RiceSmart: Web-Based Multi-Agent Communication Platform For Rice Production Industry

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Abstract— Complex Adaptive systems demonstrate a new paradigm for solving real world complex problems. Multi-agent System Technology is one of the most powerful technology used to build complex adaptive systems. This paper presents a web based multi agent system named RiceSmart which provides an efficient and effective communication platform for the people who are engaged in rice production industry. This system provides five types of agents as farmer, miller, buyer, seller and transporter, to represent key persons in the rice production industry. The agents in the system works as web clients and they have been designed through using both PHP and AJAX. RiceSmart is a Extended version of the Rice Express. Through the agent communication, system should able to allow joint selling and buying facility to take maximum profit from both ends. The RiceSmart has been successfully tested in the practical environment, and successful results were obtained.

Keywords— **Rice Production Industry, Multi-Agent Systems, Web Technology**

I. INTRODUCTION

The agricultural industry can be classified as rice cultivation, tea plantation, oilseed crops, fruits and vegetables. The primary form of the agricultural industry in Sri Lanka is rice production industry. Rice is cultivated throughout two seasons which might be named as Maha and Yala. Rice crop occupies 34% of the overall cultivated area in Sri Lanka and 1.8 million farmer families are engaged in paddy cultivation island-wide. This Country currently produces 2.7 million tonnes of rough rice annually and satisfies around 95% of the domestic demand.

(Techopedia.com, 2019) Artificial Intelligence (AI) or machine intelligence is a branch of computer science which has an aim to create intelligent machines that work and react like humans. Today, Artificial Intelligence has been become an essential part of the technology industry. (Alanturing.net, 2019) Artificial Intelligence was first introduced by classical philosophers who tried to explain the process of human thinking as the mechanical manipulation of symbols and the field of AI research was founded in 1956. In addition, the field of AI has major components which are learning, reasoning, problem solving, perception and language understanding.

The traditional Artificial Intelligence field consisted with several systems as Artificial Neural Networks, Expert Systems, Genetic Algorithms, Fuzzy Logic and Decision Trees which can be achieved via stored knowledge. But Multi-Agent System is a new technological area to the artificial intelligence which does not contain pre stored knowledge base. Not only that but also Multi-Agent technology is considered as one of the core field in Artificial Intelligence. Today, artificial intelligent based software development has been become a modern software technology and the trend.

Multi-Agent Technology is a software. When compare Multi-Agent System software and conventional software, Multi-Agent System software has more advantages than conventional software such as it is distributed, knowledge driven, adaptive, emergent behavior and parallel process. In addition, the most important benefit of Multi-Agent System is, it uses a large number of programs which are known as agents. These agents communicate with each other and run simultaneously in-order to find the suitable and best answers for the problems.

(En.wikipedia.org, 2019) Multi-Agent System is a computerized system which has been composed of multiple agents. This technology can solve problems which are difficult and the intelligence may include procedural, methodic, functional approaches, algorithms and reinforcement learning. This system is consisted with agents which are known as software agents and their environment. (George, 2019) In addition, the key components of this system are Multi-Agent Engine, Virtual

World, Ontology and Interfaces. When consider the Multi-Agent Engine, it provides run time support for the agents. Then Virtual World is one of the environments where agents live, perceive inputs, cooperate and compete with each other. Ontology is consisted with conceptual problem domain knowledge network and Interfaces provides an environment to communicate among user and the system.

Today, web technology has been become very famous as well as the most powerful information distribution media all over the world. Web technology allows users and computers to communicate with each other using multimedia packages and markup languages. In addition, using this technology anyone can access to websites in any place when internet connection is available. When consider a standalone application it contains several disadvantages compared with web technology as it need to install some software. But using web technology, the only requirement to access websites is a web browser and doesn't need to install a software. As a result web technology has been become very famous.

This paper presents a web based multi-agent system named RiceSmart which can be used to provide an efficient and effective communication among key persons in the rice production industry. This system is consisted with five types of agents as farmer, seller, buyer, miller and transporter which deputize the key persons in the rice production industry. Accordingly, this system provides facilities to establish an effective and efficient communication between persons in this industry.

The rest of the paper is structured as follows. Section 2 gives a brief introduction on existing rice production information systems . Section 3 presents the multi agent technology. Section 4 presents descriptions about design of the RiceSmart System. Then, Section 5 describes how the developed system works in the practical environment and section 6 presents experimental results of the system. Finally Section 7 gives a conclusion and further works of the project.

II. EXISTING RICE PRODUCTION INDUSTRY INFORMATION SYSTEMS

(Jayarathna and Hettige, 2019) have developed AgriCom: A Communication Platform for Agriculture Sector which is an novel practical Multi-Agent System for Agricultural Communication. They state that Multi-Agent technology will be used to handle the required communication with success among connected persons within the agricultural sector. Consequently, the system has provided four types of agents; farmer, buyer, seller and instructor. The system was developed through the MaSMT design.

(Adikari and Karunananda, 2009) Multi Agent System for Agricultural stakeholders has been developed by Adikari and Karunananda which has been combined with five types of agents such as Message Agent, Interface Agent, User Profile Agent, Crop Management Agent, and Selling Agent. This has been developed on JADE environment and can be connected though web access.

(Tharaka and Kulawansa, 2019) have developed a system named Information System for Cultivation which has been based on modern IT infrastructure including web services and mobile services. The framework of this system is based on fuzzy predictive models and provides functions to the farmers to enhance their cultivation process.

(Jayarathna and Hettige, 2019) have developed a Web – Based Multi-Agent solution for Agriculture Community named WMAC. This is the web based development of the AgriCom which is a standalone Multi-Agent System. The system provides four types of agents named farmer, buyer, seller and technical instructors in the agriculture community and uses MYSQL database as the ontology. The agents of the system have been designed through PHP and AJAX technologies.

III. MULTI-AGENT TECHNOLOGY

The multi-agent system technology is a modern computerized system technology and a novel concept that is designed to interact with intelligent agents. This technology consists of a large number of small programs which can be known as agents that can run in parallel and communicate with others to make a solution. Multi-Agent Systems consist of a set of agents and their environment where agents perceive inputs and perform actions. Multi-Agent Systems are referred to software agents could be either robots or humans. Typically, agents can be divided into passive agents, active agents and cognitive agents. The environment that agent lives can be classified as virtual, discrete and continuous. When consider the advantages of Multi-Agent System, the main advantages are robustness and scalability. In addition, this technology is very effective compared with the conventional software development. Basically, any Multi-Agent System contains four major components namely Multi-Agent Engine, Virtual World, Ontology and Interfaces. Multi-Agent Engine is a component which provides run time support for the agents and Virtual World is one of the environments where agents live, perceive inputs, cooperate and compete with each other. Ontology is consisted with conceptual problem domain knowledge network and Interfaces provides an environment to communicate among user and the system.

Design and develop a multi-agent system for a particular problem is a bit challenging task and it required to select

the most suitable agent development frameworks and toolkits. Today, there are several toolkits and frameworks are available for the development of Multi-Agent Systems. Among them most of them have been built up with Java programming language and C/ C++ programming language. The popular toolkits and frameworks are JADE, Jason, Madkit, FIPA-OS, AgentBuilder, ZEUS, NetLogo, AgentSheets, Jack and OpenCybele.

(Jade.tilab.com, 2019) JADE (Java Agent Development Framework) is a software framework which is fully implemented in the Java language. This has been designed to create intelligent agents and provides facilities to develop Multi-Agent systems. In addition, JADE provides support to maintain the coordination between the agents and use FIPA-ACL as the communication language.

(platform), 2019) Jason is a Java based platform for the development of Multi-Agent Systems. It is an open source software that is distributed under GNULGPL. Jason is an extension of the AgentSpeak which is an agent-oriented programming language and used to program the behavior of individual agents.

(Madkit.net, 2019) MadKit is stand for Multi-Agent Development Kit. It is a versatile agent platform to design any Multi-Agent System. This is cross-platform framework works on several operating systems such as Linux, windows, Mac OS and does not contain a prerequisite on agent model. In addition it supports many simultaneous communication model such as message parsing and broadcast.

(Toolkit, 2019) This platform supports communication between multiple agents using an agent communication language. The key focus of this system is to support openness. FIPA-OS is being deployed in several domains including virtual private network provisioning, distributed meeting scheduling and a virtual home environment.

(Agentbuilder.com, 2019) AgentBuilder is an integrated software toolkit which allows facilities to develop intelligent software agents and agent-based applications quickly.

(Issuu, 2019) ZEUS is an open source agent development framework that is implemented in Java. This is a very famous agent development framework which can plan and schedule agents to develop a collaborative Multi-Agent System.

(En.wikipedia.org, 2019) NetLogo is an agent based programming language and an integrated modelling environment which enables exploration of emergent phenomena. In addition it is as open source framework which is freely available from the NetLogo website.

(AgentSheets, 2019) AgentSheets is an agent-based simulation tool. It provides facilities to the end-users to create simulations in a GUI development environment. Not only that but also AgentSheets uses Tactile programming as the concept to develop agents visually and representing them in graphically in their environment. The emphasis is placed on visual development and the communication of the underlying rules, behaviors, and actions of agents during real-time simulation.

(En.wikipedia.org, 2019) JACK Intelligent Agents is a framework which is developed in Java for multi-agent system development. JACK Intelligent Agents is a third generation agent platform building on the experiences of the Procedural Reasoning System and Distributed Multi-Agent Reasoning System. This is one of the few multi-agent systems that uses the BDI software model and provides its own Java-based plan language and graphical planning tools.

Separately, there are many systems which have been developed using Multi-Agent System technology and Web-Based Technology. Among them there are some systems which have been developed using both of these technologies.

IV DESIGN

Rice production industry in Sri Lanka contains several different types of persons such as farmers, buyers, millers, transporters and sellers. Due to the poor communication between these people, rice production industry faces lot of problems. Therefore efficient and effective communication can help to achieve many desired goals in this industry.

RiceSmart is a web based multi agent system application which has been designed to reduce the communication gap between the key persons in the rice production industry in Sri Lanka. This developed system is combined with two areas as Web technology and Multi-Agent System technology. When consider the design of this system, the front end of the system has been developed using HTML (Hyper Test Markup Language) and the back-end of the system has been designed using PHP and AJAX.

This web based application provides three types of users such as farmers, buyers and transporters and any person can get registered according their occupation and requirement.

The system uses a common MYSQL database as the ontology which is consisted with information and messages of all the users. In addition this database has been used as a common message space of the system. Figure 1 shows the top level design of the web application.
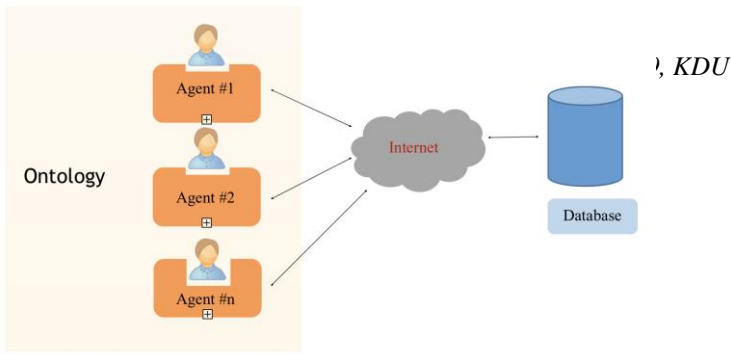
Figure 1. Top Level design of the RiceSmart web application

Figure 2 shows the design Architecture of the RiceSmart Agent. This agent is consisted with three components named Web Interface,RM Engine and the Web Server.A brief description of each module has given below
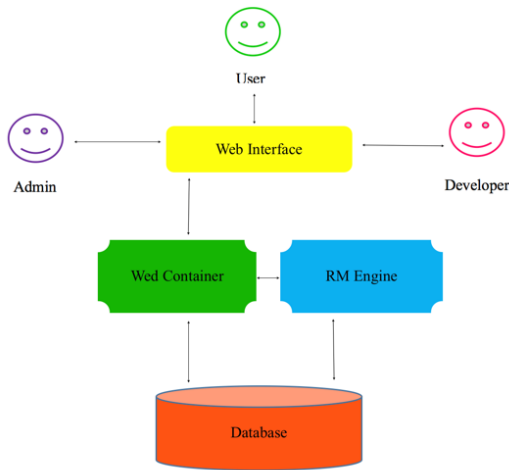

Figure 2. Design of the RiceSmart

A. Web Interface

This system is consisted with users and agents. They are communicated via a web interface. In addition, the users can registered to this system as farmer, buyer, seller, miller and transporter. According to their occupation or the registered type features and functionalities of web interfaces are different. After creating an account users can easily log into the system and can interact with the system. Not only that but also users can get all the facilities which are provided by the system. The figure 03 shows the initial RiceSmart web interface.
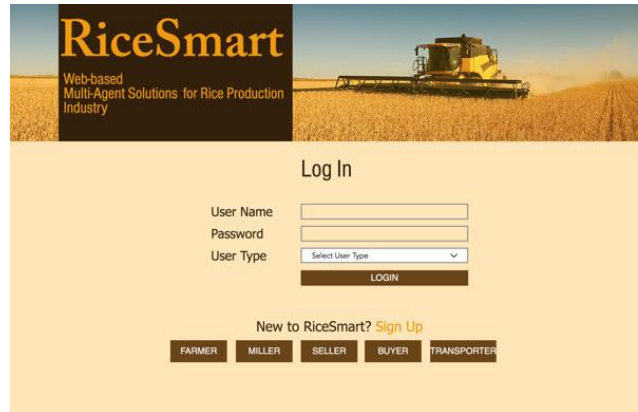

Figure 3. Initial RiceSmart Web Interface

B. RiceSmart Engine

This is the important module of this system. RiceSmart Engine also can be defined as the controlling module of this system as it controls all the features, functions and tasks in the RiceSmart. In addition, this is the backbone of this system as it makes communication between the web server and the RiceSmart database. This was developed using AJAX and communicates with Web Container and also with the Database. In addition RiceSmart Engine checks the Database and also updates the Web Container. This module provides facilities to the user to log into the system, perform a task and stop that any time.

C. Web Container

Web Container contains all the web pages and when user requests a web page, the browser displays the content of the web page which is available in the web browser. Apache has been used as the web server to this system as it contains very valuable features.

V. RiceSmart In action

This chapter discuss about how RiceSmart works in the practical environment. Basically when user wants to log in to the system, first he has to run a web browser and should go to the RiceSmart website. When consider a website all the users who are going to that website are considered as visitors. When anyone wants to get a service from this RiceSmart system the user must registered to

the system. They can be registered as a farmer, buyer and transporter. Then user become a member of this RiceSmart system and can get all the facilities which are provided by the system.

The system has two types of working modes as manual mode and the automated mode. When a user registered to the system, he can add details, send and view messages and as well as can delete viewed messages. These functions are performed in the manual mode. In the manual mode any farmer, buyer, seller, miller or transporter can set task(s). Then the mode of the system will be converted into the automated mode and user can leave from the system. When the system is in the automated mode, the system replies to the messages which were sent by several users. This will be done using a predefined message structure which has been developed in the development stage. The figure 4 shows the common message interface for a particular person.

Figure 4. RiceSmart Common Message Web Interface for Viewers

Figure 3 shows the communication diagram of the RiceSmart System. This diagram shows the way of how agents communicate with others.In this diagram, there are three types of agents as rice buyer, transporter and individual farmers. First, the rice buyer makes the request, and it will send to the transporter, and then this will be forwarded to the each and every individual farmer. Then finally he will receive all the response of these farmers and send the final solution to the transporter. Finally, it will send to the rice buyer.
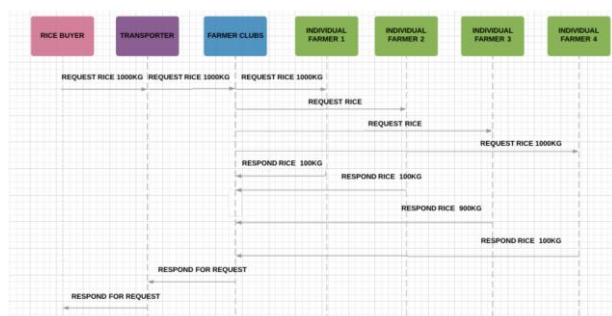

Figure 5. Communication Diagram for buying rice from multiple farmers

VI. EVALUATION

RiceSmart has been successfully evaluated through a test environment using 40 persons who are involved in the rice production industry. Accordingly, farmers, buyers, sellers, millers and transporters were involved as the key persons in this system. To conduct this evaluation, the system has been freely distributed among 40 persons and allowed them to register and provide facilities to use this system within 14 day period. During these 14 days, questioners are provided to them and obtained results which are shown in table 1.

Parameter	Very Easy	Easy	Difficult	Very Difficult
Accessibility	22	18	0	0
Usability	12	25	3	0
Understandability	17	23	0	0
Ability to sell products	8	12	5	0
Ability to buy a product	7	10	3	0
Ability to order a product	3	2	0	0

Parameter	Very Good	Good	Poor	Very poor
Attractiveness	13	22	5	0
Usefulness	16	21	3	0

Table 1. Results obtained by the questioner

Then the figure 04 shows the summary of results which have been obtained by the evaluation.
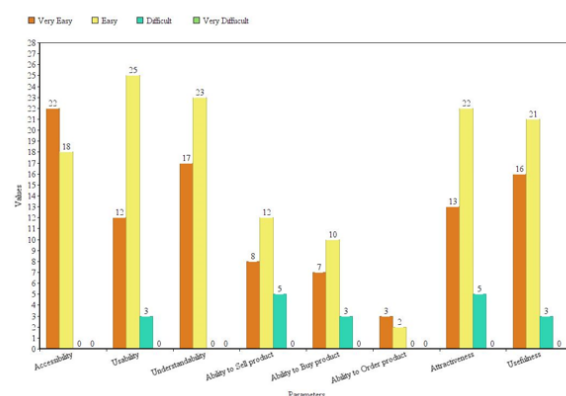

Figure 6. Summary of the Evaluation

VII CONCLUSION AND FURTHER WORKS

RiceSmart is an innovation practical Web-Based Multi Agent System that is designed to establish an effective and

efficient communication among key persons in the rice production industry in Sri Lanka. This paper has illustrated the design and the architecture of the developed RiceSmart system. In addition this system provides five types of agents as farmers, buyers, sellers, millers and transporters who are the key persons in this industry. RiceSmart system provides two modes as manual mode and the automated mode.

RiceSmart has been successfully tested with 50 users in the practical environment and obtained successful results. As the further work of this project, it is useful to develop a mobile application which will provide a better communication platform which will be essential and useful to the people who are involved in this industry. Finally, RiceSmart is a very user-friendly and a simple easy to use system for the rice production industry in Sri Lanka.

References

Techopedia.com. (2019). *What is Artificial Intelligence (AI)? - Definition from Techopedia*. [online] Available at: https://www.techopedia.com/definition/190/artificial-intelligence-ai

Alanturing.net. (2019). *AlanTuring.net What is AI? Part 10*. [online] Available at: http://www.alanturing.net/turing_archive/pages/Reference%20Articles/what_is_AI/What%20is%20AI10.html

En.wikipedia.org. (2019). *Multi-agent system*. [online] Available at: https://en.wikipedia.org/wiki/Multi_agent_system

George, R. (2019). *A new direction of research into Artificial Intelligence.* [online] Available at: https://www.researchgate.net/profile/Budditha_Hettige/publication/235350879_Muliti_Agent_Technology_for_Morphological_Analysis/data/0fcfd511348a6011f3000000/Presenatation.pdf [Accessed 13 May 2019].

Jade.tilab.com. (2019). *Jade Site | Java Agent DEvelopment Framework*. [online] Available at: https://jade.tilab.com/

platform), J. (2019). *Jason (multi-agent systems development platform) - Software | Facebook*. [online] Facebook.com. Available at: https://www.facebook.com/pages/Jason-multi-agent-systems-development-platform/129983830376565

Madkit.net. (2019). *MadKit Development Guide*. [online] Available at: http://www.madkit.net/documentation/devguide/devguide.html

Toolkit, F. (2019). *FIPA-OS Agent Toolkit / List fipa-os-developers Archives*. [online] Sourceforge.net. Available at: https://sourceforge.net/p/fipa-os/mailman/fipa-os-developers/?viewmonth=200011 [Accessed 13 May 2019].

Agentbuilder.com. (2019). *AgentBuilder Pro*. [online] Available at: https://www.agentbuilder.com/Documentation/Pro/

Issuu. (2019). *La Grande Observer Daily Paper 09-01-14*. [online] Available at: https://issuu.com/northeastoregonnews/docs/observer_09-01-14 [Accessed 15 May 2019].

En.wikipedia.org. (2019). *NetLogo*. [online] Available at: https://en.wikipedia.org/wiki/Netlogo

AgentSheets, I. (2019). *Coding for Kids | Computer Programming | AgentSheets*. [online] Agentsheets.com. Available at: http://agentsheets.com/

En.wikipedia.org. (2019). *JACK Intelligent Agents*. [online] Available at: https://en.wikipedia.org/wiki/JACK_Intelligent_Agents

A.A.P.S Adikari and A.S Karunananda, MultiAgent Systems for Agricultural stakeholders Proceedings of the ITRU Research Sysmposium, Moratuwa(2009)

A.A.P.S. Adikari and A.S. Karunananda, Multi Agent Systems for Agricultural stakeholders, Proceedings of the ITRU Research Symposium, Moratuwa, 2009.

K.J. Tharaka, K.A.D.T. Kulawansa, Information System for Cultivation, Joint National Conference on Information Technology in Agriculture, 2011

H.M.H.R Jayarathna, B Hettige, (2019) "WMAC: Web-Based Multi-Agent Solution for Agriculture Community", *Slaai.lk*. [Online]. Available: http://slaai.lk/proc/2013/s1304.pdf.