iAgri – An Agent Based Agricultural Information Provision

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***Abstract* – Agriculture has become one of the most important areas of the world with the current food crisis. But, still there is lack of technological aid that can be assisted to increase the efficiency and effectiveness of the agricultural sector. To properly manage the whole process, there is a need for expertise knowledge and a proper communication channel between stakeholders. Nevertheless there is no fully fledged mechanism between farmers and agricultural experts to interact and share the knowledge effectively. This system is an effort to solve the problem of deriving information from scattered and distributed sources.**

As the solution, an Agricultural Value Chain Management system based on agent technology has been implemented to provide common space for improving the transparency of information by centralizing disseminated agricultural expert information whenever it's needed to the farmers. The system divides agricultural value chain in to 6 stages called Deciding, Seeding, Preparing and Planting, Growing, Harvesting and Selling. The necessary information needs are identified at the each stage by the system and the information is derived from the various agricultural information sources using agents. Then the most suitable information is provided according to the crop and the value chain stage of the crop via a multi agent system.

1 INTRODUCTION

Sri Lanka has been an agricultural based country since the ancient times and also the agricultural industry possesses a high importance in country's economy. However the contribution of the agricultural sector to the economy has been deteriorating due to the various reasons over the past few decades. The contribution of agriculture to the local economy accounts for just over 11%, but agriculture is still the most important source of employment in rural areas which provides 32.7% of employment in the country [2].

Though local farmers have lot of knowledge on agriculture, the lack of technological aid to effectively manage the agricultural life cycle has been a major problem, since this knowledge is scattered everywhere and due to the lack of transparency of the information. It was also found out, that there is lot of inefficiencies in economic activities of the agricultural sector in the areas like production, transportation, processing, storing, customer interaction etc. This situation is further aggravated by poor collaboration between the parties involved in the entire process.

A substantial amount of crops are wasted annually in Sri Lanka due to the unavailability of a market, some disease etc. If there is a way to forecast these problems and provide the accurate and complete information before these problems arise, then such kind of a waste would not occur, so that resources would have been used in an efficient and effective manner.

Therefore, the lack of availability of complete and accurate information at the right time and the non transparency of information has become burning problems for the future development in agricultural industry in Sri Lanka. So by addressing these problems, Sri Lankan economy can thrive in terms of increased contribution from agriculture to the local Gross Domestic Product. My solution focuses on providing correct and complete information at the correct time, upon a request by a farmer without much intervention continuously, throughout the whole agricultural value chain. This will help local farmers to effectively derive required information and cultivate crops ensuring that the life cycle can be efficiently managed and also knowing that there will be a market to sell the crops.

This information unavailability has restricted the farmers' ability of being commercial farmers [3] who are responsive to market needs by deciding what, when and how much to produce accurately. According to Harsha De Silva [3], the agricultural value chain consists of following 6 stages which are Deciding, Seeding, Preparing and planting, Growing, Harvesting and Selling. Having these different stages, farmers will seek for different kind of information which is unavailable in the current context. For ex: in seeding stage farmers may look for information on seed availability, quality and price of such seeds etc. De Silva [4] has found that 70% of all transaction costs are related to information search along the value chain of the agriculture.

Having considered these issues and with my knowledge on Artificial Intelligence field, I'm motivated to implement a comprehensive solution which can solve all the above mentioned issues by providing accurate and

timely information for the farmers whenever they need necessary information without any cost.

The rest of the report structures as follows, Section 2 include a comprehensive review about others' work and Section 3 provides an insight of the adapted technologies. My approach to solve the problem is presented in Section 4. Section 5 offers details of analysis and design. Implementation detail of each module is presented in Section 6. Section 7 reports on the evaluation of the system and last section discusses on the overall achievements of the project solution as well as about further work.

2 CURRENT STATUS OF AGRICULTURE INFORMATION PROVISION

Currently, there are some systems to aid the farmers by providing necessary expertise information about the particular related areas of agriculture.

aAqua[12] is an online multilingual, multimedia agricultural portal to distribute information to and from the rural areas of India. This system has been developed to assist the Indian agricultural sector by allowing either the people having similar experiences or enrolled experts to share their experiences through the portal. aAqua is basically a database back ended, question and answer system of which the information repository is accessed through a web portal and which also allows the users to create and view the contents in their mother tongue. (Hindi, Marathi etc). Some problems are addressed through the presentation of photographs, audio and video files.

Another system called, eSagu[9] which is a data warehouse enabled personalized agricultural advisory system , aims to provide fresh agricultural expert advice to the farmers in a timely and personalized manner. Through eSagu, around 6000 farmers in India were advised covering 6 crops, which helped those farmers to achieve savings in capital investments and improve the crop yield. eSagu system consists of farms, eSagu local centers, coordinators, eSagu main center, agricultural experts, agricultural data warehouse and communication system. In traditional agricultural systems, physical presence is necessary to deliver the advice but with eSagu, the agricultural scientists deliver the expert advice by getting the crop status in the form of digital photographs and other information.

MAXCROP project which was implemented in Sri Lanka and China [1] targeting the small and medium scale farmers, addresses the issues dealing with broader agricultural priorities such as improving productivity in rural areas, enabling better access to extension services, enabling stakeholders to join in addressing the need to improve production, increased collaboration in research and ultimately increase food production thereby improving the food security.

Dmbadeniya Development Foundation in Sri Lanka has initiated a project for the dairy farmers in Alawwa and Narammala area to improve the productivity of diary based activities at the Grassroots [11]. The dairy farming system is more complex than other sectors in agriculture due to the continuous nature of input and output causing the farmers to make informed decisions continuously. So the access to the information in a timely manner is vital for effective and optimized harvest.

A web based agricultural Wikipedia and e-learning system [11] has been developed for Sri Lankan farmers which consist of specific information related to all major local crops. This system is also enriched with audio, video and flash animations to make the information more understandable to the local farmers. Pre-defined levels of privileges for administrators and Cyber units agricultural instructors are assigned. An e-learning system is also integrated with the web based system with multiple levels of administration privileges based on the users. Agricultural Wikipedia interlink the various information sources to a community driven dynamic agricultural database where farmers enrich the site with their own ideas and practical experience resulting an effective tested knowledge base.

3 AGENT TECHNOLOGY FOR AGRICULTURAL VALUE CHAIN MANGEMENT

This chapter describes the technologies which are used to develop the iAgri system and also why these technologies are appropriate to solve the problem.

3.1 Agent Technology

An agent is a small computer program capable of composing, sending, receiving, interpreting messages and capable of independent action on behalf of its user or owner. Corporation, coordination and negotiation help agents to interact with other agents. These interactions are basically in terms of message passing. Agents are active and autonomous components designed to act independently or to assist users to execute some task or operation [13].

Autonomy in decision making, Social ability, communication and corporation, Monitoring, perceiving, reactiveness, possession of knowledge, learning are some of the features of agents. The main difference between agents and the traditional software program is the ability of agents to interact with the environment. Agents are sensitive to the environment within which they operate. Their actions effect the environment and the changes of the environment have an effect on the system also. The ability of an agent to maintain an ongoing interaction with

the environment even during the execution is one of the main advantages for the selection of agent based technology. Therefore the system can adapt to the dynamically changing, uncertain environments unlike the traditional technologies.

3.2 Multi Agent Systems

Multi agent system (MAS) [10] is a set of agents which perform communication, coordination and negotiation between each other in order to achieve a common goal.

Apart from that, MAS also has the ability to use agents even when they are not available at the right time at the right place. This is achieved by the common message space in the MASs. Another advantage of MAS is that the interactions among agents are autonomous and therefore user intervention is not required for agents to communicate or to carry on tasks. MAS provide a coordination mechanism for agents to work towards a common goal even if the individual's goals of agents are different or cause conflicts.

To define the behaviors and to derive the necessary knowledge regarding the operation, a knowledge base is required. Ontology is useful as a knowledge base where some form of knowledge can be stored; therefore, class files such as Java classes or simple eXtensible Mark-up Language (XML) [7] files can easily be used for this purpose. Alternatively, dedicated ontology development tools can be used when the individual agents, working among each other need some kind of knowledge store, procedures, rules and constraints to govern their behavior in interactions. A central domain ontology or individual ontology for each agent can support this requirement.

3.3 Suitability of Agent Technology

To achieve the agricultural complexity in delivering the necessary, useful information in a timely manner, Multi agent systems can be used. Since there are several requests from number of users and also there are more than one resource providers to cater for those requirements, the agent based technology is the most suitable technology that can be adapted to develop the system. For e.g.: when a particular farmer wants to buy fertilizer, if there is only one brand, then there's no need to use agent technology because the scenario can be successfully accomplished by traditional software programs. But when there are many farmers, many shops and many brands of fertilizer exist at the same time, there should be an efficient mechanism to negotiate and communicate in order to find the most suitable fertilizer which can be achieved through agents.

Apart from that, since the agricultural systems that consist of various information, are heterogeneous, agents with different behaviors can be used to interact with these heterogeneous environments and to combine those systems together. Through this manner, there is no need of integrating the heterogeneous systems themselves; rather agents provide an interface for the effective integration of those systems.

4 AGENT BASED APPROACH

This chapter describes how the agent based technology is used to manage the agricultural value chain by providing accurate and timely information to the farmers and by improving the transparency of the information.

When considering about the approach, there are some important factors which need attention prior to the design and implementation. The system should have a high accuracy in terms of the output that is presented to the users. Otherwise users may think that the system is insufficient. This is vital since whole agricultural value chain may depend on the information derived through the system. Usability is another important factor due to the lack of familiarity of farmers with computer systems. The user friendliness and the usability of the system should be at its best to provide the necessary information to the farmers in an understandable way. With the expansion of the researchers carried out in the field of artificial intelligence and agent base applications, there are many possibilities to be expanding the functionalities of the system.

The approach with reference to input, users, output, processes etc… is as follows. Initially, a user has to log in to the system by entering the user name and the password. If the user is a new user, then the user has to register with the system before using it. When the user posts a request for particular information through User Interface agent by selecting the crop and the value chain stage, User Profile agent picks the user information and pass it to the Message agent. The User Profile agent stores some of the information regarding the user, so that the stored information will be helpful in the future to recognize the user, when the user logs again to the system. The Message agent posts the message on the message space for which all the other agents can access. Then the interested resource agents (Value Chain agents) are initiated and search for the relevant accurate information from the other agricultural information sources. The Data Base agent also searches the local data base for the related information and all information will also be passed to the Message agent. The best useful information will be presented to the end user via User Interface agent finally.

5 DESIGN OF iAGRI

This chapter describes the details of the design and the analysis of proposed solution. By designing the system using agents, an intelligent behavior is added to the complete system. Ontology, which is the knowledge base provides the foundation for the intelligence and can be

considered as the brain of agents. The design is simple, but effective in terms of gathering and centralizing the disseminated information and improving the transparency of related information. The design is focused on the basic functionalities of the system, which is to handle user requests efficiently by presenting accurate and relevant information to the users while utilizing the existing resources in the best way possible.

iAgri has been designed by integrating several agents together forming a multi agent system. These agents will be the main modules of the complete system. Agents act as information generators and distributors in iAgri. The agent module can be broadly categorized as request agents, resource agents, message agent and the ontology. Following "Fig.1"illustrates the components with in iAgri and their interaction between each other.

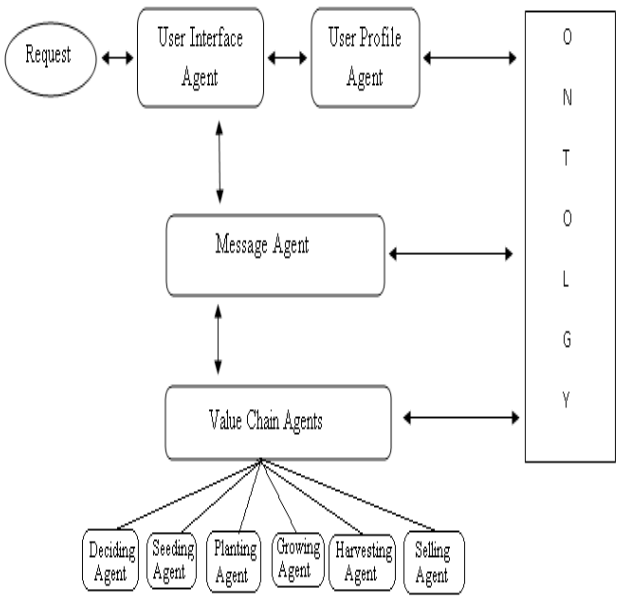

Fig.1 High Level architecture of iAgri

The system consists of several agents which are interacting with each other.

User Interface Agent - User Interface (UI) agent is the front end of the system. UI agent is implemented to take the user input to the system. . As the final output, user can view a simple list of information through the UI agent. Also UI agent interacts frequently with the User Profile agent to identify the background of a particular user and historical data to present the information in a most appropriate way.

User Profile Agent - User Profile (UP) agent is implemented to profile the user information by identifying whether the user is visiting the system for the first time or not, once a user interacts with the iAgri. The information which is entered to the system when the user gets registered for the first time, is used as the input for the UP agent.

Message Agent - Message agent manages the communication between other agents in the multi agent system by acting as the information distribution channel of the system. Message agent sends and receives messages from different other agents and identify the message uniquely.

Value Chain Agents – Value Chain (VC) agents are one of the most important modules of the entire system. Value Chain agents act as resource agents from which the information is provided to the system by searching other different agricultural data sources. Each VC agent will provide all the necessary information regarding a particular stage of the agricultural value chain. Following are the Value Chain agents that are available in the system and the nature of the information that will be delivered by those agents.

Crop deciding agent provides information related to, how much land to be allocated for the given crop, what is the best crop to grow, Information about arranging the working capital, the minimum working capital to cultivate the crop etc…

Crop seeding agent provides information related to, what are the best types of seeds for a particular crop, the places at which those seeds are available, how to prepare own seeds, prices of the seeds at various places, quality and availability of seeds etc…

Crop planting agent provides information related to, how to prepare the land for each crop, what are the machinery to be used, from where to get those machinery, price levels of the machinery at each place, any specific methods to plant the seeds etc…

Crop growing agent provides information related to water management, most suitable fertilizer and their prices, from where to buy the fertilizer, required pesticides and prices, from where to buy those pesticides etc…

Crop harvesting agent provides information related to methods of harvesting, about machinery to cut the crop, from where to hire or buy those machines and heir prices, how to find the required labor for harvesting, locations for storage of cultivation, most suitable packing methods, from where to get the packing materials etc…

Crop selling agent provides information related to prices at various markets, options in transporting the harvest, the details of registered buyers in the system etc…

6 iAGRI – IMPLEMENTATION

As mentioned in the design section, the system is mainly designed to be implemented using multi agent technology. Agents are created using JADE framework. The overall

architecture of the system is implemented using JAVA programming language. J2EE platform [6] (Java server pages and servlets) will develop the user end of the system while the processing is carried out by agents. For storing and transferring information between agents, information stored in a XML file is used, so that any application in any language or platform can access the XML file.

6.1 Agent Based Development

Agent based development assists the system to be autonomous (activate with little user intervention), reactive (respond on requests), proactive (still works even without a request), rational (do the most appropriate thing), intelligent and communicate with each agent module. The key concept in a multi agent system is the communication between agents. Agents use a special communication language to interact with each other with special protocols to handle mutual communication between other agents. ACL [5] (Agent communication language) is used to achieve the communication between agents.

6.2 JADE – JAVA AGENT DEVELOPMENT ENVIRONMENT

iAgri is developed using JADE[8] which is a widely used efficient agent development environment. This framework provides agent management facilities as well as graphical tools for debugging and development of agents which makes agent development lot easier. JADE conforms to the FIPA specification and it simplifies the development of multi agent systems through a middle ware. JADE helps to hide the complexity of the middleware from the user by means of various APIs which are independent from the underlying network and Java version. This makes the JADE also portable frame work.

6.3 SYSTEM DEVELOPMENT PLATFORM

To implement the agricultural value chain management system, J2EE platform is used. J2EE is used to develop distributed enterprise software applications. J2EE adds libraries which provides fault- tolerant, distributed, multi-tier Java software, based largely on modular components running on an application server [6]. J2EE provides number of advantages for developing business applications such as standards for areas of enterprise computing needs such as database connectivity(hibernate), enterprise business components, message-oriented middleware (MOM), Web-related components(Struts), communication protocols, and interoperability. In addition to that, J2EE accommodates standard platforms for building software components that are portable across many vendor implementations.

"Fig.2" shows the flow diagram of iAgri.

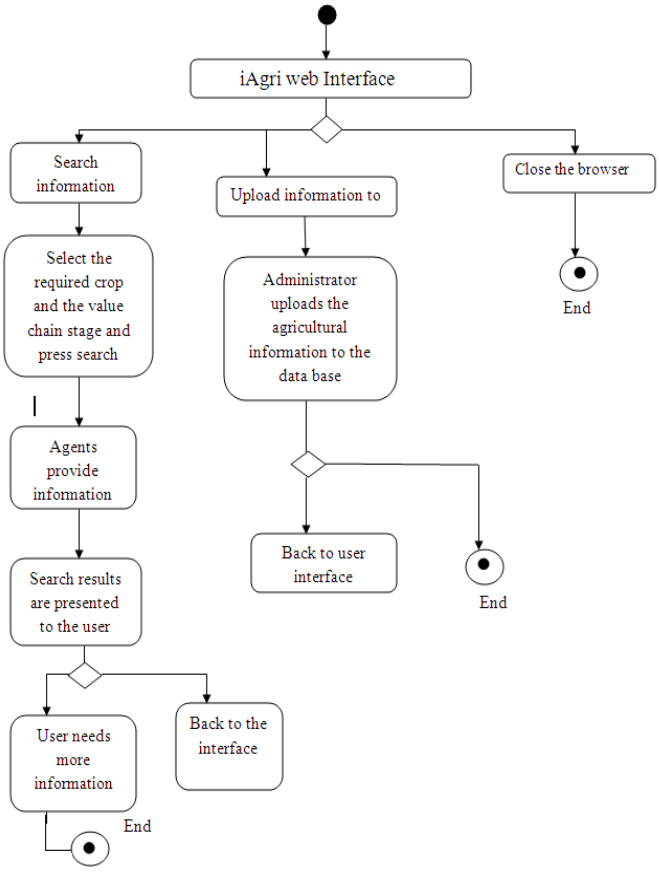

Fig.2 Flow Diagram of iAgri

7 EVALUATION OF iAGRI

This chapter focuses on testing and evaluation of the Agricultural Value Chain Management system.

Testing of the system was done as a whole. After the implementation, whole system was tested using Black Box Testing to check whether the system works as intended. Sub modules are tested separately before integrating them. After integration, whole system testing was easy to conduct, as errors had been addressed before integration. Black Box testing was done against following test cases illustrated by Table 1.

Implemented system for iAgri has been evaluated to check whether it produces acceptable results. Evaluation has been done in terms of accuracy of processing final decision respect to different information types. Accuracy is compared with a real world scenario which has the same amount of agriculture based information similar to the system. To test the multi agent systems, JADE Test Suite were used which allows testing the communication between agents which is called functionality test. Results obtained are as shown in Table 2.

Table 1: Black Box Testing

Test Case ID	Feature Description	Prerequisites	Test Steps	Input Data	Expected Result
1	User register with the system	• *iAgri* system get started • Registration page is focused	1).Fill all text fields 2).press submit key	Name Zone Username Password	• Display the message "" • User profile agent identified the user and add into the repository
2	User login to the system	• Text boxes of login page should be set focused.	1).Fill the text fields 2).Submit	Username Password	Welcome message with the full name
3	User search information	• *iAgri* system get started • Text boxes of search page are focused.	1).Enter a data according to the requirement 2).press Submit	• Plant name • Value Chain Phase	New window is popped up and display the information. Show final decision on the search page

Table 2 : Evaluation Results

information type	#times	Achieved Output (Decision)	Accuracy
Deciding	25	100%	84%
Seeding	25	90%	75%
Planting	25	95%	80%
Growing	25	100%	90%
Harvesting	25	85%	80%
Selling	25	95%	82%

From the above evaluation results, it is evident that the accuracy of the system is relatively high since all the information provided for value chain phases exceeds 75% of accuracy.

8 CONCLUSIONS AND FURTHER WORK

iAgri was initiated with the aim to develop an agent based system to centralize the disseminated agricultural information and to improve the transparency of the related information. Though there are several other systems which have been implemented to provide information to the farmers, most of those systems are traditional software where the information is delivered irrespective of the users' needs. iAgri, since it's an agent based system, provides only the information that is most suitable for the particular user's needs. As the conclusion, it can be mentioned that the outcome of the overall project is a success. All the objectives which were initiated at the beginning of the project have been successfully achieved.

There are several future enhancements that can be performed to improve the usability and other functional and nonfunctional performance of the system. As the most important enhancement, the system will be implemented in all 3 languages which are Sinhala, Tamil and English. Also an SMS module can be added to the system. This SMS module will help the farmers to get the information to his/her mobile phone itself, so that there's no need to go for a computer to access the information.

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