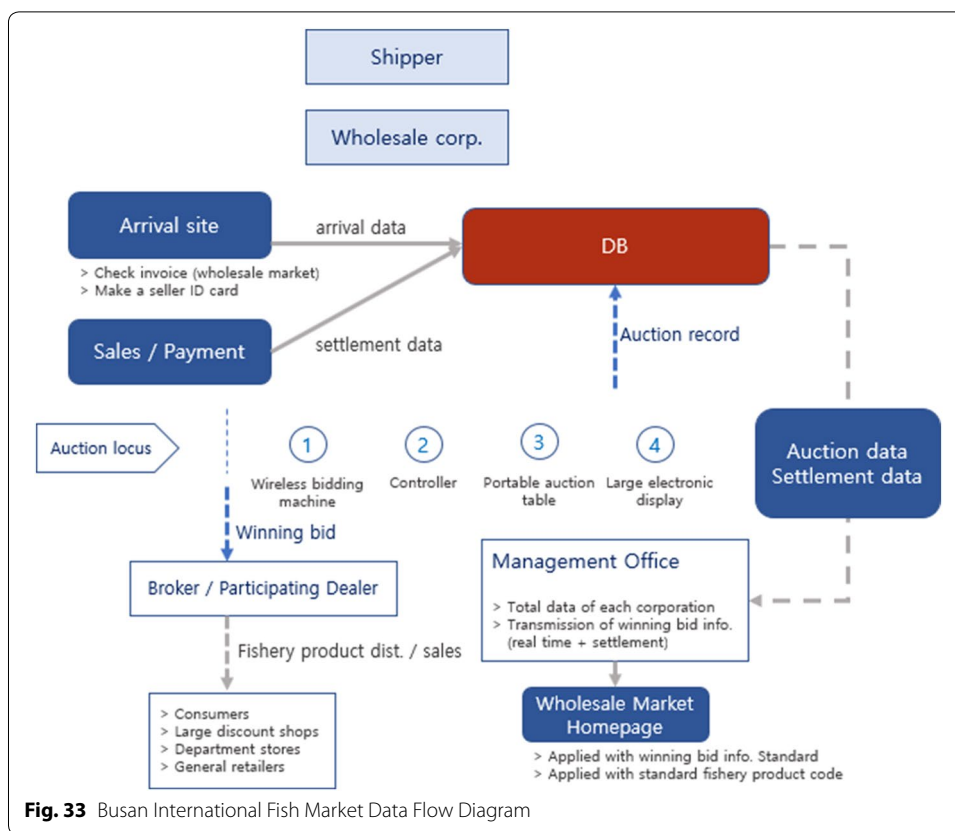
those who are willing to buy it. Figure 33 shows Busan international fish market data flow diagram.

Discussion

The context-aware auction solution proposed to Busan Cooperative Fish Market is an improved system from the existing ones and it has been implemented with a Java Android-based Unified Modeling Language. The big data generated from this system is expected to stabilize the prices by simplifying the auction procedure or reducing excessive competition. Such a simplified process will contribute to maintaining the catch in fresh condition or enhancing the competitiveness of the auction houses around the nation while assisting brokers or wholesalers who are having difficulty in deciding their bidding prices.

Meanwhile, the multi-agent system introduced in this research work is for the Android operating system and consists of a series of agents interacting together intelligently to provide a solution to a complex problem. Such a problem is often difficult or impossible to solve without collaborating with each other and also, a unit program is required to form an independent judgment or a decision. One successful example of this is the context-aware auction solution developed especially for the cooperative fish market monitoring system, which is an efficient real-time expert support context-aware system enabling the human agent collaborative interactions.

Thus, this study focuses on software engineering in the field of computer engineering/science where speed and cost are deemed essential. Thus, cost reduction was considered mainly in terms of software engineering. The proposed system is to be supplied with a price 30% less than the existing systems.

Conclusion and future works

An context-aware auction solution suitable for the Busan Cooperative Fish Market was proposed in this paper. The existing auction model being used by the Noryangjin Fish Market was used as a model for comparison with the one-billion won auction model we've proposed to Busan city. The existing system model was developed in 2015 and underwent testbed experiment, after which it was introduced by the market for actual use since 2016. We've completed the software development and as of Oct. 31th, 2019, the cost used for its development was analyzed and compared. The result showed that our program was more concise than the existing model in terms of software engineering and required a fewer cost.

The proposed solution informs a reasonable auction price for the brokers along with the size and other essential information of a catch for the consigned sales considering the elements which could affect the price. Such a digitized auction method can strengthen the competitiveness of the fish market or contribute to food safety by replacing the current finger-based auction system.

Also, the proposed solution can be used to upgrade the current traditional analog auction procedure being adopted at the Busan Cooperative Fish Market with its efficient UML designs developed with Java Android.

We hope that the data obtained by the proposed solution would simplify the current auction procedure, reduce excessive competition, and contribute to the price stabilization of the marine products while they go through brokers and distributors. It is expected that the solution will assist the auction brokers who often experience difficulties due to many variables.

Finally, it is possible to make a more reasonable and economic decision based on the previous auction records accumulated over time by developing an interface which can apply fluctuating fish prices to Module/App.

If the business goes well in the future, the model is expected to be installed at Busan Cooperative Market and most of the profits from this business will be donated to the people who suffered from the industrial accidents while working for the fishing industry as such incidents are still happening a lot at Busan Cooperative Fish Market.

Also, we are planning to publish this paper including the overall details of our system and intend to disclose more content in a textbook as an open-source material while proceeding with patent application and registration.

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