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AGENT-BASED BIDDING APPLICATION FOR MOBILE PHONES

BY

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Declaration

I <u>WILFRED IJAA</u> do declare that this research project report is my own original work and has not been presented anywhere for any academic award.

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P58/75863/2012

I <u>DR. ELISHA T. OPIYO OMULO</u> as the University supervisor do confirm that this research project report was presented for evaluation by my approval as partial fulfillment of the requirements for the award of the degree of Master of Science in Computer Science of the University of Nairobi.

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LIST OF ABBREVIATIONS

MOAAM–Mobile Auction Agent Model

JADE - Agent Development Framework

MAS- Multi-Agent System

Gaia Methodology- methodology for agent-oriented analysis and design

SMS-Short Message Service

WWW-World Wide Web

E-Auction- Electronic Auction

SAAS- Software As A Service

ATM- Automated Teller Machine

TCP/IP- Transmission Control Protocol/Internet Protocol

API- Application Programming Interface

SDK-Software Development Kit

OS-Operating System

GUI- Graphical User Interface

FIPA- Foundation for Intelligent Physical Agents .Agent Communication specifications

ACL-Agent Communication Language

ECC- Elliptic Curve Cryptosystem

AAPN- Auction Platform Agent Network

WSIG- Web Service Integration Gateway

HFT-High Frequency Trading

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ABSTRACT

Buying and selling through mobile devices poses many challenges such as the need for active user participation in the auction process, tedious searching of items and services, limitation of mobile device resources and security related issues. To support automated and efficient mobile device based Auctions, an agent based solution can perform better than traditional SMS-based or online auctions. This research uses Gaia methodology to design agent based mobile auction model and to develop a prototype system to address the aforesaid challenges. The prototype is developed using Jade framework and android platform to evaluate the performance of the proposed design. The design and the prototype is also verified to ensure that it complies with electronic auction requirements such as anonymity, traceability, no-framing, non-repudiation, fairness, public verifiability and one time registration. The research improves on item search process, auction strategies, device resource utilization and proposes a secure auction and payment process.

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I am grateful to God for the wisdom for witty ideas and inventions which He has given to me as part of my inheritance. I thank God because wisdom dwells with prudence, and finds out knowledge of witty inventions. I thank God because he gives wisdom and prudence so that I can discover witty inventions because of Him.

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CHAPTER 1 INTRODUCTION

1.0 Introduction

There has been a recent rapid increase in access and use of mobile phones in the world. "The ubiquitous accessibility of communication networks, variously selectable mobile applications, and increasing computing capability of mobile devices have jointly enabled the new generation of mobile financial investment services – mobile algorithmic trading"[Chaoran Zhou , Junwei Ma, Xubin Cao] and have reinforced the era of mobile commerce (m-commerce), defined as "e-commerce for users on the move" [Kalakota and Robinson, 2001].

One of the most important applications in m-commerce is mobile bidding application which allows customers who are the willing buyers to tender bids on available products using their mobile phones. While the challenge of creating meaningful services for these platforms is constantly being addressed by various simple applications, the communication between these systems is most often scaled down to local exchanges of information, typically over a unique, homogeneous type of a wireless environment[Rodolfo Kohn,2004].

This study involved the design and implementation of an agent based bidding application that takes full use of mobile computing resources. It took into consideration the existing frameworks and middleware (Jade, MOAAM) in order to come up with a better design. Most mobile bidding solutions are SMS based. They bill the consumer's phone each time they place a bid and rely on a one-time purchase or one-time subscription. Although these SMS based bidding applications offer access to auction market, human users cannot compete agents in processing mass data and tendering bids in speed and accuracy. Agent based solutions are able to make more transactions over a long period of time on behalf of the user. Agent based applications however come with dangers for the user in terms of loss of control of applications and data as portions move through mobile devices in the network.

An agent consists of software code and data that is self-governing and can operate in heterogeneous network, migrating from a host to host and interacting with other Agents. An agent is autonomous, mobile, goal driven, intelligent, can learn and cooperate with other agents. It can be redistributed throughout the network and can act as clients or servers depending on its goal.

Agents use the capabilities and resources of remote servers to process their tasks. When a user wants to do tasks beyond the capabilities of his or her mobile device, the agents that perform the tasks can migrate to and be executed at a remote server.

Using a proxy server, users can generate a mobile agent by providing bidding information through a mobile terminal. The agent then moves to the required server to bid according to the user requirements. The server will then locate the required auction from a very large pool of available services and bid as per the agent's requirement.

1.1 Problem Statement

The bidding service discovery and actual bidding process for mobile customers in the mobile network poses the following challenge. Most mobile applications require active participation of the user. Searching available bids manually is time consuming and needs continuous human interaction with phone through SMS based application or interaction with the servers on the Internet till it is completed. Selecting the best strategy to buy and sell items at an optimal price is a hard task for inexperienced users. Hence automation of service discovery and auction process is required to ease the role of the user. Automation of the discovery and bidding process is supported by software agents due to their ability to perform autonomous task execution as per the user's requirements.

The software agents are responsible for collecting and interpreting information on merchants and products, making decisions on merchants and products, selecting best auction strategy and making payments on behave of the user.

This research also explored the possibility of users in mobile network of using utility computing paradigm. Users with low end devices can use the unused resources of proxy servers or the users with high end devices.

1.2 Objectives

The objective of this study is to design, develop and implement Mobile auction agent technology that can be used in both low end and high end mobile devices. These will be achieved as outlined in the following categories of specific objectives.

          A. Research Objectives

  i.   Test and evaluate agent-based mobile auction system in mobile phones

  ii.   Evaluate the performance of the Agent-based mobile auction system in phones

          B. Project Objectives

  i.   Collect the initial requirements of the system

  ii.   Describe the system model

  iii.   Design the agent implementation model for each agent involved in the auction process

iv.   Develop the agents using JADE Android framework

v.   Develop the auction market model for auction agents with well-defined auction protocols, ontology, communication and roles

vi.   Conduct system testing and evaluation

vii.   Deploy the prototype agent system in a mobile phone

C. System Objectives

i.   Enable an agent system that facilitates auctions on behalf of mobile phone users.

ii.   Allow users to bid by applying different strategies for the bidding

iii.   Enable a Security agent that monitors ongoing auctions for undesired bidding patterns

iv.   Enable platform for mobile phone users to market their products

1.3 Justification

There is a vast potential market for mobile agent bidding application since most people are moving to mobile computing and have embraced mobile payments system. Little research has been done to exploit the full potential of mobile bidding applications. Mobile computing resources for high end devices owned by incompetent users remain unused and such resources can be turned into an enterprise by taking advantage of metered utility computing paradigm and agents.

Mobile-agent systems provide clean abstractions to represent trading protocols and distribute resource consumption over a network.

The following are some of the advantages of the mobile bidding agent

I.   The bidding agent participates on behalf of the bidder in multiple simultaneous auctions and is trained to bid in a highly dynamic, uncertain and unpredictable environment.

II.   The bidder's participation in the auctions can be ubiquitous.

III.   The connectivity of the bidder with WWW is required only to start the bidding transactions and can get disconnected until the results are obtained due to which the participation in the auctions is carried out in an uninterrupted manner regardless of spotty or no connectivity.

IV.   The dynamic factors involved in E-auction such as behaviour of risk averse/neutral bidders (fluctuations in bid rate of the co-bidders), remaining budget etc. Can easily be considered to compute the bid value at each call.

V. The bidding agent computes and bids concurrently in real time in all the participated relevant auctions.

VI. The bidding agent have the capability to withdraw its participation from the auctions when the payoff of the auction reduces.

There is need to develop prototype systems which will help to understand issues related with mobile commerce and other related fields like algorithmic trading.

1.4 Limitations

The development and testing of the proposed design will be based on the android platform. This might not reflect the challenges in a heterogeneous environment. More time will be required to test it in other platforms.

1.5 Contributions

The key contributions of this dissertation are:

1. Describing a system architecture that can be used to develop mobile phone agent based bidding systems.
2. Implementing a fully working prototype android bidding system that allows users to test various auction protocols.
3. Commanding the acceptance of independent professional experts on the applicability of mobile phone agent based bidding system
4. Applying multi-agent system for implementation of phone based bidding system

1.6 Organization of the dissertation

The dissertation is organized as follows. Chapter one covers the introduction, the statement of the problem, objectives and justification. Chapter two reviews the literature. Chapter three gives the outline of the methodology to be used to achieve the research objectives. Chapter four describes the proposed system architecture together with the underlying technologies used to develop the prototype system. Chapter five presents the test and the evaluation results .Chapter six presents

conclusions and possibilities for future research. References supporting the study are attached at the end of this dissertation.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

This chapter provides a detailed review of agent based auction process, JADE framework, grid computing, electronic payment systems and other previous the related work.

2.2 Auction Mechanisms

An auction is a process of buying and selling goods or services by offering them up for bid, taking bids, and then selling the item to the highest bidder. In economic theory, an auction may refer to any mechanism or set of trading rules for exchange.

Auctions are generally used by sellers in situations where they do not have a good estimate of the buyers' true values for an item, and where buyers do not know each other's values.

An auction is a process of private and incomplete information:

a. Bidders are competing to win an object.

b. There are N players, or bidders, indexed by $i = 1 . . . N$.

c. Each bidders possess a piece of information related to the valuation of the object: $X1, ., XN$. These information signals are private, in the sense that only bidder i knows Xi.

d. If bidder i were to win the object, she would obtain a utility equal to $u_i (Xi, X{-}i)$, where $X{-}i = \{X1, . . . , Xi{-}1, Xi{+}1, . . . , XN\}$, the vector of signals excluding bidder i's signal. That is, bidder i's utility depends not only on her information Xi, but also on her rivals' information $X{-}i$. Since signals are private, $V_i = u_i (Xi, X{-}i)$, which we call bidder i's valuation, is incompletely known to her.

Differing assumptions on the form of bidders' utility function lead to an important distinction:

a. Private value model: $Vi = Xi$, 8i. Each bidder knows his own valuation, but not that of his rivals. More generally, in a private value model, $u_i (Xi, X{-}i)$ is restricted to be a function only of Xi. Example 1 above.

b. Common value model: When $u_i (Xi, X{-}i)$ is functionally dependent on $X{-}i$, we have a common value model. In these models, rivals possess information which is valuable to bidder i in figuring out how much the object is worth.

2.3 Types of Auctions

<u>First-price sealed-bid auctions</u>

Bidders place their bid in a sealed envelope and simultaneously hand them to the auctioneer. The envelopes are opened and the individual with the highest bid wins, paying the amount bid.

This usually involves multiple bidders, one good. Bidder i's valuation for the good is vi and is known only by bidder i. Valuations are independently and uniformly distributed on [0, 1]. Each bidder i submits a nonnegative bid bi. The higher bidder wins and pays his bid. In case of a tie, the winner is determined by a coin flip.

Assume the winner is bidder i, whose bid is bi. Since his value for the sold object is vi, his payoff (profit) is vi-bi. For the other players the payoff (profit) is 0. Note that the winner's profit can be negative. This happens when he wins the object by overbidding, i.e., submitting a bid higher than his valuation of the object being sold. Such a situation is called the winner's curse.

<u>Second-price sealed-bid auctions (Vickrey auctions)</u>

Bidders place their bid in a sealed envelope and simultaneously hand them to the auctioneer. The envelopes are opened and the individual with the highest bid wins, paying a price equal to the second-highest bid.

In the Second Price Sealed Bid auction, there is a dominant strategy for each bidder, which is to bid the true value of the object.

A Vickrey auction is decision efficient (the winner is the bidder with the highest valuation) under the most general circumstances.

However it does have a number of weaknesses. It does not allow for price discovery, that is, discovery of the market price if the buyers are unsure of their own valuations, without sequential auctions. Sellers may use shill bids to increase profit and it is also vulnerable to bidder collusion.

<u>Open ascending-bid auctions (English auctions)</u>

Participants make increasingly higher bids, each stopping bidding when they are not prepared to pay more than the current highest bid. This continues until no participant is prepared to make a higher bid; the highest bidder wins the auction at the final amount bid. Sometimes the lot is only actually sold if the bidding reaches a reserve price set by the seller.

<u>Open descending-bid auctions (Dutch auctions)</u>

The price is set by the auctioneer at a level sufficiently high to deter all bidders, and is progressively lowered until a bidder is prepared to buy at the current price, winning the auction.

In a Dutch auction, the item being sold is initially offered at a very high price, well in excess of the amount the seller expects to receive. Bids are not sealed, as they are in some types of auctions. The price is lowered in decrements until a bidder accepts the current price. That bidder wins the auction and pays that price for the item.

2.4 Requirements of secure electronic auction protocols

a. Anonymity: During the course of an auction, no one is able to recognize the other bidders' identities.

b. Traceability: The winner's real identity can be recognized at the end of the auction.

c. No framing: The identities of all bidders remain independent. No one can falsely claim to be any other bidders who participate in the auction.

d. Unforgeability: Nobody is able to forge another one's valid bidding price.

e. Non-repudiation: The winning bidder is unable to deny the proposed bidding price after being announced.

f. Fairness: All bidding must be conducted in an open and fair manner.

g. Public verifiability: Anyone can verify the identities and bidding prices of the participated bidders.

h. Unlinkability among various auction rounds: Nobody will know the same bidder's identity among different rounds of auction.

i. Linkability within a single auction round: The bidders can repeatedly place new bidding prices within a single auction round and can be recognized by other bidders.

j. Efficient bidding: In order to make the bidding become efficient, computation

k. One-time registration: The bidder only needs to register once and then he/she can participate in all auctions that are opened.

l. Easy revocation: The registration manager can easily revoke someone's right to bid.

2.5 Electronic Auction Security issues

a. Bid shielding in which a high value bid is withdrawn at the last minute allows a low bid to be accepted.

b. Bid siphoning in which a seller observing an auction makes direct contact to a bidder to offer an alternative (or equivalent) item available directly to the bidder. This can allow sellers to obtain buyers for their goods without paying the commission to the auction site.

c. Shilling is making bids on an item with the intent to artificially increase its price or desirability. The shill collaborates with the seller and in the event of the shill winning the auction the item may be re-sold at a different site. eBay for instance forbids shilling; its rules do not allow friends or employees of a person selling an item to bid on the item.

d. Sniping is last minute bidding in the hope of preventing other bidders from responding. This applies mainly on sites which have a fixed bid close time.

e. Denial of service attacks on the online site may delay other customers from making their bids on time.

f. Misrepresented or non-existent items are a common complaint of auction buyers.

2.6 Theory of Agents and MAS Systems

Software agent technologies have been developing rapidly in the past several years. As said by Guilfoyle (1995), in ten years' time, most new IT development will be affected, and many consumer products will contain embedded agent-based systems [N. R. Jennings, M. J. Wooldridge, 1998].

An agent is a program that can delegate a task. The difference between "traditional software" and an agent is that an agent is personalized, continuously running and semi- autonomous [R.H. Guttman, A. G. Moukas and P. Maes, 1998]. These features make agents useful for a wide variety of information and process management tasks.

The first idea to develop machine independent executable messages could be traced back to the early days of AI work. Carl Hewitt has put forward a concurrent actor model in1977, in which the concept of a self-contained, interactive and concurrently executing object called an actor was proposed.

Now day's agents have many more characteristics. Autonomy, learning and cooperation are the basic attributes. Autonomy means that agents can operate on its own without the need of human guidance. An agent is cooperative because it can work with other agents to complete a task. Some agents can even automatically learn information from the outside environment to enhance their performance. Agents with all of the above three characteristics are considered to be intelligent [W. Brenner, R. Zarnekow and H. Wittig, 1998]. There are also several other attributes to classify agents. One of them is mobility. After initiation, some agents only work in the original server; where as other agents can move across computers over a network. These agents are called mobile agents

The agent technology is quite useful in online auctions [Jie Zhang, 2004]. Currently, most popular auction sites only provide a human interface. To bid for an item, users have to search on the Internet, find the items they want and send the bid message themselves. Unlike auctions in physical world which only lasts for a short time and bidders can know the auction result quickly, online auctions usually last for a longer time, from 2-3 days to even several weeks. It is quite in convenient for users to monitor the bidding situation and respond quickly. Agent technology is a good way to facilitate auctions. Agents can stay alive in an auction, observing the fluctuation of prices and providing responses in a timely manner. Other than bidding in just one auction, mobile agents could even automatically wander on the Internet to search for appropriate auctions to participate. With the learning ability, intelligent agents can even perform better than humans in the aspect of negotiation. Intelligent agents can collect the records of all previous auctions and analyze them quickly. With good bidding strategies and rich history information, agents can perform better than human beings. Furthermore, with high computation power, intelligent agents can give much faster responses than human beings [Jie Zhang, 2004

2.7 Agent Design Methodologies

The following are agent-oriented software engineering (AOSE) methodologies

2.7.1   Gaia

Gaia is a methodology initially proposed by M. Wooldridge, N.R. Jennings, and D. Kinny in the article "A methodology for Agent-Oriented Analysis and Design" (1999)

Recently, a new version of Gaia has been proposed by M. Wooldridge, N.R. Jennings and Franco Zambonelli (2003). The new version extends the range of applications to which Gaia can be applied

Gaia is a methodology for agent-oriented analysis and design. The Gaia methodology is both general, in that it is applicable to a wide range of multi-agent systems, and comprehensive, in that it deals with both the macro-level (societal) and the micro-level (agent) aspects of systems. Gaia is founded on the view of a multi-agent system as a computational organization consisting of various interacting roles. Gaia does not explicitly deal with the activities of requirements capturing. Figure 1 below shows the Gaia methodology.
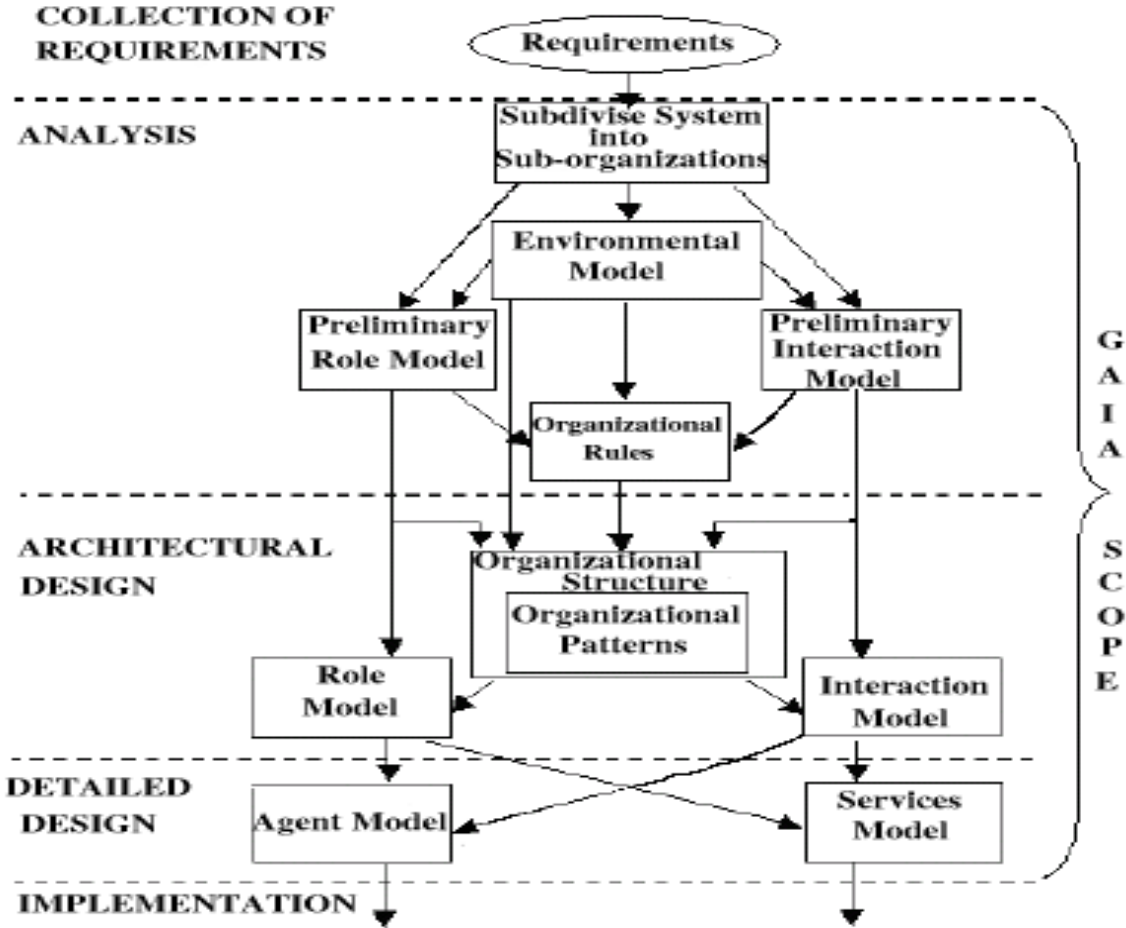
Figure 1: Gaia methodology

2.7.2   Prometheus

Prometheus is a methodology proposed by L. Padgham and M. Winikoff in the article " Prometheus: A methodology for Developing Intelligent Agents ''(2002). Figure 2 below shows the Prometheus methodology.

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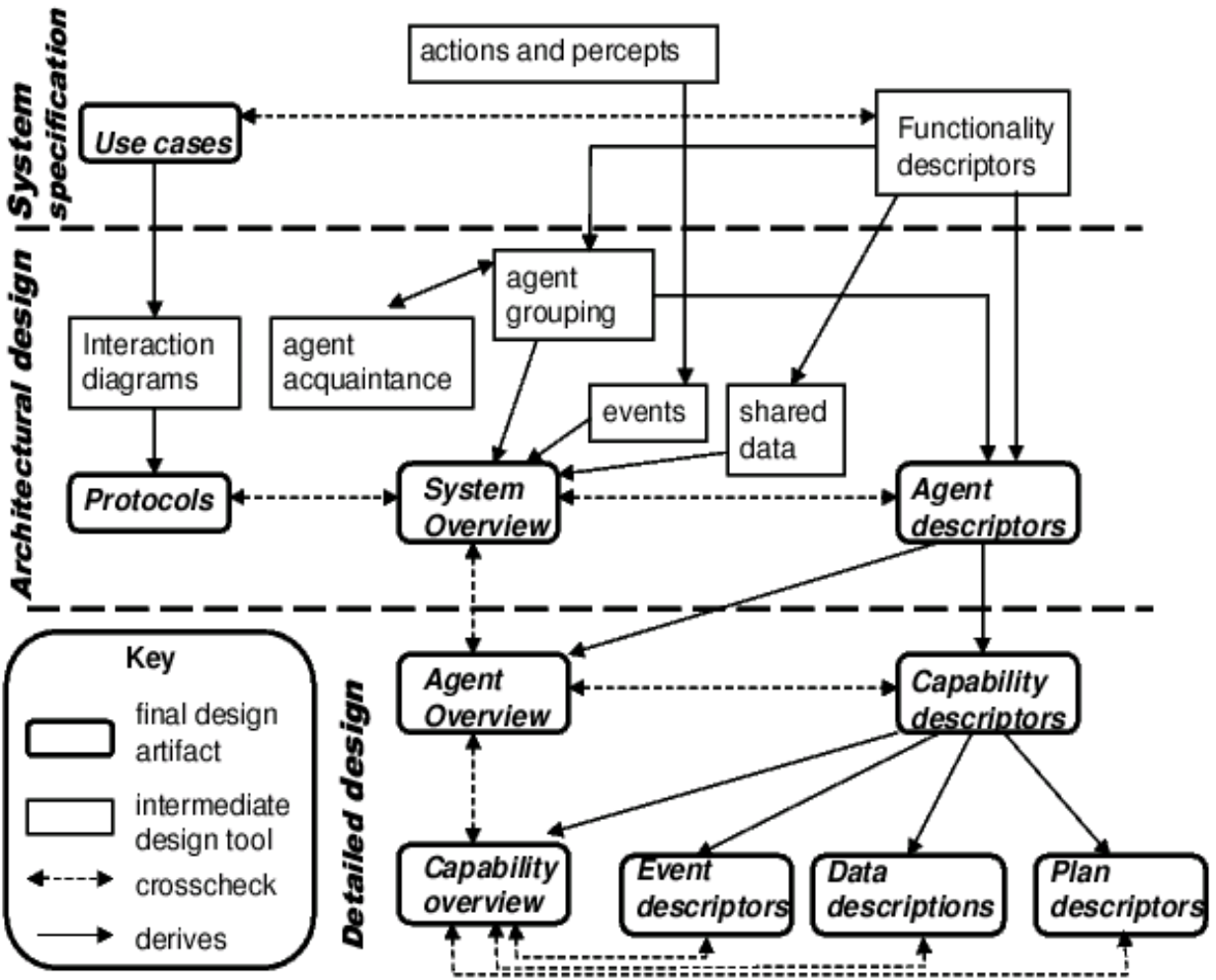
Figure 2: Prometheus methodology

2.7.3 Tropos

Tropos is a methodology proposed by J. Mylopoulos, M. Kolp and P. Giorgini in the article "

Agent Oriented Software Development " (2002)

It has five main development phases: Early Requirements, Late Requirements, Architectural

Design, Detailed Design and Implementation

2.7.4 Other methodologies

Other agent-oriented software engineering (AOSE) methodologies that have been are

CommonKADS, MaSE, PASSI, IODA, MOBMAS, SODA, KGR, MASSIVE, MASB.

These methodologies should have their main focus on of the following areas of MAS development:

    a. Agent internal design – design of agent mental constructs such as beliefs, goals, plans and actions;

b. Agent interaction design – design of interaction protocols and exchanged messages; and

c. MAS organization modelling – design of acquaintances and authority relationships amongst agents or agents' roles.

2.8 Mobile and electronic Payment services in Kenya

Kenya has in recent times witnessed remarkable growth in mobile-phone based money transfer, online payments and micro financing services. Mobile payment is primary choice for service providers.

All the mobile operators in the country, Safaricom (M-Pesa), Airtel (Airtel Money), YU (Yu Cash) and Orange (Orange Money) are operating a money transfer service each, thus offering a huge growth avenue for start-ups.

An estimated 29.7 million Kenyans have mobile phones, while about 14.3 million have access to the internet.

Other online payment services in Kenya

a. Pesapal is a payment gateway in Kenya supporting over 9 payment methods including mobile transfer services, credit cards and ATMs. Their services extend to the greater East Africa region. They support MTN Uganda's mobile money and Vodacom Tanzania's cash service.

b. Kopo Kopo is a subscription based Software As A Service (SAAS) mobile payment service. It allows small businesses to aggregate their mobile money accounts to one location and save on the costs for subscribing to costly corporate mobile money solutions.

c. iPay is a global mobile and internet payment solution that also connects to banks in Kenya via the Kenswitch, a financial switching network. It serves e-payment, credit card networks, and mobile and banking transactions. iPay also has a re-seller and referral program for its payment solutions.

d. 3G Direct Pay is a gateway that offers payment solutions in Kenya and East Africa. The gateway supports VISA, MasterCard, American Express, JCB, PayPal and mobile money-M-pesa and Airtel Money. 3G Direct Pay has close to 70 corporate integrations in the country.

This online service will leverage the deep penetration of the mobile phone and the proliferation of Internet services to ease the shopping experience for customers while allowing merchants to match their goods and services directly to consumers.

2.9 Related work

Development of the Internet has spurred a number of attempts to create virtual market places. However, only human's interfaces are provided by concurrent online market places. With the development of agent technology, auction sites with agent interfaces have been available. Some of the famous auction sites are described as follows:

eBay and Onsale

Besides a user interface, eBay and Onsale also provide some simple agent- like interfaces. For example, Onsale provides a proxy agent called BidWatcher, which can automatically bid on the user's behalf. Before bidding in an English auction, the user tells the agent the maximum price he/she is willing to pay and the BidWatcher will automatically bid the minimum price possible to win the auction without exceeding the user's assigned price ceiling. Given an English auction with current price c, minimum incremental price d and the user's maximum bidding price l, the agent will always bid the price c+d if it is no higher than l. Otherwise, it will not submit any bid. However, proxy agents provided by the auction sites are not secure and trustful. The maximum bidding price may be disclosed to the auction site and a shill bidder can be created [Jie Zhang, 2004].

AuctionBot

Michigan AuctionBot was developed by the Artificial Intelligence Laboratory at University of Michigan. It has been available for public use at the University of Michigan since September 1996 and to the entire Internet since January 1997. In particular, it has been used for selling used text books. AuctionBot can handle many auctions simultaneously and all its auctions are organized in a hierarchical structure. Sellers can choose the catalog in a systematic manner and create an auction at whatever layer he/she wants. One of the most significant features of AuctionBot is the parameterization of auctions. After analyzing the characteristics of all auctions, they decompose the auction design space into a set of orthogonal parameters such as "Bidding restrictions", "Auction Event", "Information Revelation" and "Allocation Policies".

Besides user interface, AuctionBot also provides agent interface. The database stored parameters of all auctions, which be accessed by users and agents through interfaces by certain rules. The agent interface provided by AuctionBot is a TCP/IP-level message protocol that allows agents to access all the features of the AuctionBot present in the web systems. Agents can place bids, create auctions, request auction information or review their accounts. The API provided by AuctionBot

is self-contained such that developers can use it to build their own front end to AuctionBot. A backend decision program runs cyclically, which is up to conclude imminent auctions and make final decisions. When the auction is over, results will be notified to users through emails. However, AuctionBot provides only an information service. It collects bids, determines the results of the auction by using a well-defined set of auction rules, and notifies the participants. No actual money exchange is executed [Jie Zhang, 2004].

Kenyan Online Market

There has been a rapid increase in online marketing and selling in Kenya as people turn to internet platforms to advertise, buy and sell various items because of low advertising fees and easy accessibility of internet through mobile phones. Popular sites include http://www.olx.co.ke, http://www.bidorbuy.co.ke and http://www.kenyaonlineauction.com

Popular items sold include mobile phones, vehicles, motorbikes, iPads, video cameras, furniture, fridges and vehicle tracking devices. The process begins with someone posting the photo of the item they want to sell and giving its details, for instance, whether it is new, used, or reconditioned. Sellers must further specify minimum bids they are willing to accept and if they will meet shipping costs in the case of international buyers.

These platforms have made payments real time by using mobile phones to facilitate the transactions. Mobile transaction has become the preferred modes of payments. Unlike globally acclaimed online auction site e-bay, Kenya's online marketing platforms do not collect or distribute payments. They are merely e-commerce platforms that link sellers and buyers. It is upon the two to agree on modes of payments they will use.

Despite the growth of online market in Kenya, the sites are yet to gain wide acceptance because of the challenges that come with online transactions, which include fraud. Internet and mobile phone fraud has been on the rise in Kenya. There is a great need for secure platforms to advertise products and auction them.

OLX

OLX (short for online exchange) operates local online classifieds marketplaces accessible through the internet and through native apps on mobile phones. OLX hosts free user-generated classified advertisements providing solution for selling, buying, trading, discussions, organizing and meeting people near you. OLX does not own any of the items or services but allows users to

sell or buy products listed in its site. OLX has no knowledge of the actual transactions that take place between sellers and buyers and has no control over such transactions.

Other related online shopping sites such in Kenya are OLX, RupuShops, Bid or Buy, Jumia, and Cheki

2.10 Mobile grid computing and utility mobile computing

Mobile grids will not require much investment since they are designed to make use of `idle' power on already existing phones. This is because most smart phone users only use their phones for a few minutes or a few hours every day and yet, these phones are powered up 24/7. These kinds of grids are most favorable to developing countries where the penetration of mobile phone exceeds other forms of ICTs. Once in place, the grids can then be utilized to run the much-needed applications such as the bidding agents.

One of the examples of mobile grid system is the MobiGrid. MobiGrid middleware for mobile phone grid is part of a larger research project that aims at integrating mobile phones and sensors to come up with a drought predication tool for use in the developing countries. MobiGrid is an API on which distributed applications can be built. Unlike the rest of grid middleware solutions, the uniqueness of our approach lies in the fact that the middleware is for mobile phones environment. However middleware for agent based mobile phone bidding application for mobile grid does not exist. The contribution of this research work will be a major milestone towards mobile grid computing.

Mobile devices utility computing paradigm is new in the field of mobile computing devices. Utility computing is the packaging of computing resources in mobile device or grid, such as computation, storage and services, as a metered service. Users with high end devices will be able to sell their unused resources to the users with low end devices.

Repackaging of computing services has become the foundation of the shift to "on demand" computing, software as a service and mobile grid computing models that further propagated the idea of computing, application and network as a service.

IBM, HP and Microsoft were early leaders in the new field of Utility Computing with their business units and researchers working on the architecture, payment and development challenges

of the new computing model. Google, Amazon and others started to take the lead in 2008, as they established their own utility services for computing, storage and applications.

"Mobile Utility computing" envisions some form of virtualization so that the amount of storage or computing power available is considerably larger than that of a single time-sharing mobile device. Users with high end devices will be able to sell their unused resources to the users with low end devices.

2.11 JADE –Agent development Framework

JADE (Java Agent Development Framework) is a software framework fully implemented in Java language. It simplifies the implementation of multi-agent systems through a middle-ware that complies with the FIPA specifications and through a set of tools that supports the debugging and deployment phase. The agent platform can be distributed across machines (which not even need to share the same OS) and the configuration can be controlled via a remote GUI.

The configuration can be even changed at time by creating new agents and moving agents from one machine to another one as and when required. The communication architecture offers flexible and efficient messaging, where JADE creates and manages a queue of incoming ACL messages private to each agent

The full FIPA communication model has been implemented and its components have been clearly distincted and fully integrated: interaction protocols, envelope, ACL, content languages, encoding schemes, ontologies and, finally, transport protocols.

 Most of the interaction protocols defined by FIPA are already available and can be instantiated after defining the application-dependent behaviour of each state of the protocol. SL and agent management ontology have been implemented already, as well as the support for user-defined content languages and ontologies that can be implemented, registered with agents, and automatically used by the framework.

The LEAP add-on is used to execute JADE agents on lightweight devices such as cell phones running Java and on devices running Microsoft .Net Framework. The LEAP add-on was created to solve these problems and allows deploying JADE agents on handheld devices.

2.12 MoAAM -Mobile Auction Agent Model

Mobile Auction Agent Model [4], called MoAAM, is designed to enable users to use their mobile devices participating in online auctions. MoAAM consists of four agents, namely (1) Personal Agent, (2) Customer Agent, (3) Auctioneer Agent and (4) Broker Agent.

Inside the mobile device, there is an interactive interface, called personal agent, which would connect with an agent house server via the wireless network. A personal agent is a preset agent that operates on the mobile device and provides an interface to allow users to communicate with the agent house server. The customer agent, the auctioneer agent, and the broker agent all operate in the fixed network. The personal agent connects to the customer agent when a mobile network user wants to buy a specific product. Then, the personal agent sends the description of desired products and price information to the customer agent. On the other hand, an auctioneer registers the information of products to the broker agent. After the broker agent receives the user's request, an auction list, which meets the user's needs, will be generated and sent back to the user. If the user decides to purchase the auction items from the received list, a bid agent will be created by the customer agent and be dispatched to an auction house server to participate in the bidding

2.13 The proposed model

To meet auction security demands through encryption Kuo-Hsuan Huang mobile auction agent model (MoAAM) protocol employed modular exponentiation operations which require a large computation amount, bringing a gradual degradation of performance in key generation, bidding, and verification phases.

Yu-Fang Chung [1] proposed to add the concept of Elliptic Curve Cryptosystem (ECC) onto MoAAM,. ECC provides low computation amount and small key size. This led to a positive improvement of performance in key generation, bidding, and verification phases

This the study improves on the MoAAM by avoiding key generation leading to reduced workload in the mobile device.

The proposed design also has the following additional features

a. Support for multiple auction protocols. Prototype implements Vikrey and the English auction protocols.
b. User of registered mobile phone number as a unique identifier for users. A onetime unique identifier is generated at user generation

c. Marketing module. This will involve the ability of agents to market sellers products and analyse the market

d. Device local database- Sellers with high end mobile devices can store their products data locally and will be made available only when the sellers wants to start the auction process. On start-up the agent will automatically copy the prepopulated local listing of user products to the yellow pages of the agent platform.

e. Decentralised agent platform and ability for users to migrate their services from one platform to another. A single platform is hosted in a single machine with a public IP address. A group of platforms will form Auction Platform Agent Network (AAPN). Users will be able to subscribe and migrate their services to any of agent platform nodes

f. Web service- **Automatically exposes agent services registered with** Auction Platform Agent Network as Web Services. This will enhance interoperability with other various web platforms

g. Payment scheme. This will is the middle link between the local electronic payment system and user application. Once a buyer has won an auction and wants to make a payment to the appropriate seller, the payment module authorises and debits payment from local digital cash and credits it to the seller's account.

The proposed design is described in detail in the Design and Implementation section. The proposed design is shown in figure 3.
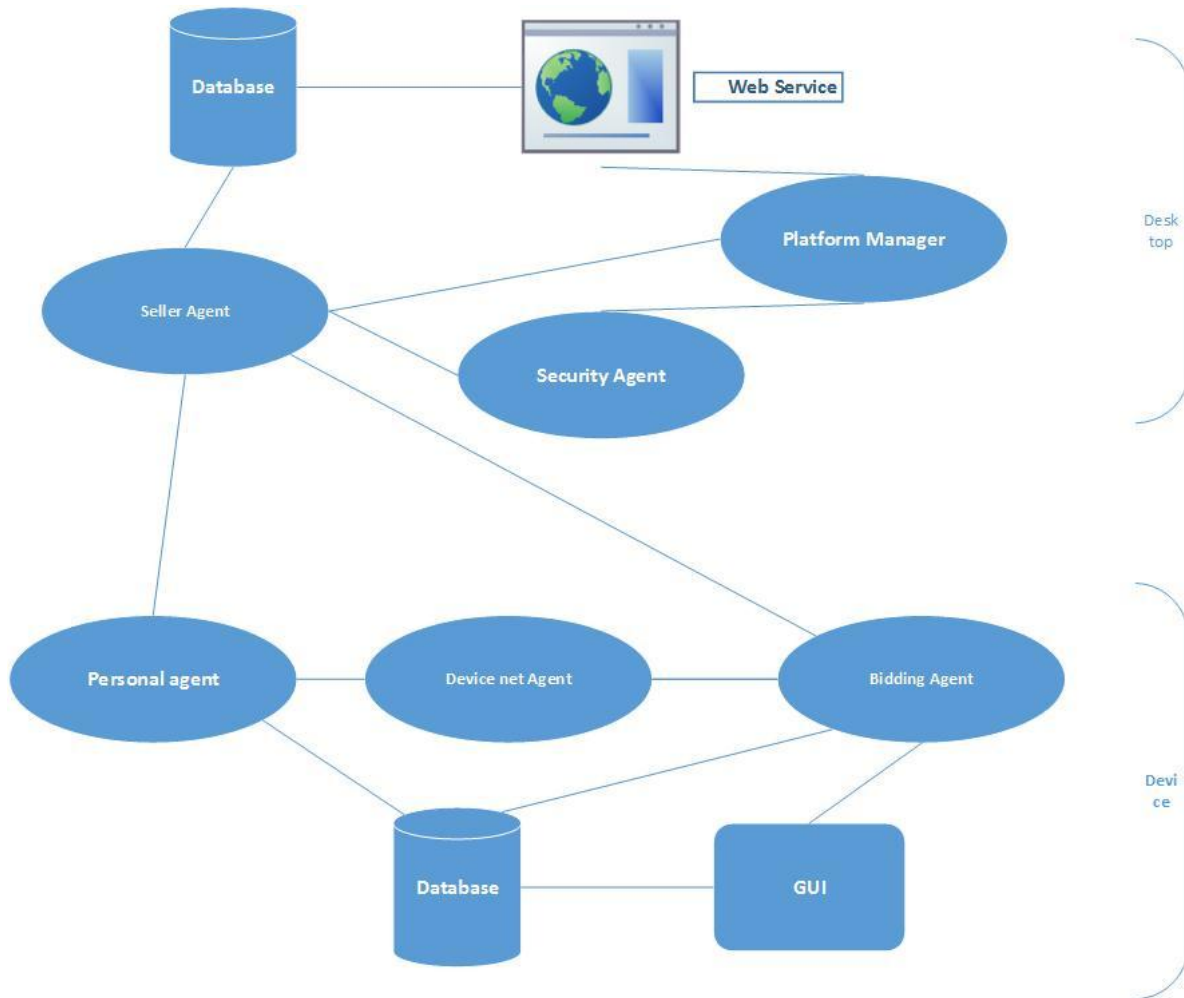
Figure 3 : Agent based bidding architecture

2.14 Chapter summary

This chapter gave a detailed review of auction mechanisms, auction related issues, agent technology and related work.

Previous research has shown that software agents can be used to tender bids on behalf of the user. Little research has been done on how to use agents in the mobile phones and other low end mobile devices.

CHAPTER 3 METHODOLOGY

3.1 Introduction

In this chapter a methodology is outlined for the development of the mobile agent based bidding systems using the JADE platform. The analysis phase is generic in nature, while the design phase specifically focuses on the constructs provided by the popular FIPA-compliant JADE platform.

This research incorporated Gaia methodology since it enables definition of individual level agent structure and society process (Auction Market). The basic stages of this methodology are as shown in the figure 4.
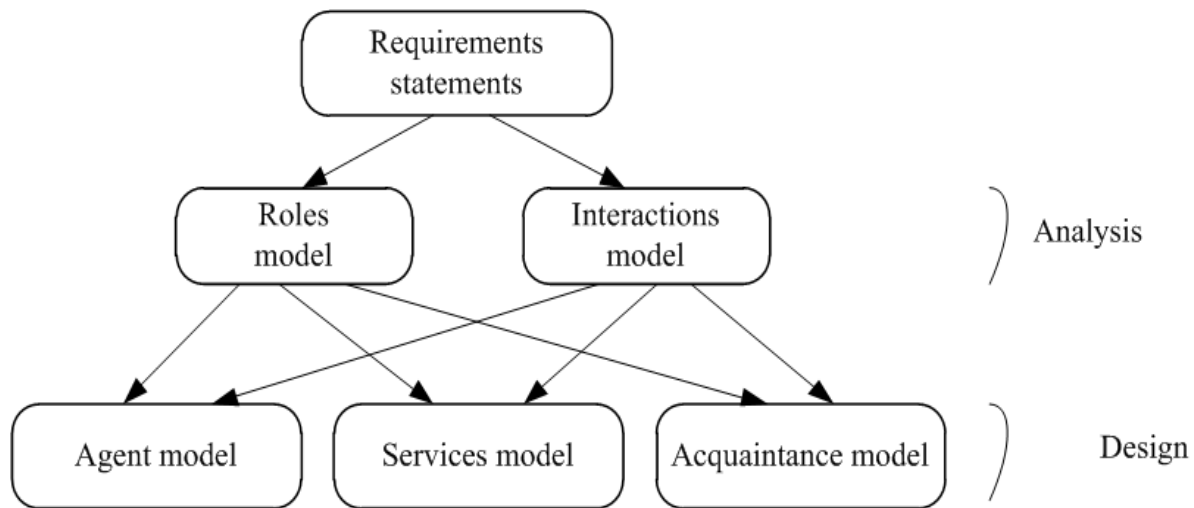
Figure 4 : Gaia Methodology

3.2 Requirements gathering

The initial requirements for the system were obtained from Kenyan mobile phone users, Kenyan online marketing websites and study of previous work.

3.3 Analysis

This involves development of roles model and interactions model as follows

Roles Model

Various roles of the system are defined. Each role is defined by the following four attributes

    a. Permissions: rights associated with a role, resources that are available.

    b. Activities: computations to be carried out by the agent.

    c. Protocols: interactions with other roles.

d. Responsibility determines functionality of role and includes Liveliness properties which contain system reaction to external exposure (reactive component) and Safety properties which define a set of activities that should not occur during role functioning.

Interactions model

This model defines the links between the roles. This includes definition of the attributes of interaction protocols: interaction goal, interaction initiator role, interaction respondent role, interaction input and output resources and text definition of interaction process.

3.4 Design

Agent model

This process involved defining system agents' types and agent types' correlation with defined roles. During implementation a defined number of agent instances, in accordance with instance generation rules, are created for each type.

Services model

This is provided for agent functionality definition. Each agent service is mapped to a role defined on role activity analysis phase. Service has information inputs and outputs (corresponding to attributes of roles interaction protocol), as well as start and finish conditions in form of role safety properties.

Acquaintance model

This involved documenting the lines of communication between the agents. The model represents a directed graph with agent types as graph nodes and communications between agent types as arcs.

3.5 Prototype development

This involved writing and testing of the software code for the engine and graphical interface of various components auction system. The systems with be developed using eclipse, ANDROID SDK and JADE_LEAP platform.

3.6 System testing

Five android users tested the system. The activities done in the testing process included user registration, bidding participation, agent verification, seller and product search and auction protocol verification.

The questionnaires used to test the system are as specified in the appendix

3.7 System evaluation

Will do usability and user experience test to measure the performance of the system. Usability and experience testing approach will involve representative users working on typical tasks using the system (or the prototype) and filling a questionnaire.

The questionnaires used to evaluate the system are as specified in the appendix

3.8 Outputs

The following are the outputs: Auction Model, System prototype, Thesis and Journal Articles

CHAPTER 4 DESIGN AND IMPLEMENTATION

4.0 Introduction

This chapter describes the implementation of the proposed model using the Gaia methodology.

4.1 Requirements statement

The target users of this system are Kenyan mobile device users.

The proposed agent system architecture is comprised of the server and client node applications.

The nodes are mobile devices. The communication is based on 2G and 3G technology over mobile

telephony network.

 The task handling involves the following;

    a.   Ability of client to register in the system

    b. Ability of the mobile system to generate agents which will sell, search or bid on behalf of
the client

    c. Ability of clients to market their products to registered clients using marketing platform
agents

    d. Ability of registered clients to analyse the market and place their products for bidding or
place bids for products of a preferred seller

    e. The ability bidding platforms (servers) generate agents to monitor business activities in the
auction market and to offer security

    f. A platform where clients can search for products they intend to buy.

    g. Ability of the system administrator to manage user and product profiles

4.2 Agent Roles model

The following roles were identified

Role	Description	Interacts with	Permission
Seller	Post items to be auctioned	Platform manager	Access to customer profile data
Bidder	Make bids on behalf of the customer using customers preferred strategy	seller	Sellers product information

Finder	Searching for sellers, products and services	Platform Managers, sellers	Sellers product information
Platform Manager	Manager platforms and keep current status of platforms(activity and performance)	Platform Managers	Platform network information
Security Manager	Manage security issues of the system	Platform Managers, sellers	Sellers and sellers information
Communicator	For sending general messages to agents	Sellers, bidders	Sellers and bidder information
Marketer	Customized marketing for customers' products	Sellers, bidders	Sellers product information
Pay master	Making payments for winning bidders and rates for platform resources	Sellers, bidders	Account information
Device network advisor	Monitors phone network and advices mobile which technology to use (internet or SMS)	bidders	Device network resources

4.3 Agent Interaction model

The various roles interact as in shown in diagram 5 and the full description is provided in the table below

4.3.1   Interaction model description

Initiator role	Respondent role	Interaction goal	Input resource	Output Resource	Interaction description	protocol
Seller	Platform Manager	Register seller	Customer details	Registration results	Registers the seller in the platforms	
Seller	Marketer	Request for marketing service	Sellers products to be marketed	Sellers Products marketed	Requests marketing agent to market on behalf of the seller	

Seller	Pay master	Make & receive payments	transaction instruction	Transaction output	Credit or debit sellers account	
Bidder	Finder	Find a product	Item description	List of sellers with product description	Search sellers for a specific product	
Bidder	Seller	Make bids	Bid price quotation	Auction outcome	Participation in bidding	
Bidder	Pay master	Make payments for the client	transaction instruction	Transaction output	Make payments for products bought	
Finder	Platform Manager	Get list of seller	Item description	List of sellers	Search product sellers	
Platform Manager	Platform Manager	Get service	Service request	Service agreement	Join other platform networks	
Security Manager	Platform Manager	Secure platform	Platform agents	Secure platform	Validates agents' activities	
Marketer	Bidders	Promote products	Products summary	Service acceptance or denial	Product promotion	
Marketer	Sellers	Promote products	Products summary	Service acceptance or denial	Product promotion	

4.3.2 Interaction Diagram

Seller

Platform Manager

Security Manager

Register

monitor

Register

Register

Confirm payment

Register

Marketing Items

Register

Bidder

marketer

request item search
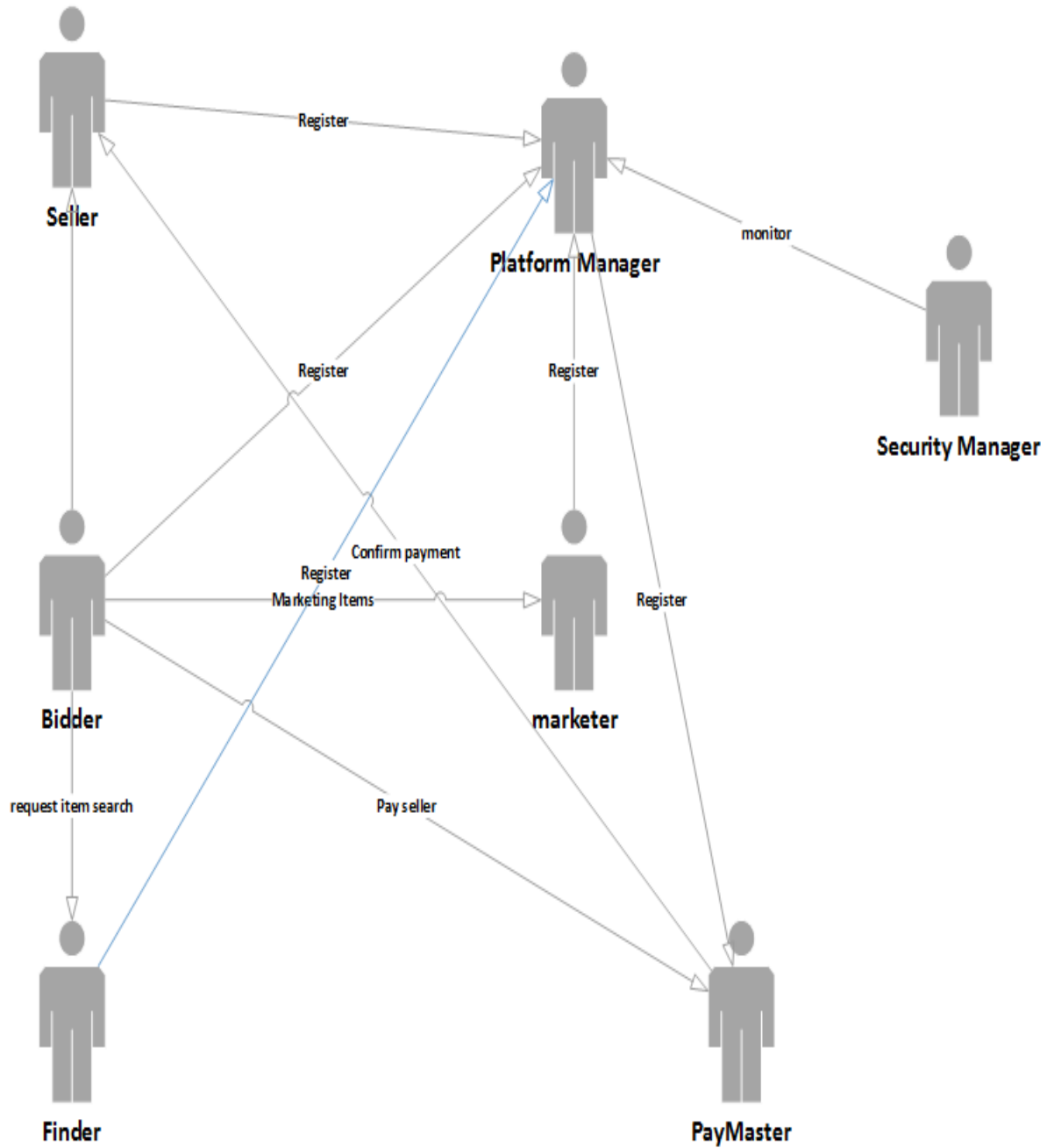
Pay seller

Finder

PayMaster

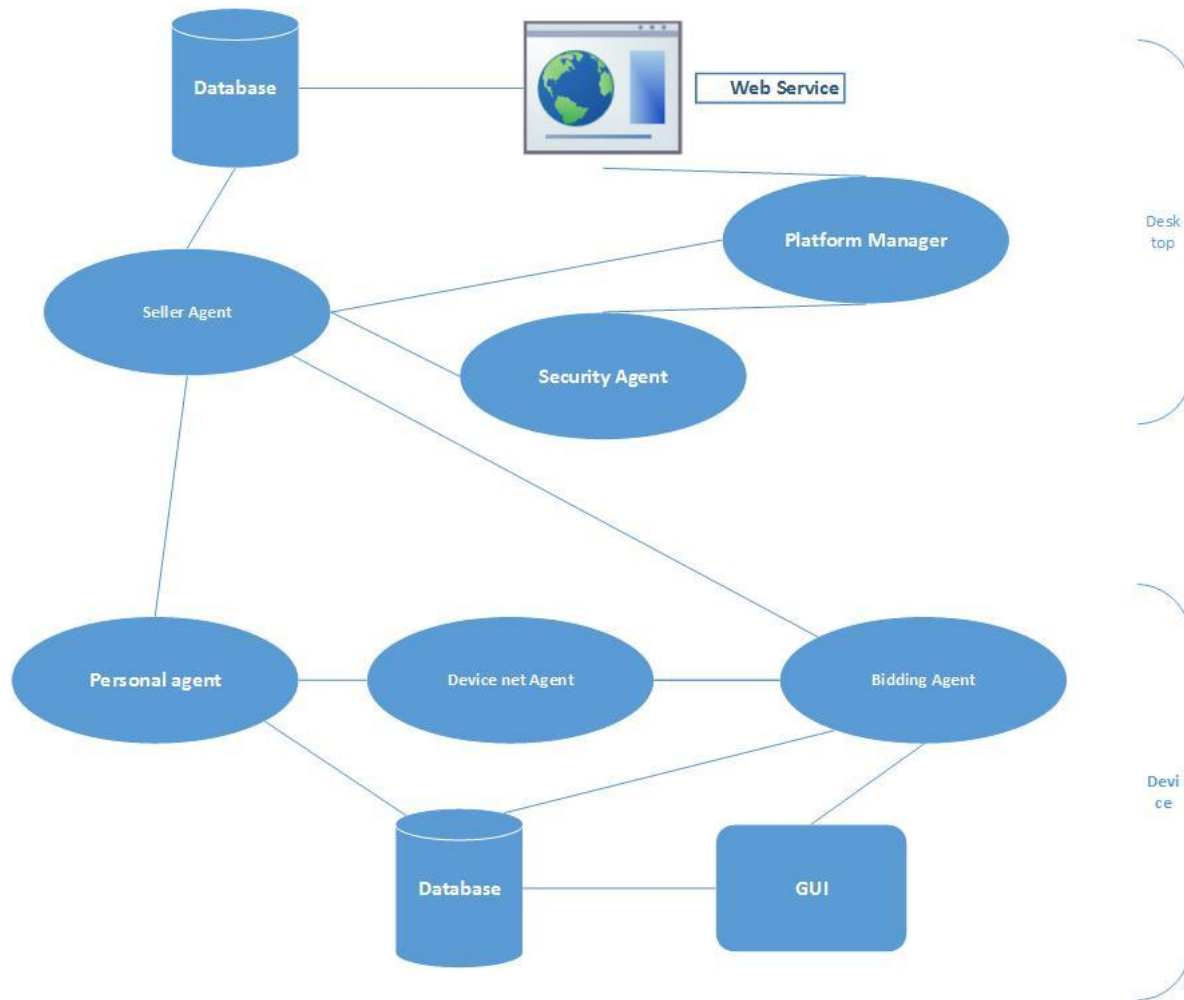*Figure 5: Agent Interaction Model*

4.4 Agent model

Figure 6: Agent Model

Agents in the system architecture are shown in figure 6 above and operate as follows

i.   Platform manager agent: creates new customer accounts, handles validates agents, monitors system performance and handles server communication services. Maintains collection of all available auction platforms

ii.   Seller agent: Every customer maintains one seller agent. Keeps current catalogue of all products to be sold by a particular customer and their respective auction protocols. Creates customer auctions. Manages customer's auctions. Updates customers through their personal agents the status of running auctions.

iii.   Personal agent: Searches for auctions on behalf of the user. Updates the customer's seller agent with new items to be sold and other updates. Registers customer with main agent. Monitors device connection.

iv.   Bidding Agent: Makes bids on behalf of the customer. It does this bit submitting customer preferences as the customer's requirement

v.   Security Agent- Validates platform users by ensuring only registered mobile phones participate in auction.

vi.   Device network monitor- Monitors device network availability and advices personal agent on which communication channel to use.

4.5 Services model

Service Name	Related Roles	Inputs	outputs	Start Condition	Finish Condition	Description
Searching	Finder	Platforms addresses	List of agents	Running platform	Platform terminated	For searching products and agent services
Bidding	Bidder	Bid description	Bid outcome	Availability of products	Product auction termination	Bidding on behalf of the customer
Security	Security Manager	Running agents	Secure platform	Running platform	Platform terminated	Managing security issues at various levels
Selling	Seller	Customer products	Products sold	Customer registration	Customer withdrawal	Selling products for the customer
Marketing	Marketer, Finder	Customer products	Customer adverts	Platform Started	Platform terminated	Customized marketing of products
Platform network monitoring	Platform Manager	Platform IP address and port	Running platform	Network availability	Platform terminated	Manage connections with other platforms in APAN or JVPN
WSIG Web service	Marketer, Finder	Platform IP address and port		Platform Started	Platform terminated	universal interoperability with other web applications

To enable universal interoperability (platform independence) with other web applications the marketing service is exposed to other platforms using Jade Web Service Integration Gateway

(WSIG). WSIG add-on provides support for invocation of JADE agent services from Web service clients. WSIG is deployed in a servlet container such as Apache Tomcat and is executed within the JVM of the servlet container.

4.6 System prototype

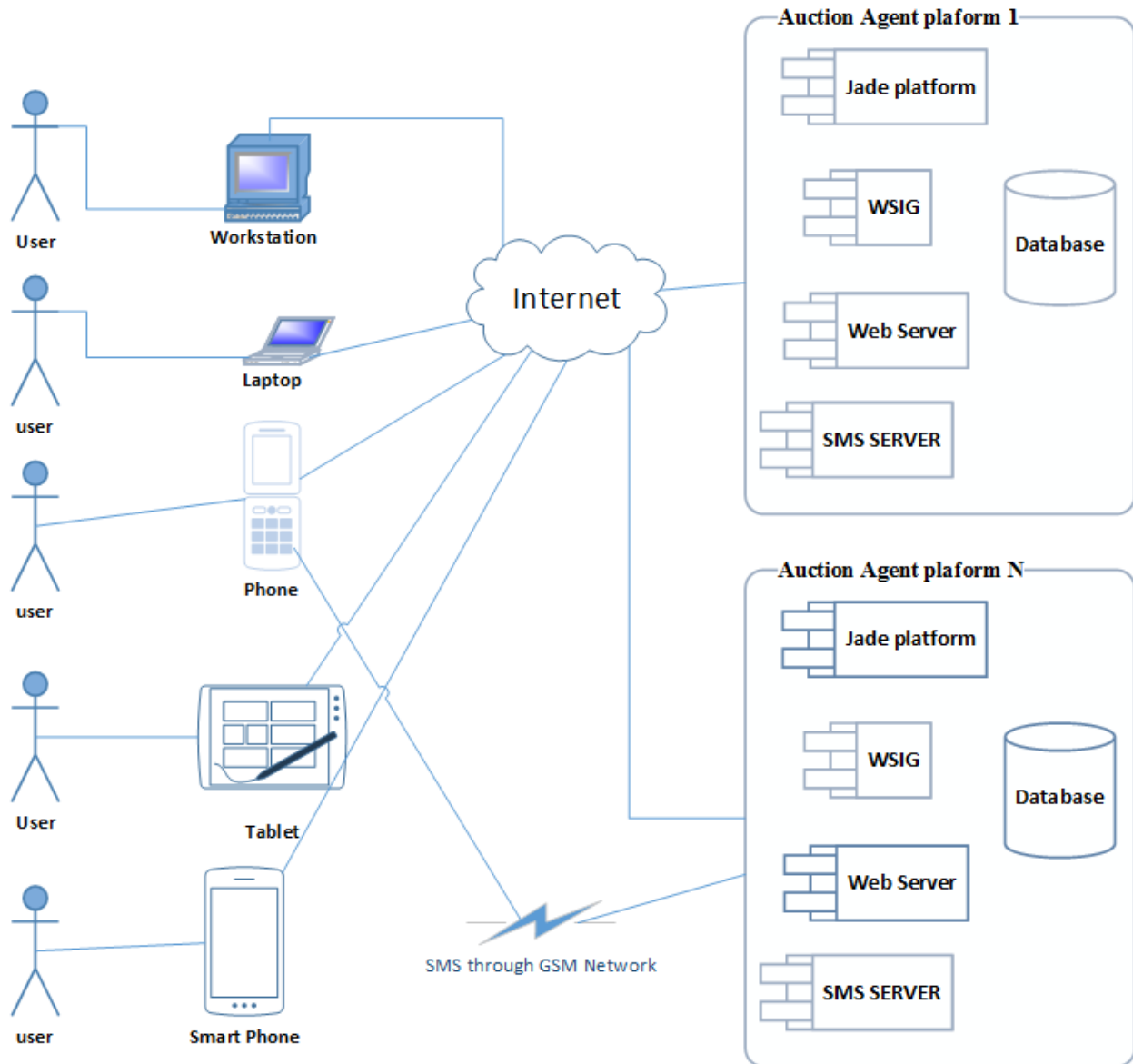### 4.6.1   Physical Architecture

Figure 7: Physical Architecture

4.6.2 Hardware and Software Tools

The following tools and resources were used to develop the prototype

Tool	Description
JADE	Java agent development Framework
Netbeans IDE	Java development environment
Android SDK	SDK for developing the android app
JADE-LEAP	allows deploying JADE agents on Java enabled cell-phones
WSIG (Web Service Integration Gateway)	Allows automatically exposing agent services registered with the DF as Web Services.
JADE Security Add on	This add-on allows deploying JADE-based system where each component (agents, containers) is owned by an authenticated user.
GlassFish webserver, Oracle webLogic	Web server for running web services
Computer with public IP address	For running host agent platform
Android Mobile phone	For running sellers and bidders application

CHAPTER 5 RESULTS AND DISCUSSIONS

5.0 Introduction

This section will show the sample screens of the prototype screens and the prototype test results

5.1 Prototype sample screens
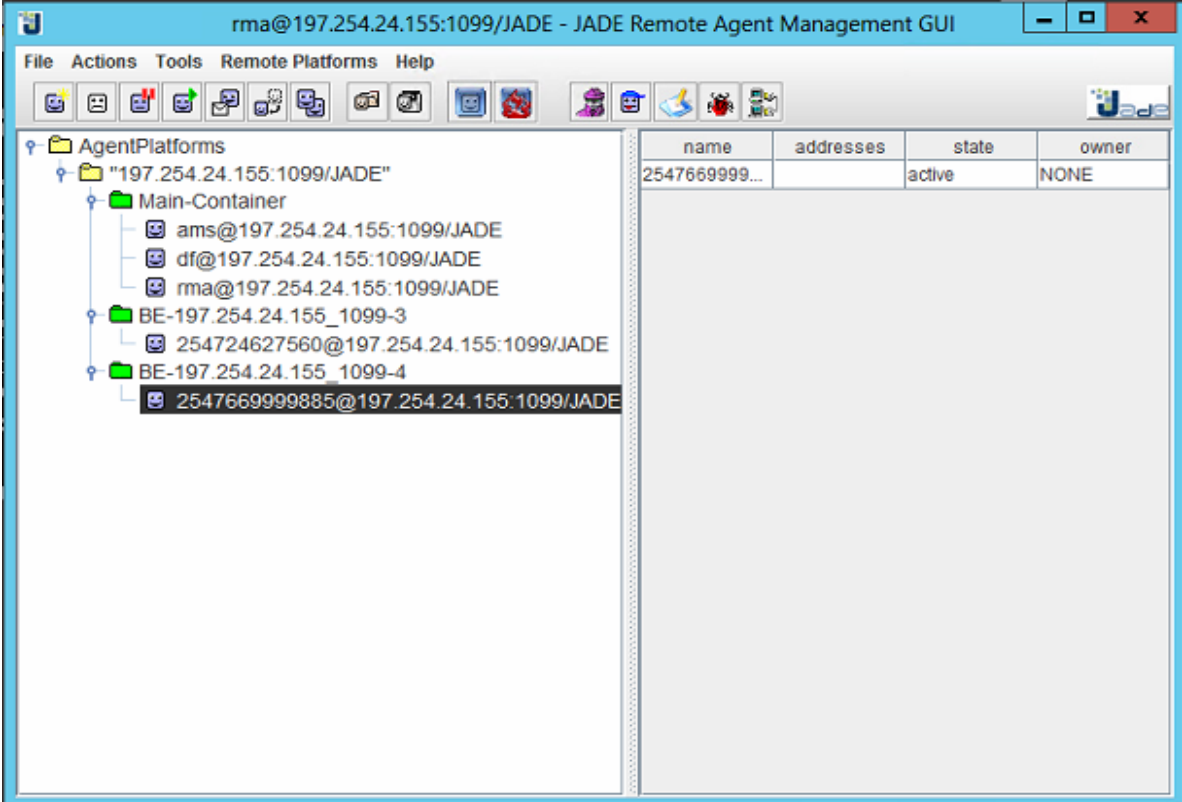
Figure 8 : Jade Platform server screen
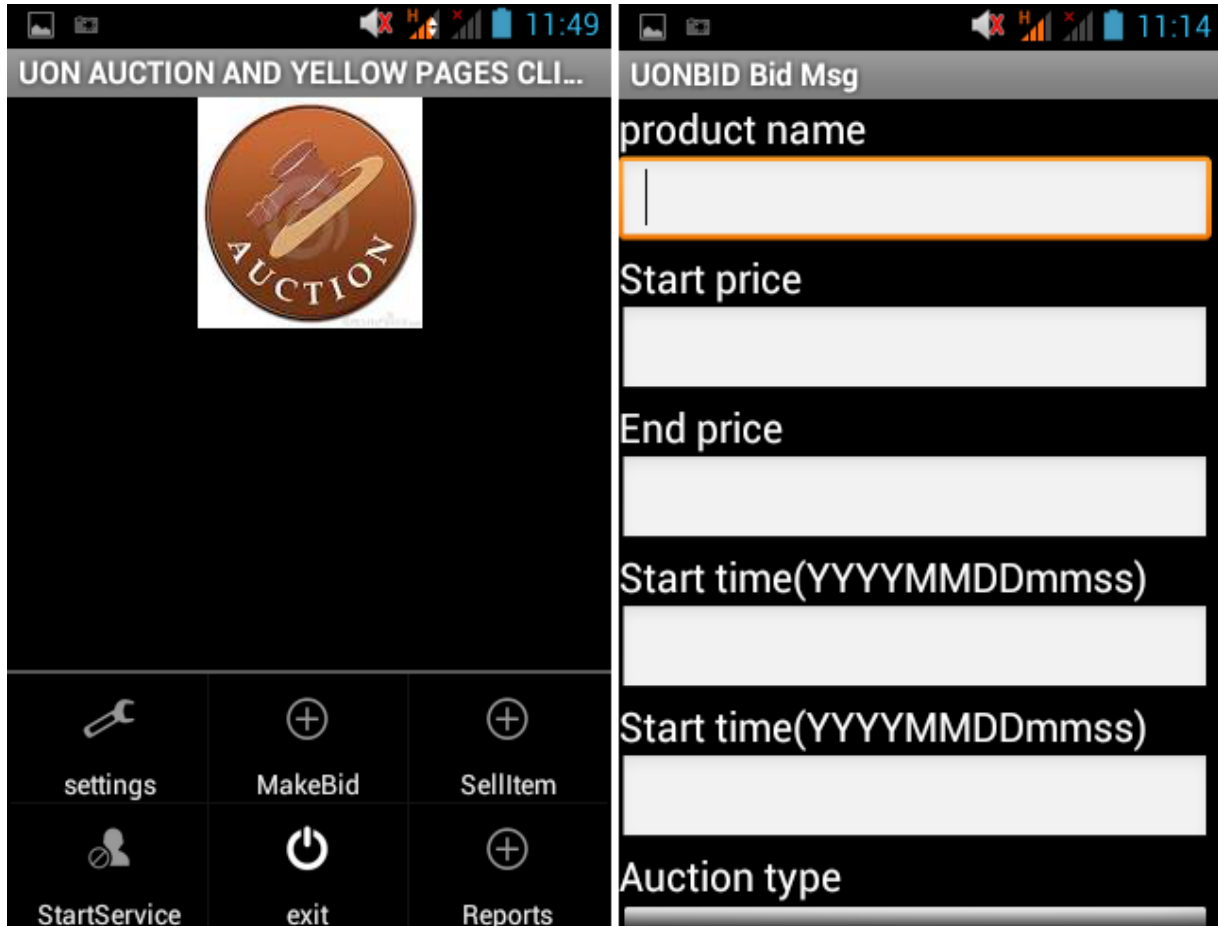
Figure 9 Mobile device sample GUI screen

5.2 User test results

The result is as shown in the table below. All the two users were able to achieve the goal of the tasks specified in the test questionnaire.

Test User ID	Question	Result
T001	1	1
T001	2	1
T001	3	1
T001	4	1
T001	5	1
T001	6	1
T002	1	1
T002	2	1
T002	3	1
T002	4	1
T002	5	1
T002	6	1

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5.3 System Evaluation Result

 Overall rating was 93%. The table below and the chart shows the rating for each evaluation parameter considered in the questionnaire.

Evaluation Parameter	Total Rating
Ease of learning	23.8
Ease of use	23
Satisfaction	22.2
Usefulness	24
Grand Total	**93**

Figure 10: Evaluation result
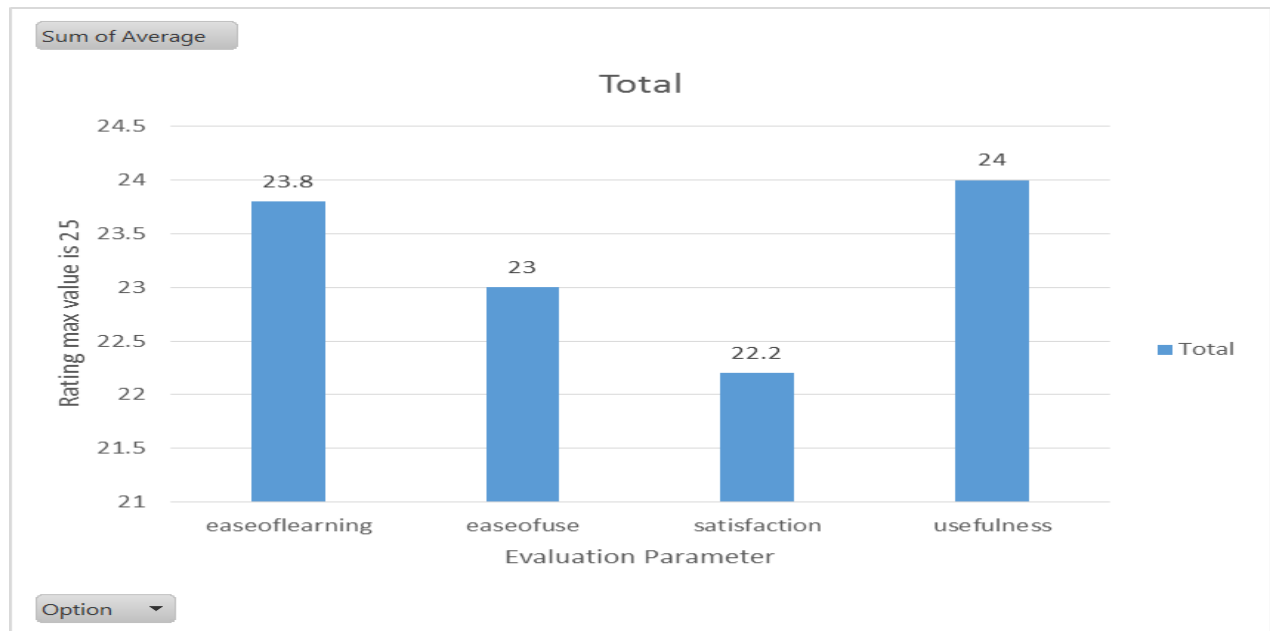
The following table shows detailed result of the evaluation results.

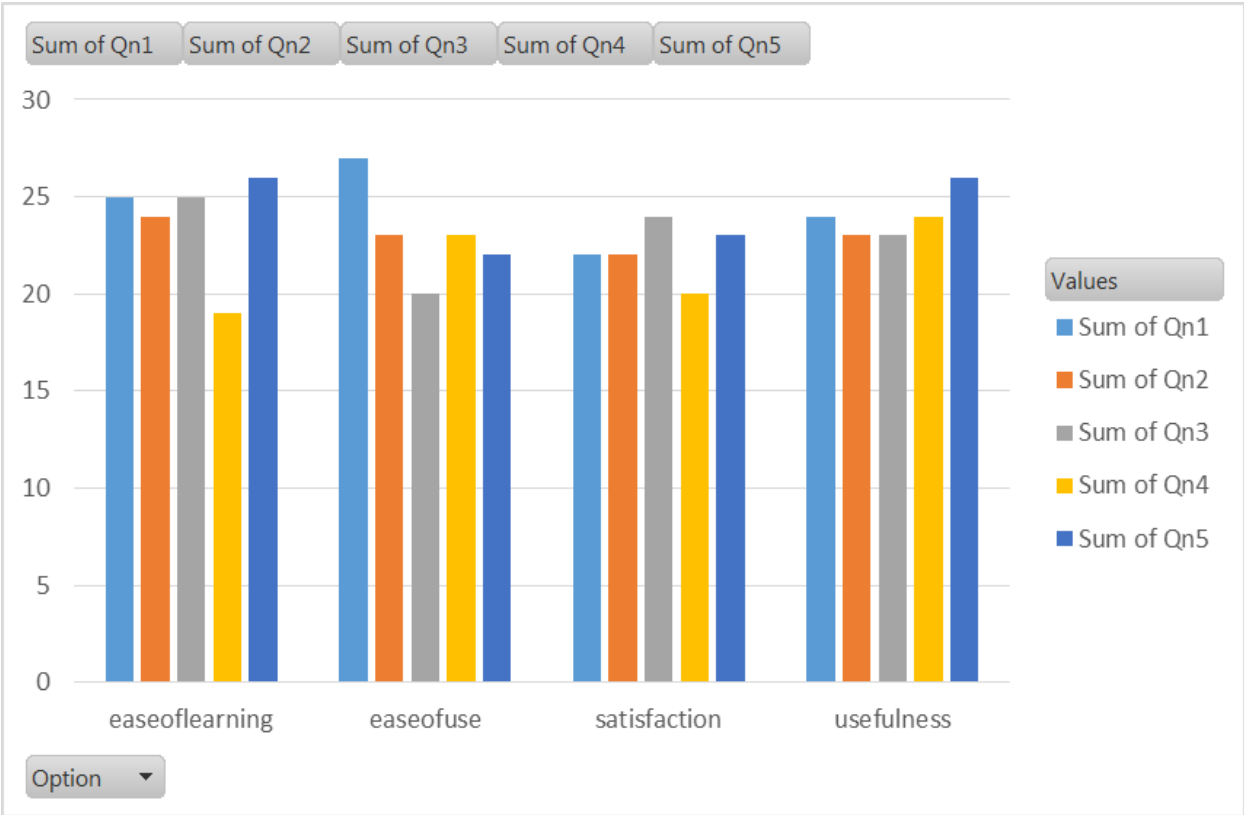| Parameter	Sum of Qn1	Sum of Qn2	Sum of Qn3	Sum of Qn4	Sum of Qn5
Ease of learning	25	24	25	19	26
Ease of use	27	23	20	23	22
Satisfaction	22	22	24	20	23
Usefulness	24	23	23	24	26

Figure 11: Detailed evaluation result

CHAPTER 6 CONCLUSION AND FUTURE WORK

6.1.1 CONCLUSION

The research presented an enhanced version of the MoAAM model. The decentralised approach of the proposed system and exposing agent services through web service greatly improves the scalability of these model. Prototype system was successfully developed, deployed and tested. The results showed the possibility of using simpler design to develop mobile agent based auction system.

Gaia methodology was used to systematically adopt and implement this design proposed and it is validated with the implementation of the mobile auction prototype system. The testing of the prototype was limited to android devices. It is still uncertain how the system will perform in other mobile device platform.

The prototype developed can be used to study other related fields like AlgoTrading or HFT (high frequency trading).

6.1.2 RECOMMENDATIONS AND FUTURE WORK

There is a need to develop a language and generic interface for users to generate configurable custom auction protocols depending on the line of business

The proposed model can be used to study automated retail trade with decentralized agent based market platforms. Agents can be designed do actual negotiations with each other on behalf of consumers and retailers by searching specific products or variants, discussing terms of delivery or special conditions, and performing the transactions automatically, based on their owners' preferences.

It is also important to do precertification of bidders. Confirming that users' credit is satisfactory prior to permitting them to bid is useful in screening out fictitious registrants or those with poor credit. It may also consist of conducting background checks and obtaining credit reports.
Electronic auctions should require the same type of licensing and regulations as live auctions to help the government track on revenue from sellers.

It is important for auction system to use escrow services for their bidders and sellers. An escrow service is an intermediary between buyer and seller which collects the payment from the bidder but will not release it to the seller until the bidder confirms delivery.

CHAPTER 7 References

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CHAPTER 8 APPENDIX

8.1   Evaluation Questionnaire

The questionnaire constructed as five- rating scales with following questions each with 5 response options.

Strongly Disagree 1	2	3	4	Strongly Agree 5
○	○	○	○	○

Usefulness

1. It is useful.
2. It gives me more control over the activities I do
3. It saves me time when I use it.
4. It meets my needs.
5. It does everything I would expect it to do.

Ease of Use

1. It is easy to use.
2. It is user friendly.
3. Using it is effortless.
4. I can use it without written instructions.
5. I can use it successfully every time.

Ease of Learning

1. I learned to use it quickly.
2. I easily remember how to use it.
3. It is easy to learn to use it.
4. I quickly became skillful with it.
5. Can easily demonstrate to someone else

Satisfaction

1. I am satisfied with it.
2. I would recommend it to a friend.
3. It is fun to use.
4. It works the way I want it to work.
5. It is pleasant to use.

8.2   Evaluation Raw Data

ID	Respondent	Option	Qn1	Qn2	Qn3	Qn4	Qn5	Averag	maxValue
1	1	usefulness	5	4	3	5	5	4.4	5
2	1	easeofuse	5	5	5	5	4	4.8	5
3	1	easeoflearning	4	5	4	4	5	4.4	5
4	1	satisfaction	3	2	5	4	5	3.8	5
5	2	usefulness	2	3	4	4	3	3.2	5
6	2	easeofuse	5	4	3	3	3	3.6	5
7	2	easeoflearning	3	3	4	3	5	3.6	5
8	2	satisfaction	4	5	4	3	4	4	5
9	3	usefulness	5	5	5	5	5	5	5
10	3	easeofuse	4	5	3	4	4	4	5
11	3	easeoflearning	3	5	4	3	4	3.8	5
12	3	satisfaction	5	5	4	3	3	4	5
13	4	usefulness	4	3	1	2	5	3	5
14	4	easeofuse	3	1	1	2	4	2.2	5
15	4	easeoflearning	4	1	4	1	3	2.6	5
16	4	satisfaction	2	2	2	3	2	2.2	5
17	5	usefulness	1	1	1	1	1	1	5
18	5	easeofuse	1	1	1	1	1	1	5
19	5	easeoflearning	1	1	1	1	1	1	5
20	5	satisfaction	1	1	1	1	1	1	5
21	6	usefulness	3	4	4	3	3	3.4	5
22	6	easeofuse	5	3	4	3	3	3.6	5
23	6	easeoflearning	5	4	4	3	4	4	5
24	6	satisfaction	3	4	3	2	3	3	5
25	7	usefulness	4	3	5	4	4	4	5
26	7	easeofuse	4	4	3	5	3	3.8	5
27	7	easeoflearning	5	5	4	4	4	4.4	5
28	7	satisfaction	4	3	5	4	5	4.2	5

Figure 12: Raw Data

8.3   System test Questionnaire

The result is as shown in the table below

1. Were you able to register? (1.yes, 2.No)

2. Were you able to view sellers and their products (1.yes, 2.No)

3. Were you able to add a product and sell it using your preferred auction protocol? (1.yes, 2.No)

4. Were you able to view bidders participating in your products' auction? (1.yes, 2.No)

5. Did selected bid protocol work as expected? (1.yes, 2.No)

6. Were agents created in the platform (1.yes, 2.No)