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AGENT-BASED SELF STUDY CENTRE MANAGEMENT SYSTEM

BY:

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Declaration

This research project report is my original work and has not been submitted for any academic award in any other university.

SIGNED: …… DATE ……

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This research project report has been submitted for examination as a partial fulfillment for the award of the Degree of Masters of Science in Computer Science at the University of Nairobi with my approval as a Supervisor.

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Dedication

I dedicate this project to my family for their continued support and encouragement. Above all I thank the almighty God who made all things possible throughout my studies.

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I would like to extend my gratitude to Dr. Elisha T.O Opiyo (Supervisor) for his continued support and guidance, Prof. Peter W. Wagacha and Mr. Joseph O. Ogutu for their positive criticism throughout this project.

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List of Abbreviations:

ACC – Agent Communication Channel

AI – Artificial Intelligence

AMS – Agent Management System

API – Application Programming Interface

COD – Communication Ontology Description

DF – Directory Facilitator

DOD – Domain Ontology Description

ICT – Information Communication Technology

GUI – Graphical User Interface

JADE – Java Agent Development

KIPPRA – Kenya Institute for Public Policy Research and Analysis

KQML – Knowledge Query and Manipulation Language

MAS – Multi- agent Systems

MDGs – Millennium Development Goals

OO – Object-Oriented

PASSI – Process for Agent Societies Specification and Implementation

SDL – Self Directed Learning

SSC – Self Study Center

STI – Science, Technology and Innovation

UML – Unified Modeling Language

FIFA – Foundation for Intelligent Physical Agents

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Abstract

The education sector is faced with many challenges such as meeting the human resource requirements for a rapidly changing and more diverse economy and ensuring quality education that meets the needs of the economy. Formal education is also faced with learning disparities and disruptions like learners' strikes and industrial unrests. Self Directed Learning (SDL) or self study which empowers learners to take responsibility for their learning can be adopted to enhance learning as well as provides learners with flexibility and independence. In previous studies we note an agent based English learning system which can be used without restriction by using popularized cellular phones. Grockit educational software that enables learners master skills and exercise what they learn through individual study, small group study and instructor-led classes is also highlighted.

Agent systems emerge to be a promising approach to deal with the challenges of the educational system because they have the potential to enhance learning by enabling scenarios which are not feasible with other technologies. And this answers why the study adopts an agent based self study management system to address the shortage of human resources requirement and produce a pool of qualified graduates matched with skills demand of the industry to ensure effective synergy.

CHAPTER ONE: INTRODUCTION

1.1 Background

According to the Kenya Vision 2030 education and training is one of the social pillars required to provide skills required to steer Kenyans to the economic and social goals of the vision. Education and training of all Kenyans is crucial for equipping citizens with the understanding and knowledge needed to make informed decisions. It is therefore the responsibility of the education sector to create a knowledge-based society that upholds justice, democracy, accountability and encourages issue-based and results-oriented engagements.

Considered crucial in the Vision 2030 agenda is the integration of Science, Technology and Innovation (STI) in national productive processes. This is crucial within the context of demands for global economic competitiveness, sustainable development, and equity concerns. Consequently, the development of the vital scientific and technological infrastructure, as well as the technical and entrepreneurial skills is a vital requirement towards transforming our country into a knowledge-based society. This call for adoption of modern teaching techniques to support the use of STI in institutions of learning and research centers.

A recent study by (Ojiambo, 2009) stresses that education is a vital tool in the development process of any nation. With the recognition of this noble role the Kenyan Government has spend a lot of time and money on education to improve both the access and quality of education, in an effort to achieve the education-related Millennium Development Goals (MDGs) and Vision 2030. Despite this enormous investment the education sector is still marked by various challenges and predicaments and so has been its impact on national development.

One of the challenges facing this sector is how to meet the human resource requirements for a rapidly changing and more diverse economy. Another challenge is to ensure that the education provided meets high quality standards, and that its curriculum is relevant to the needs of the economy, industry and the society. According to (Ojiambo, 2009) the education system in Kenya stands accused of being insensitive for adopting irrelevant and rigid

curricula, for embracing outdated teaching and learning techniques, for dampening innovation and curiosity of learners and for producing dependent minded graduates. It is in the light of these tensions that education reform and development have been long standing objectives of the Kenyan Government.

Another challenge is that formal education remains highly esteemed by most societies, and many people find it hard to trust what is learned outside the formal system. Self study learning continues to address many challenges associated with keeping up to date with the dynamic knowledge. Currently some people are able to carry out self study outside institutions of learning, and stakeholders are beginning to look at this mode of study as a means of optimizing scarce education resources. A study by (Hiemstra, 1991) shows that giving learners learning responsibility is more advantageous than the formal education approach because they are in control of their study and can learn at their own convenience despite busy schedules.

For Kenya to compete globally a new strategy on developing competent human resources should be adopted and education and training standards raised to international levels. At the same time the pool of graduates should be matched with skills demand of the industry to ensure effective synergy. To reform the education sector, emerging Information and Communication Technology (ICT) innovations ought to be implemented to improve access and quality of education to all. Applications such as Self Study Centers (SSC) can be developed to tackle this concern as illustrated in the block diagram below:-

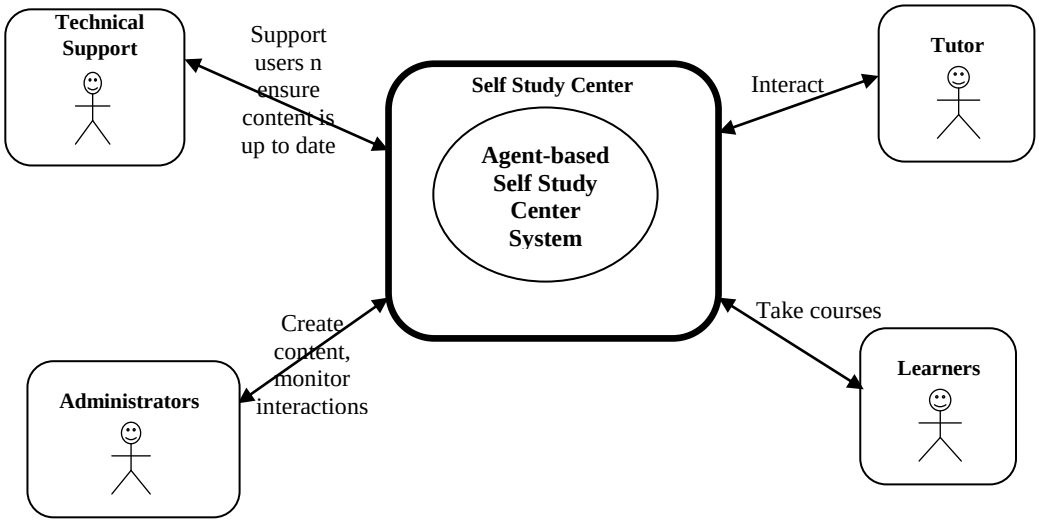

Figure 1: Block diagram of the proposed Self Study System.

1.2 The Problem Statement

In a formal education setup there are learning disparities and slow learners tend to lag behind leading to poor performance and as a result some may opt to drop out. According to the business daily a research by the Kenya Institute for Public Policy Research and Analysis (KIPPRA) shows that the survival rate from class one to form four is below 20% while those who survive from class one to university is 1.69%. Nevertheless Vision 2030 is relying on the education sector to provide the skills required to steer Kenyans to the economic and social goals of this vision. Formal education is also limited and it cuts out many people, who cannot qualify due to poverty as shown by global education fund where children are forced to drop out of school to provide for the family, girls are forced into early marriage and motherhood to raise their siblings.

Formal education is prone to learning disruption like learner's strikes, industrial unrests, busy schedules at work, and also during programme transitions learners have to substitute courses which would not be the case with SSC. According to a policy framework for STI there is also a rising age-gap between the senior and junior scientists, engineers, technologists and researchers. As a consequence, the economy has started showing skills constraints, particularly in the most specialised scientific areas. It is in the light of these challenges that this study explores an Agent-based Self Study System to address them.

1.3 Objectives of the study

ICT can play a significant role in equalizing education opportunities through content delivery and giving learners the flexibility of learning despite their busy schedules.

The following are the objectives of this study:-

1.3.1 Research Objectives

i) Investigate the learners experience with the current education system
ii) Assess the readiness of adopting self study for university education
iii) Find out the impact of using agents in self study

1.3.2 Project Objectives

i) Perform a system analysis process, design and develop the agent-based self study system
ii) Test the working of the agent based self study system

iii) Evaluate the agent based management system

1.3.3 System Objectives

i) Provide support to learners such as enrolling for units or take exams, assistance from tutors

ii) Provide a forum where administrators can monitor the interactions of the learners and the tutors

iii) Provide a forum where learners can learn at their own convenience.

1.4 Research Questions

i) What are some of the challenges facing university education in Kenya?

ii) What are the learners' perceptions on the current teaching techniques?

iii) How can we optimize the scarce education resources and still maintain quality of education and training?

iv) Is the education sector providing the necessary skills to steer Kenyans to the goals of Vision 2030, and how does this affect national development?

v) Is the education system able to produce an innovative pool of graduates ready for the industry?

vi) How can we involve stake holders in curriculum development to match the skills demand of the industry?

1.5 Significance of the Study

This research work focuses on empowering learners to take responsibility for their decisions associated with the learning endeavor. The Self Study System entails various activities and resources, where learners will be able to access self-guided reading, participation in study groups and discussion forums. It will also facilitate interaction between the learners and the tutors, evaluation of outcomes which will make learners develop confidence in their own abilities and become more goal-oriented as they enjoy their learning. Self study also improves learners cognitive abilities such as problem solving and also enhance encoding and retention of learning content (Bader-Natal et al, 2011).

1.6 Assumptions and limitations of the study

This study assumes that learners have the ability to diagnose their own learning needs according to the level of competence required. The study will also assume that learners know how to research and locate the most relevant and reliable information and knowledge

sources. Learners should also have the ability to design a strategy of making good use of available learning resources to meet their learning needs. After designing the strategy it is assumed that learners will be able to implement their learning plan systematically to achieve their set goals. Learners are also expected to assess and evaluate if their learning objectives have been met and evidence validated through subsequent performance.

The institutions of higher learning are assumed to have in place the necessary network infrastructure and bandwidth to support the proposed system. The research will only focus on institutions of higher learning and not the whole education system. This research is limited by the conceptual framework and it will entail development of a prototype system which will be implemented to solve a real-world problem.

1.7 Expected Contributions

i) The first contribution will be a prototype
ii) The prototype will facilitate institutions of learning in producing an innovative and skilled pool of graduates ready for absorption in the economy.
iii) Also using agents in self study will add to the existing body of knowledge.

1.8 Definition of important terms

Self-study also known as **Self Directed Learning (SDL)** is a defined by (Knowles, 1975) as: "A process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating their learning outcomes p.18".

Learner refers to someone who is learning or gaining knowledge of something.

Agent is a computer system capable of autonomous action in some environment in order to meet its design objectives (Wooldridge, 2002).

A Multi-agent system is one that consists of a number of agents, which interact with one another. In most general scenarios, agents will be acting on behalf of users with different goals and motivations. To successfully interact, they will require the ability to cooperate, coordinate and negotiate with each other, just as people do (Wooldridge, 2002).

JADE –This is 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 FIPA specifications and through a set of graphical tools that support the debugging and deployment phases.

FIPA - It refers to the Foundation for Intelligent Physical Agents. The FIPA 97 specification is the first output of the Foundation for Intelligent Physical Agents. It provides specification of basic agent technologies that can be integrated by agent systems developers to make complex systems with a high degree of interoperability. FIPA specifies the interfaces of the different components in the environment with which an agent can interact, i.e. humans, other agents, non-agent software and the physical world.

FIPA Agent Communication specifications - deal with Agent Communication Language (ACL) messages, message exchange interaction protocols, speech act, theory-based communicative acts and content language representations.

Coordination - Refers to how agents interact, which includes methods of communication and cooperation between agents when achieving their tasks.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Education is the sole most significant factor essential for economic growth, technological innovation, healthy living and successful political governance. Nelson Mandela affirms this by stating education is the most powerful weapon, which can be used to change the world (Rheede, 2009).

A recent study by (Ojiambo, 2009) shows that Education is a central component of any nation‘s development and learners should be transformed into problem solving agents. A World Bank report indicates that youth account for approximately 60% of the unemployed in Kenya, and that 72% of adolescents in Sub-Saharan Africa live below the "$2 a day" poverty line (World Bank, 2009). The education system must present knowledge, skills such as creativity, flexibility and independence among learners. This will transform them to successful thinkers able to understand current problem complexities and solve those using innovative solutions. Wainaina, (2011) in his study reported that there has been a rapid expansion of programs in our universities today and they are endangered by various socio-economic circumstances given drive by globalization forcing universities to transform in an effort to increase their capital base in the face of consistently decreasing capitation by the government. This can be addressed by adopting SDL applications and at the same time maintain quality in the education system.

2.2 Self Directed Learning

The origin of self-directed learning can be traced in the realm of adult education back in the late 1960's and recently expanded to children's education. The body of knowledge about SDL has grown and various definitions have come into sight. Knowles, (1975) defines SDL as:-

> "A *process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating their learning outcomes p.18*".

Brockett and Hiemstra, (1991) define SDL as:-

> "*The process where the learner assumes the primary responsibility of planning, implementing, and evaluating the learning process p.24*"

SDL is also defined in terms of the amount of responsibility a learner accepts for his or her learning (Fisher et.al, 2001). In this mode of study learners take the primary responsibility for planning, carrying out and evaluating their goals with flexibility and independence among learners as it offers unparalleled learning.

2.3 Benefits of Self Directed Learning

i) Individual learners become empowered to take increasingly more responsibility for decisions associated with their learning;
ii) Learners are able to apply learning both knowledge and study skill from one problem situation to another;
iii) SDL study provides various activities and resources, such as self-guided reading, participation in study groups, internships, electronic dialogues, and reflective writing activities;
iv) Tutors are able to execute their roles such as interaction with learners, reviewing learning content, evaluating outcomes, and promoting critical thinking;

2.4 Self Directed Learners

Self-directed learners are individuals who take the major responsibility for planning, carrying out and evaluating their own learning endeavours, learners can help each other during their course of study and tutors empower them to take responsibility for what they choose to learn. According to (Ambrose et al., 2010) for learners to become self-directed they must learn to monitor and change their approaches to learning when necessary.

2.4.1 Competences necessary for self directed learners

a) Goal setting skills

Many learners have not learned how to determine what is important and how to choose among many possibilities. Learners are used to questions and problems identified for them rather than developing the cognitive ability to engage in problem identification and solving. As a consequence learners may be limited in observational skills that inhibit their ability to determine what is important in the learning environment. As a result, some effort is required to help the learners develop these skills before they become self-directed.

b) Information processing skills

Self directed learners need information processing skills to be able to understand and process information from the available resources. These skills include:-

i) Observing - the ability to see and do, or the ability to see and understand.

ii) Seeing and translating - the ability to translate visual information to notes and records, or the ability to graphically reproduce visual information and to relate it to existing information schemes.

iii) Reading - the ability to read, translate, and comprehend written material.

iv) Listening - the ability to receive and process audio information and relate it to existing information schemes.

c) Cognitive skills

Learners should have the ability to select from multiple sensory in-put, identify and classify information. They should also have the ability to conceptualize something from working memory and process it by imaging, deducing and generalizing.

d) Basic content competence

Learners need to have some pre-existing awareness of fundamental vocabulary, concepts and structure of the information. For instance, someone who knows basic arithmetic may be self-directed in learning basic math, then algebra, then geometry, etc.

e) Decision making skills

Self-directed learners must develop the ability to identify, prioritize, select, validate, evaluate, and interpret information obtained through the processing skills. Successful self-directed learners develop the ability to determine and evaluate the sources of information as well as the reliability, validity, and meaning of information (including theories and other explanations).

f) Self-awareness

Self directed learners should be aware of the learning process, their weaknesses and strengths to decide when to dedicate more time in the learning, know when they need assistance and to have a realistic perception of their ability to achieve their learning goals.

2.4.2 Models of Self Directed Learning

Several models have been proposed to understand SDL, starting with Mocker and Spear's *Two Dimensional Model* in the early 1980s to a more recent model from Garrison's *Three*

Dimensional Model in the late 1990s. For the purpose of this study three models are used for understanding self directed learning. These models are:-

a) Candy's four-dimensional model

In a recent study by (Song and Hill, 2007) in reporting (Candy, 1991) self directed learning is seen as an umbrella concept encompassing four dimensions:-

i) Self-direction as a personal attribute (personal character)
ii) Self-direction as the willingness and capacity to conduct one's own education (self management)
iii) Self direction as a mode of organization instruction in formal settings (learner control)
iv) Self-direction as the individual non institutional pursuit of learning opportunities in the natural societal setting.

The variety of constructs in Candy's model brings out a deeper understanding of self-directed learning. This model was the first to state that a learners' self-direction might be different in certain content areas. This model however has shortcomings for it does not describe how self-directed learning is relevant in different learning contexts such as classroom learning or online learning.

b) Brockett and Hiemstra's Personal Responsibility Orientation Model (PRO)

Brockett and Hiemstra, (1991) provided two orientations in developing an understanding of SDL that is process and goal. First Self Directed Learning referring to the instructional process "in which a learner assumes primary responsibility for planning, implementing, and evaluating the learning process" (p.24). Second learner self-direction referring to the personality characteristic, which focuses on "a learner's desire or preference for assuming responsibility for learning" (p.24). Brockett and Hiemstra, (1991) combined both the process and personal attribute perspectives in the model. They also integrated social context as a component in the model in that they discussed the role of institutions and policies in SDL.

c) Garrison's Three Dimensional Model

This model includes the perspectives of self directed learning as a personal attribute as well as a learning process. According to (Garrison, 1997) SDL integrates three dimensions interacting with each other: self-management, self-monitoring, and motivation. Self-management entails learners taking control of their learning and aiming at achieving their stated goal and objectives. The second dimension self-monitoring, addresses cognitive and meta-cognitive process that is "the learner takes responsibility for the construction of

personal meaning of the learning" (p.23). The last dimension motivation focuses on the factors that persuade the learner to take part in SDL. This model highlights three important attributes of a leaner: motivation, self-management and self-monitoring skills which work hand in hand to achieve SDL. However, this model does not deal with the interaction of the learners and their environments.

2.5 Conceptual Model for Understanding self directed Learning

A study by (Shapley, 2000) emphasizes that SDL requires learners to have a high level of self direction to succeed. This learning context influences the amount of control given to or expected of the learner's perception in their self direction as shown by a qualitative case study by (Vonderwell and Turner, 2005). In this study learners expressed that SDL enhanced their responsibility and initiative towards learning. The learners were also reported to have more control of their learning and used learning resources more efficiently. Below is a conceptual model for understanding self directed learning in an online setup. The model incorporates SDL as a personal attribute and a learning process as pointed out earlier.

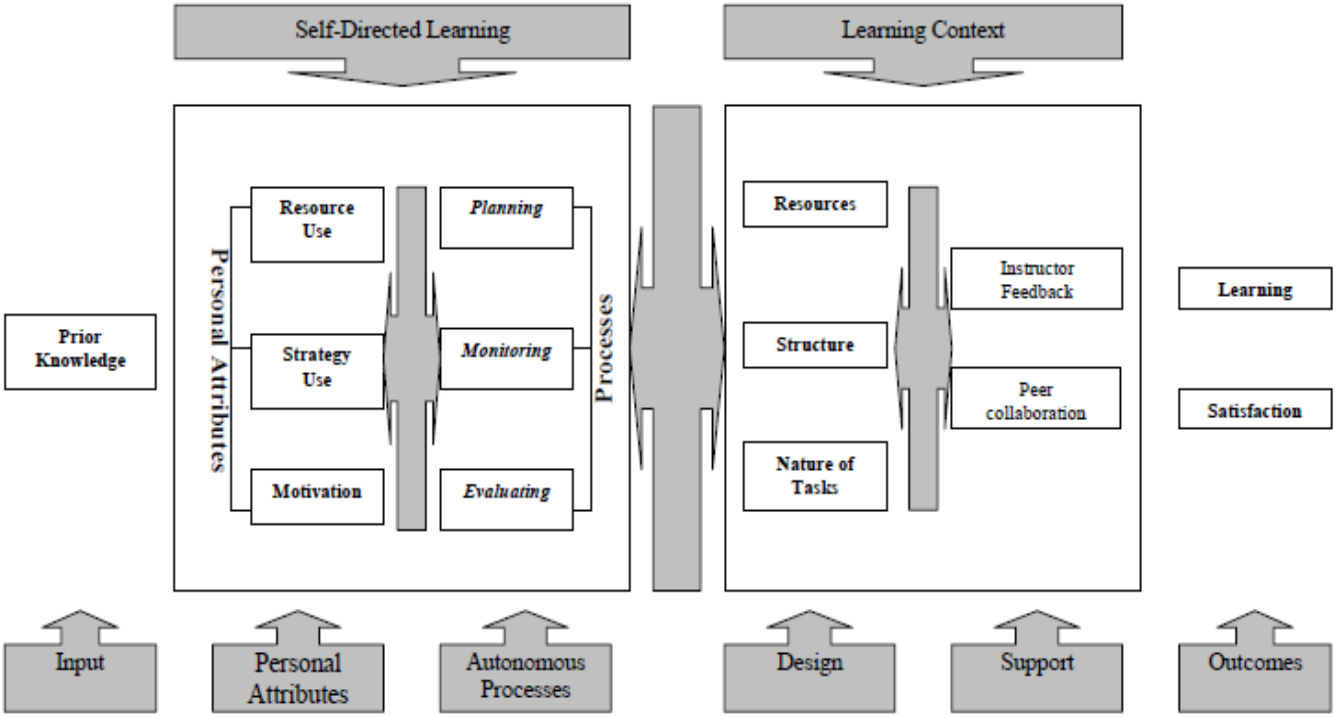

Figure 2: Conceptual model for understanding Self Directed Learning (Song and Hill, 2007).

2.6 Agents in Self Directed Learning

According to (Wolpers et al, 2005) agent systems emerge to be a promising approach to deal with the challenges of the educational system. Agents have the potential to transform education by enabling scenarios which are not feasible with other technologies. This is because of key features of agents such as distributed control, and agent autonomy. Using known agent solutions such as Voting Systems and Coalition Formation we can adopt agents to enhance learning and (Wolpers et.al, 2005) illustrates this using the following scenarios:-

A common scenario in higher education is the need by institutions to support students who are interested in a variety of course units especially elective units. Current solutions are centralized, requiring students to hand over their preferences to the institutions management. In addition students are unable to respond to cancelled units by changing their preferences. From a personalized learning point of view this is undesirable and it raises tension between the goals of the institution and the students. The institutions are keen to offer few units which they can manage effectively due to limited resources but the student are keen on their preferences. In agent systems this is characterized as a voting problem and it occurs when agents are required to vote for a limited number of options within a greater number of more or less attractive possibilities. Agents systems have transparent protocols which allow agents to choose their own voting strategies and this offers fairness, decentralization and independence. This distribution of control fits very well in self directed learning.

Another scenario is the need for learners to group themselves to share resources or participate in group discussions. Learners can group themselves or be grouped by the tutors. The learners may prefer to be grouped with their friends but the tutor may desire to mix them based on their learning capabilities and this again may not be desirable to the learners. In agent systems an appropriate metaphor for this scenario is coalition formation – a process where agents form, join and switch groups until a set of coalitions or groups are made. The agent framework provides conversation mechanisms for this negotiation, but the agents need self organization. For example each group may produce a virtual leader to negotiate with the leaders of the other groups, at the same time negotiate with the tutor agents since each group has to conform to the constraints set by the tutor agent.
Such distributed agent-based groups' enable learners' participate in discussion forum and this can work very well in self directed learning.

2.7 Agent Theory

2.7.1 Agents

Agents are sophisticated computer programs that act autonomously on behalf of their users, across open and distributed environments, to solve a growing number of complex problems (ISA, 2009). Agents are components of software or hardware, which are capable of acting exactingly in order to accomplish tasks on behalf of their users **(**Nwana, 1996). Russel and Norvig, (2003) describes an agent as anything that can be viewed as perceiving its environment through sensors and acting upon the environment through actuators. Agents are characterized by the following:-

Autonomy: - acting independently & exercise control over their internal state.

Reactiveness: - reactive system interacts with its environment; responds to changes that occur in it.

Proactiveness: - generating and attempting to achieve goals due to one's own initiative e.g. as a result of recognizing opportunities.

Social Ability: - take others into account when trying to achieve goals sometimes through cooperation, negotiation etc.

Learning/adaptation: - can improve performance over time.

Personality: – have distinct personality behavior, name, and role.

Mobility: - Ability to move around network platforms.

Veracity: - avoid communicating false information knowingly.

In order to successfully interact, agents require the ability to *cooperate*, *coordinate,* and *negotiate* with each other the same way that humans cooperate, coordinate, and negotiate with each other in everyday lives (Wooldridge, 2002).

2.7.2 Multi -agent Systems (MAS)

It is a system of agents which interact with one another through cooperation, competition, coordination or negotiation usually to accomplish some goal (Wooldridge, 2002). A multi-agent system is one that consists of a number of agents, and they interact with each other typically by exchanging messages through a computer network infrastructure (Vidal, 2007). This means that there is no agent without multi-agent systems (Demazeau, 2000). MAS make it possible to represent complex situations where global structures result from interactions between individuals (Michel et al, 2001).

Agents and multi-agent systems must be aware of their own capabilities and of changes to other agents and their environment. To remain effective, agents must be able to adapt their structures and knowledge while they carry out their tasks (Guessoum, 2004).

In this study MAS will be used to develop the Self-Study Center because of the following benefits:-

i) Ability to solve complex problems for a single agent which could result to performance bottleneck
ii) Ability of the agents to interact in their society making load balancing easy to implement
iii) Multi-agents systems are suitable in situations where expertise is distributed like in education.
iv) Enhanced performance through increased speed and efficiency during execution of tasks due to parallelism
v) Multi-agents systems are robust and reliable
vi) Multi-agent systems are flexible and scalable.

Some of the key components of MAS are communication and coordination. Agents need to cooperate with each other, communicate with users and with system resources. According to (Fabio and Dominic, 2007) agents interact with each other through agent communication languages that rely on speech act theory such as Knowledge Query and Manipulation Language (KQML) which was the first agent communication language. KQML is a protocol for exchanging information and knowledge between agents and allows messages to be represented in first order logic (Michael, 1997). However, this communication language is not enough to support interoperability between the agents since common agent services and ontology are also required. It is in this respect that the standardization work of Foundation for Intelligent Physical Agents (FIPA) is adopted because it specifies key elements necessary for the management of agent-based systems and the shared ontology to be used for the interaction.

2.7.3 Agent Methodology

A methodology is a body of methods employed by a discipline. Several agent-oriented methodologies for developing multi-agent systems have been proposed in the past, thus the need to examine them and determine the most appropriate for this study. A methodology aims to prescribe all the elements necessary for the development of a software system. According to (Giorgini, 2005) agent methodologies have several roots. Some are based on ideologies from Artificial Intelligence (AI), others as direct extensions of existing Object Oriented (OO) methodologies, while others try to merge the two approaches. The figure below shows the genealogy of ten Agent Methodologies:-

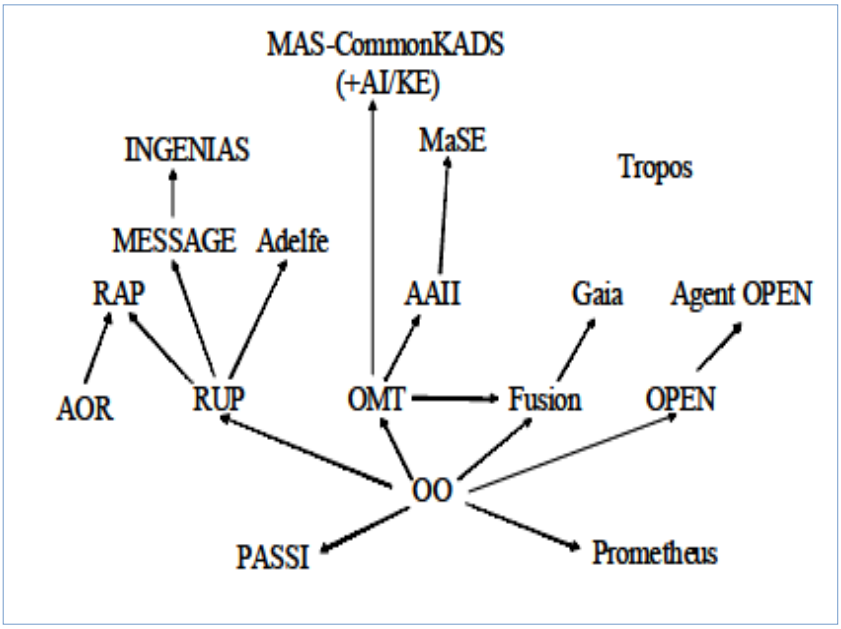

Figure 3: Agent Genealogies - (Paolo Giorgini, 2005).

The Self-Study system adopts the Process for Agent Societies Specification and Implementation (PASSI) methodology because of its clarity and completeness. PASSI is a step-by-step requirement-to-code methodology for designing and developing multi-agent societies integrating design models and concepts from both object-oriented (OO) software engineering and MAS, using the Unified Modeling Language (UML) notation. The PASSI methodology brings a particularly rich development lifecycle that spans initial requirements though deployment; in addition, it emphasizes the social model of agent-based systems (Giorgini, 2005).

PASSI methodology is composed of five Phases:-

a) System Requirement Model: This model deals with the functional description of the system, identification of the agents, role of the agents and task specification of the agents.

b) Agent Society Model: This model deals with all the aspects of the agent society are faced: ontology, communications, roles description, Interaction protocols.

c) Agent Implementation Model: This model forms a classical model of the solution architecture in terms of classes and methods. It deals with the agent structure definition and agent behavior description.

d) Code Model: This is a model of the solution at the code level requiring creation of codes for the proposed system.

e) Deployment Model: This model deals with how agents are deployed to available tasks and any constraints set on their migration and mobility.

f) Testing: This model involves single-agent test to verify the behavior of each agent with regard to the system requirements to be met by the specific agent. It also deals with society test where integration verification and validation is carried out.

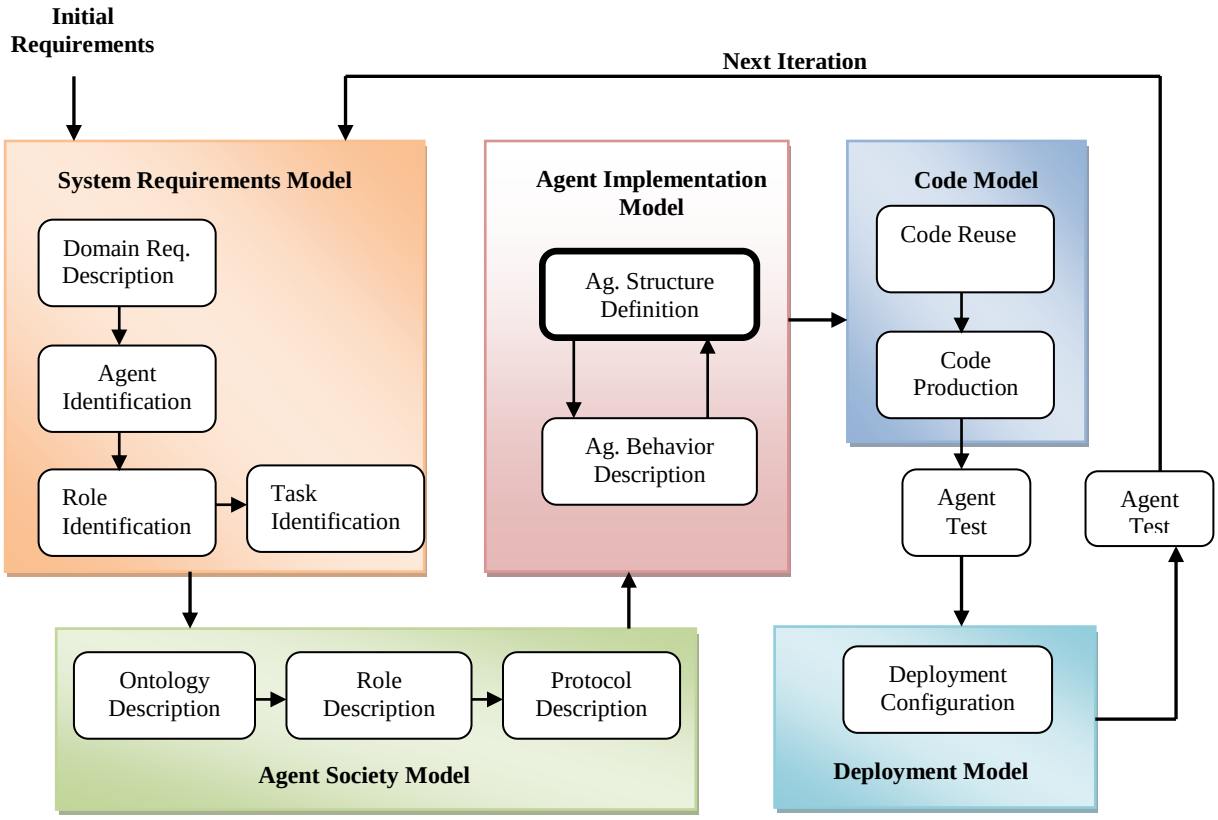

Figure 4: From Requirements to Code with the PASSI Methodology (Paolo Giorgini 2005).

2.7.4 Agent Development Methodology

MAS are considered to be a valuable technology for integrating loosely coupled systems, like information systems of different departments. These kinds of applications require agents on different platforms that might be under the control of different areas, to interact efficiently. In this study Java Agent Development (JADE) a software framework to develop agent applications in compliance with the FIPA specifications for interoperable intelligent multi-agent systems will be used. JADE enables development of applications both in the mobile and fixed environment which are based on the Peer-to-Peer intelligent autonomous agent approach. JADE enables developers to implement and deploy multi-agent systems, including agents running on wireless networks and limited resource devices (Bellifemine et al, 2003).

According to (Bellifemine et al, 2001) JADE simplifies development ensuring standard compliance and it offers the following features to developers:-

i) FIPA compliant agent platform which includes the Agent Management System (AMS), the default Directory Facilitator (DF) and the Agent Communication Channel (ACC) which are automatically activated at the agent platform start-up.

ii) Distributed agent platform which enabled agent platform to be split on several hosts. In this case agents are implemented as one java thread and java events are used for effective lightweight communication between the agents on the same host.

iii) Directory Facilitator (DFs) which can be started at run time to build multi-domain environments where domain is a logical set of agents whose services are advertised through a common facilitator.

iv) Java Application Programming Interface (API) to send/receive messages to/from other agents and these messages are represented as ordinary java objects.

v) Lightweight transport of messages inside the same agent platform, as messages are encoded and transferred as Java objects rather than strings.

vi) Library of FIPA interaction protocols ready to be used.

vii) Support for agent mobility within a JADE agent platform.

viii) Library to manage user-defined ontologies.

ix) Graphical User Interface (GUI) to manage several agents, agent platforms and also administer the roles of the agents.

JADE agents are very scalable with respect to the number of simultaneous conversations a single agent can take part in. When an agent engages in a new conversation neither new threads nor new connections are initiated, just a new behavior is created. As a result the only

overhead associated to starting conversations is the behavior object creation and its memory occupation that is why the proposed Self Study System will be implemented using this technology. Regrettably JADE does run on small devices due to constraints on memory, programming requirements and wireless links characteristics. The JADE-LEAP toolkit add-on was created to solve these problems enabling deploying JADE agents on handheld devices.

2.7.5 Related Work

A personalized mobile learning system using Multi-agent

According to (Ko, Hur and Kim, 2005) this is an English Learning System in which anyone can use it without restriction by using popularized cellular phones. The system consists of three main agents for the server and a client and three databases for personalized service as shown below:-

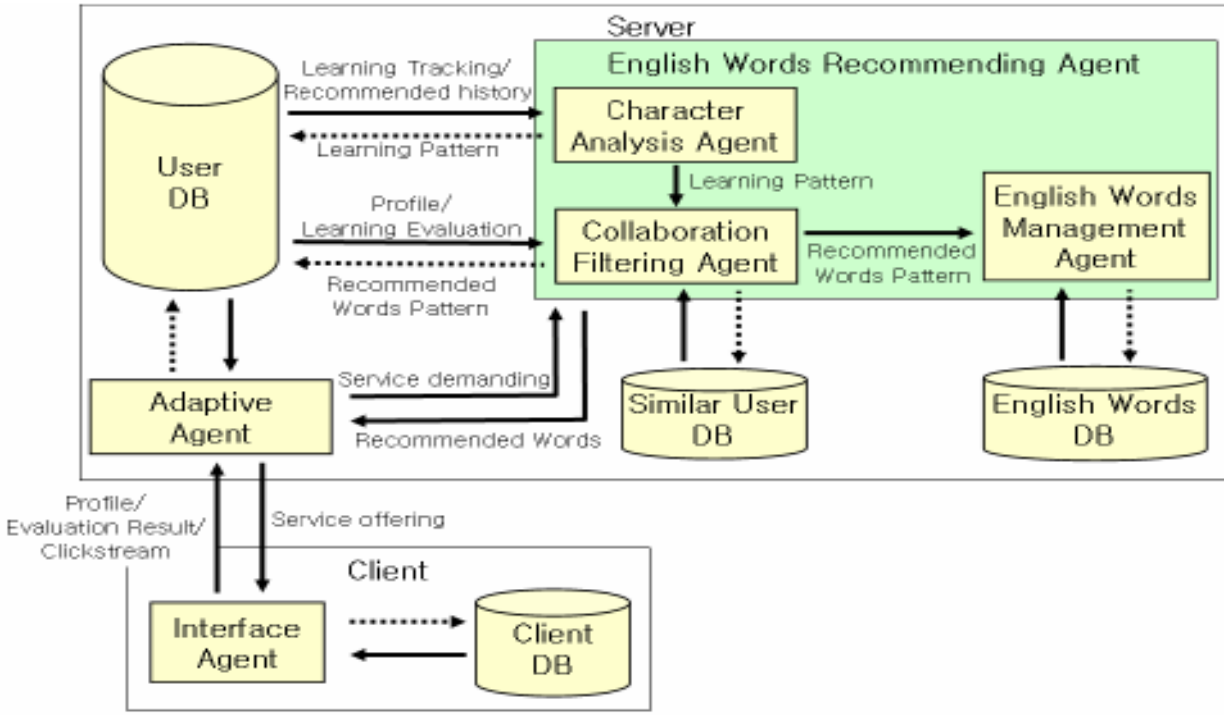

Figure 5: Multi-Agent System Structure for English Words Learning System (Jin-hee Ko, Chihoon Hur, and Hanil Kim, 2005).

The Interface Agent classifies clients who access the server and offers a personalized service to them. The English Words Recommending Agent enables learning based on levels using the information of users and it consists of:-

i) The Collaboration Filtering Agent compares and analyzes the user with the user group with similar characteristics to the user based on his profile and learning pattern. Then, it recommends an English words pattern suitable for him.
ii) The Character Analysis Agent analyzes the English words learning tracking and recommended history of the user and recommends a suitable English words learning pattern for the user.
iii) The English Words Management Agent is in charge of the management of the English Words Database including the classification of English words suitable for the user.

The third agent is the Adaptation Agent which updates the User Database through the learning results of the user. It changes the User Database using the feedback on learning evaluation results or click stream through learning or evaluation of the user on the client. Then, it stores the adaptive user information in the User database. On the server side, there is a User Database and an English Words Database. On the client side, there is a Client Database. The Client Database stores the English Words Learning System setup information and downloaded English words form the server.

An adaptive e-learning system

An adaptive e-learning system based on multi-agent technology using a distributed intelligent blackboard agent, which provides an easy way for agents to communicate, collaborate, and coordinate their actions and resolve conflicts (Hammami and Mathkour, 2013). This system has the ability to be adaptive to the learner's preference and needs and also allows teachers to advice their students. The adaptive system adopts a distributed intelligent blackboard agent that ensures the communication among participating agents.

Grockit

Grockit is a web-based learning environment offering self-directed learners a wide variety of activities (Natal et al, 2011). It is designed for individual learners who share a common domain-specific learning goal. Grockit provides a place for learners to master new skills and exercise what they learn through three contexts for problem solving:-

a) *Individual study* which uses an Item Response Theory model to provide learners with appropriate challenges for learning.

b) *Small group study* which leverages collaborative learning dynamics to provide learners with a social learning network that can help motivate and assist them

c) I*nstructor-led classes* which draws on an expert's domain knowledge and experience to provide a guided and structured path for larger groups of learners.

The core activity within all three learning contexts involves answering multiple choice and numeric response problems in some well-defined learning domain like Algebra course, and then reviewing expert-authored solutions and explanations for each of these problems. In small group and instructor-led settings, all participants access same content at the same time, enabling group discussion around problems and solutions. In addition learners have access to a number of supplemental learning activities motivated by work in prior systems, and introduced to the Grockit environment with the goal of contributing to the learning gains of participating learners.

2.8 Conceptual framework of the proposed system

The Agent-based Self Study System aims to address the challenges of the formal education system. It consists of a central content information base which will host the learning content. The System has four main agents namely:-

i) *Admin Agent:* - This agent enables administrators like Directors of Schools, Head of Departments to monitor the interactions between the learners and the tutors. This will ensure quality is maintained and learners are receiving the required support.

ii) *Technical Support agent:* - This agent supports users and ensures that the content information base is up to date with the right content.

iii) *Learner agent:* - This agent facilitates the interaction between the learners and the tutors it will also respond to the learners issues and provide the appropriate feedback. The learner agent will also facilitate discussion forums and interactive dialogs between the learners.

iv) *Tutor Agent:* - This agent enables the tutor to interact with the learners and respond to their requests.

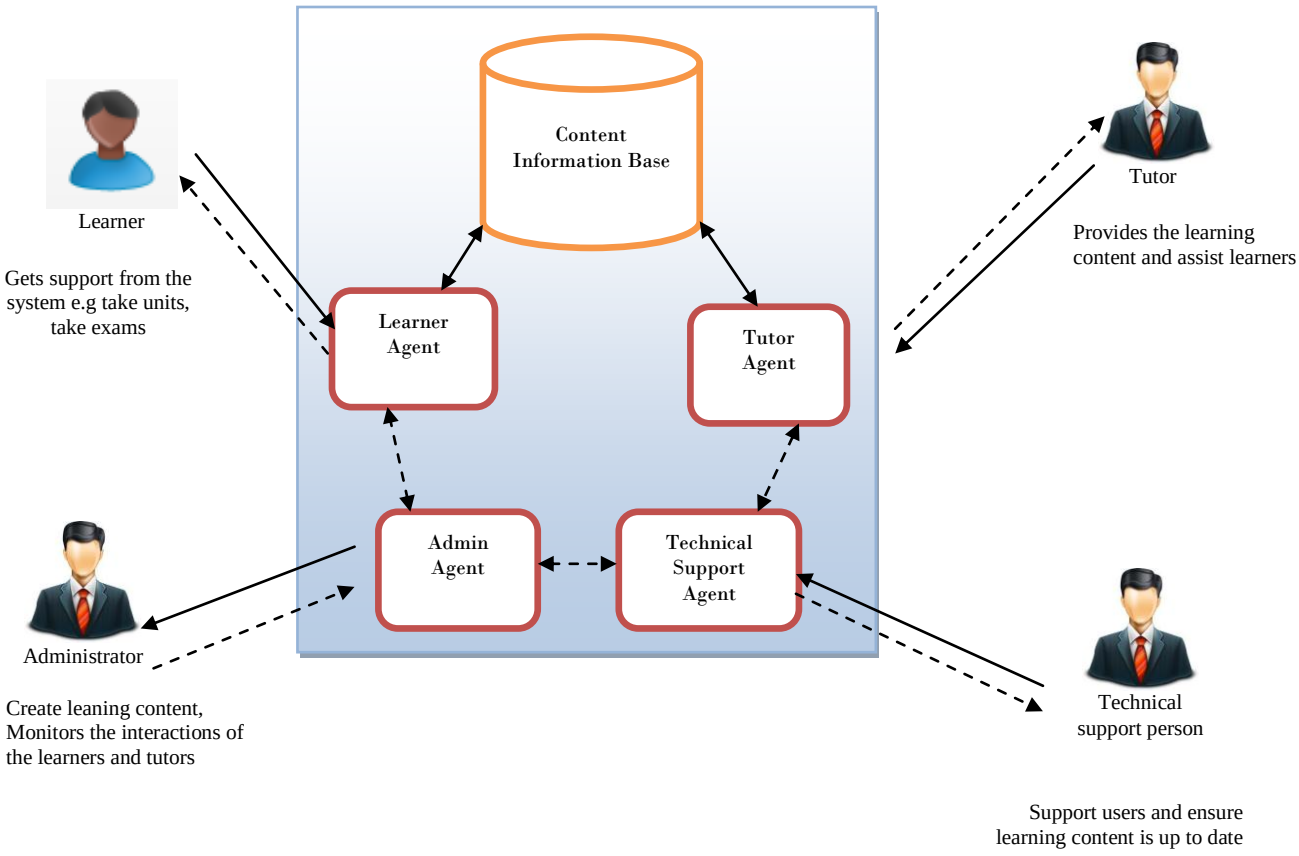

Figure 6: Block architecture of the proposed system

CHAPTER THREE: THE METHODOLOGY

3.1 Determination of system requirement

The initial requirements for the system were obtained from institutions of higher learning using questionnaires and interviews. This was done in the systems requirement model of the PASSI methodology.

3.2 Sources of Data

Data was mainly obtained through interviews, questionnaires and observations. Some data was acquired through reviewing of government reports from the Ministry of Education. This data was used to build the system. The other source is the data generated by the system such as progress reports.

3.3 Data Collection

Data for this project was collected using the following methods and tools:-

i) **Structured Interviews** – Interviews were conducted on the tutors and learners about their teaching and learning experiences respectively. This method was the most suitable way of obtaining detailed information about the experiences of the learners and the tutors.

ii) **Records inspection** – This method involved review of Government report and literature on previous research done in this area of study. This provided detailed information on the models of SDL, where it has been implemented, shortcomings and potential benefits.

iii) **Observation** – Site visits of various institutions of higher learning were made to assess their modes of training, and learning environments. This provided the actual state on how teaching and learning is conducted in these institutions. It also helped in determining the readiness for SDL among the learners and the tutors.

iv) **Questionnaires** – Questionnaires were issued to various people and this helped in assessing their attitude towards the learning modes among learners and issues on the learning environment.

3.4 Design of the System

The design and development of the Agent-based self study system was based on the PASSI methodology because it provides a rich development lifecycle. The system was designed as follows:-

3.4.1 System requirement Model

i) Domain Requirements Description

Analysis of the self directed learning was done to define the system functional requirements using case diagrams.

ii) Agents Identification

In this phase the responsibilities of each agents is represented using UML.

iii) Role Identification

Description of the agents was done using sequence diagrams showing the interactive associations between the agents

iv) Tasks Identification

The specification of the capabilities of each agent with activity diagrams.

3.4.2 Agent Society Model

i) Ontology Description

Two ontology descriptions are defined as shown below: -

- Domain Ontology Description (DOD) - In this Ontology a composite document was generated and it composed of a class diagram (whose classes represent concepts, actions and predicates) and a text document describing the elements reported in the diagram.
- Communication Ontology Description (COD) - In this Ontology description of the communication between the agents was done

ii) Role Description

Class diagrams are used to show the roles played by the agents, the tasks involved and communication protocols.

iii) Protocol Description

Sequence diagrams were used to specify the semantics of the communication between the agents

3.4.3 Agent implementation model

In this step we will dealt with agent implementation from multi-agent view and single-agent view.

i) Multi-Agent structure definition phase

Each agent was represented as the main agent class with knowledge in its attribute fields and all the tasks in its method fields. Environment and actors will also play a part in it.

ii) Multi-Agent Behavior Description Phase

In this phase we used activity diagrams to represent the behavior of the system at a level of detail that focus on the single method of each agent task.

iii) Single-Agent Structure Definition Phase

We used multi-agent behavior description diagrams, to find the methods for each agent task.

iv) Single-Agent Behavior Description Phase

We used flowcharts in this phase to explain the implementation of the methods of the classes.

3.4.4 Code model

i) Code Generation Phase

In this phase code will be generated from the model using one of the functionalities of the PASSI add-in.

ii) Code Completion Phase

Programming was done and the methods completed taking into account the design diagrams.

3.4.5 Deployment Model

In this model we described the allocation of agents to the available processing units and any constraints on migration and mobility.

3.5 Implementation of the System

Implementation of the Agent-based Self Study system was done using the JADE-LEAP toolkit. The system interfaces was build using Java Enterprise Edition technologies.

3.6 Evaluation of the system

Evaluation of the system was done with the help of students, lecturers and the Directors of School in the School of computing and Information Technologies at the Technical University of Kenya. During the evaluation the feedback was analyzed to determine if the Agent-based self-study system meets the set objectives.

3.8 Required Resources

The resources which were used for the Agent-based self study system were:-

a) Server for hosting the system and implementing the required access control policies.
b) Laptop with 4 GB RAM and a hard disk space of 320 GB and above.
c) Windows 7 and above Operating system.
d) Word processing application for report generation.
e) JADE-LEAP toolkit for implementation of agent system.
f) Java programming language.
g) Java reference materials.

CHAPTER FOUR: ANALYSIS, DESIGN AND IMPLEMENTATION

4.1 Introduction

The system was developed to manage self-study in universities to enable them serve many students and ensure quality of education and training. Self-study empowers learners to take responsibility for their learning with flexibility and independence. The development is based on the multi-agent systems technology. The Agent-based Self Study System aims to address the challenges of the formal education system. It has a central content information base which will host the learning content and nine agents to achieve the required system behavior.

4.2 User requirements

The user requirements constitute the essential building blocks of the agent-based self study system and specify the functionalities users require in the system. The following were the user requirements:-

i. Ensure secure access to the self study system
ii. Ensure interaction of the learners, technical support, tutors and administrators with the system using a web based interface
iii. Provision to create learning content which is organized in units, topics and lessons.
iv. Provision to create assessment questions which can either be CATs, assignments, and main exams.
v. Provision to create marking schemes for the assessments which can be multiple choices or structured answers.
vi. Ensure that learners are able to register for course units, access and read learning content, take CATs, Assignments and exams.
vii. Enable learners to indicate if they are comfortable with the lessons after taking them and if not they get assistance where they can be given more learning materials and if they are still not comfortable they tech-support agent can schedule an appointment with the tutor.
viii. Ensure that the learners can be assessed and graded. If they pass they are given a go-ahead to proceed and if they fail they are given a chance to re-take the course units.

Produce learners progress reports which can also be used by management to monitor the progress of the learners

4.3 System Specification

The system requirements or specifications defines how the system was developed and operates. It includes the description of the system inputs such as the learning content, assessment questions and marking schemes and they can be in word document, PDF, and power point presentation. It also describes the hardware, security and network requirements for the system to operate such as the server to host the system, the network availability to guarantee access and reliability. Lastly it also defines the how outputs will be generated out of the system such as the progress reports and their format example in PDF format. The Agent-based self-study system is composed of the following agents:-

i) Administrator Agent

The Administrator agent handles all the administrative tasks of the system such as creating learning content templates, programs, units, lessons, assessments and marking schemes. This agent also handles the requests of administrators such as the Directors of schools and Heads of departments to monitor the interactions between the learners and the system.

ii) Content Agent

The content agent generates the courses from the created templates after the academic year is set. It is able to generate the number of years a particular course takes, the semesters and the units for each semester.

iii) Technical Support agent

This agent handles all technical support tasks and supports all the users. The agent also assists learners during learning and ensures that all their requests reach the tutor.

iv) Learner Agent

The learner agent handles all the learner requests and ensures they arrive at the respective agent. The agent also facilitates the interactions of the learners and the system. It also gives responses to the learners such as assessment outcomes and progress reports.

v) Tutor Agent

The tutor agent handles all the operations of the tutor. The agent receives requests from the learners' and ensures they reach the tutor example if the learners need to make an appointment with the tutor.

vi) AMS and DF agents

The JADE platform is composed of one or more containers. The platform contains a special container called the main container. When the main container is launched it automatically starts two agents by default which are:-

- *Agent Management System (AMS) agent* – This agent provides the naming service and ensures that each agent has a unique name. It also represents the authority in the platform and it is the only agent able to perform management actions such as starting and killing agents or shutting down the whole platform. The system monitor agent informs the AMS agent of agents which need to be started.
- *Directory Facilitator (DF) agent* –The agent provides the directory services where the agents can publish their services and also be able to find other agents providing the services they need to accomplish their tasks.

vii) Remote Management Agent (RMA) agent

This is the JADE management console and it show the state of the agent platform it belongs to and offers various tools to request administrative action form the AMS agent such as the sniffer. It also helps in debugging and testing JADE applications.

viii) Web Agent

The Agent-based self-study system has a web based application which was used to develop the user interface for the system and it is hosted by the web agent. The web agent detects request via the web application and forwards them to the respective agents. It is also responsible for submitting responses to the users.

ix) System Monitor Agent

This agent initializes the platform and agents. The system monitor ensures that the database which contains the learning content is running and the environment is ready for the learning operations. This agent is also responsible for starting all the agents, monitoring the agents to ensure they are active and if any of them stops it is restarted.

4.4 Analysis and Design using the PASSI Methodology

Analysis was carried out to formulate the agent-based self study system specification. The analysis was based on the PASSI methodology systems requirement model as shown below:-

4.4.1 System Requirement Model

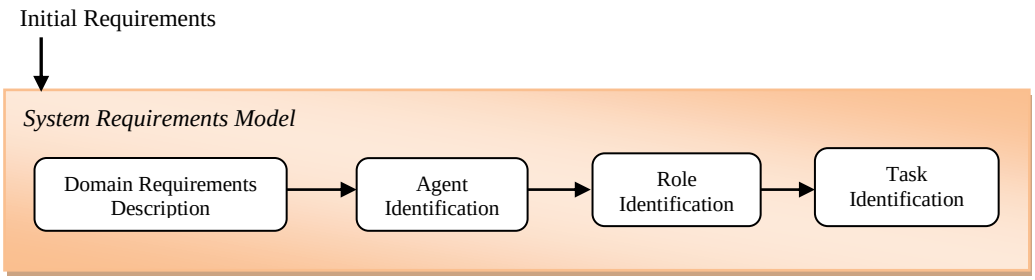

Figure 7: System Requirement Model

i) Domain requirements description

From the data collection findings the functional description of the Agent-based self-study system is defined using a series of use case diagrams as shown below:-

Use case 1

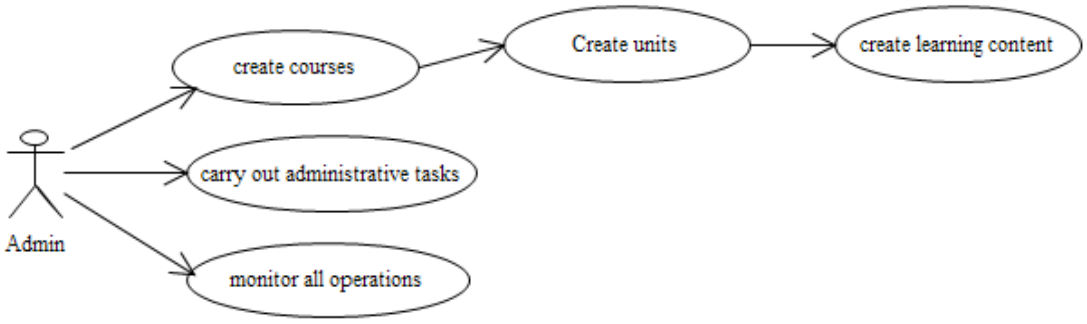

Figure 8: Use case diagram 1

The administrator of the system logs in to the system creates courses, units and learning content. The administrator carries out administrative tasks such as creating users and also monitors all the operations of the system like interactions between the learners, tutors and the learning content.

Use case 2

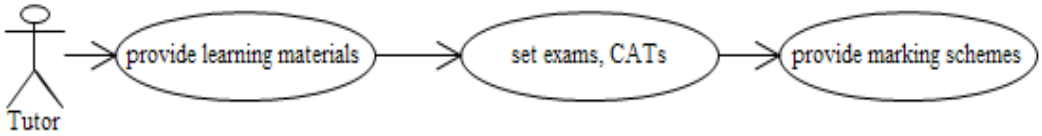

Figure 9: Use case diagram 2

The tutor provides the learning materials, sets exams, CATs and assignments. He also provides the marking schemes.

Use case 3

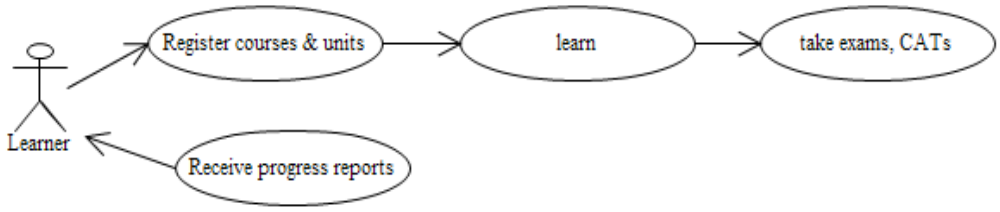

Figure 10: Use case diagram 3

Learners register for courses on offer, learn, take exams and CATs. Learners also receive progress reports.

ii) Agent Identification

Based on the functional descriptions several agents are identified to work together towards achieving the goal of the agent-based self study system. The agents are defined and assigned responsibilities and this is done by grouping one or more use cases into stereotyped packages to define the functionality of each agent. Relationship between use case of the same agent is stereotyped as "*include*" while relationship between different agents are stereotyped as "*communicate*" as shown below:-

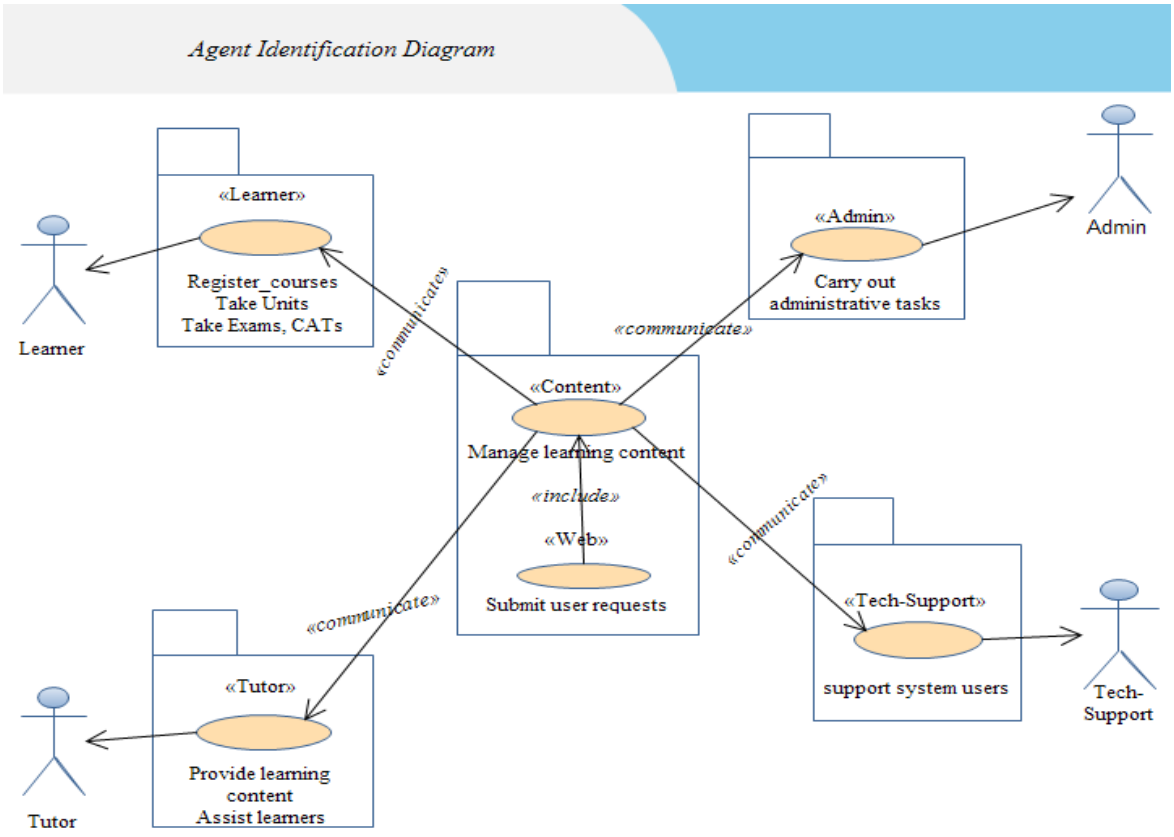

Figure 11: Agent Identification diagram

iii) Role Identification

Each of the identified Agents is assigned a role and possible interactions to achieve the required behavior. This explores all the possible scenarios of interacting agents to achieve the required behavior of the system. It is depicted using sequence diagrams in which objects symbolize roles involving.

< role_name>: <agent_name>

iv) Task Identification

The roles are translated into a set of tasks which the agents are able to execute. This stage focuses on the agent's behavior in order to translate the agent's roles into a set of tasks. This can be shown by activity diagrams what each agent is capable of doing.

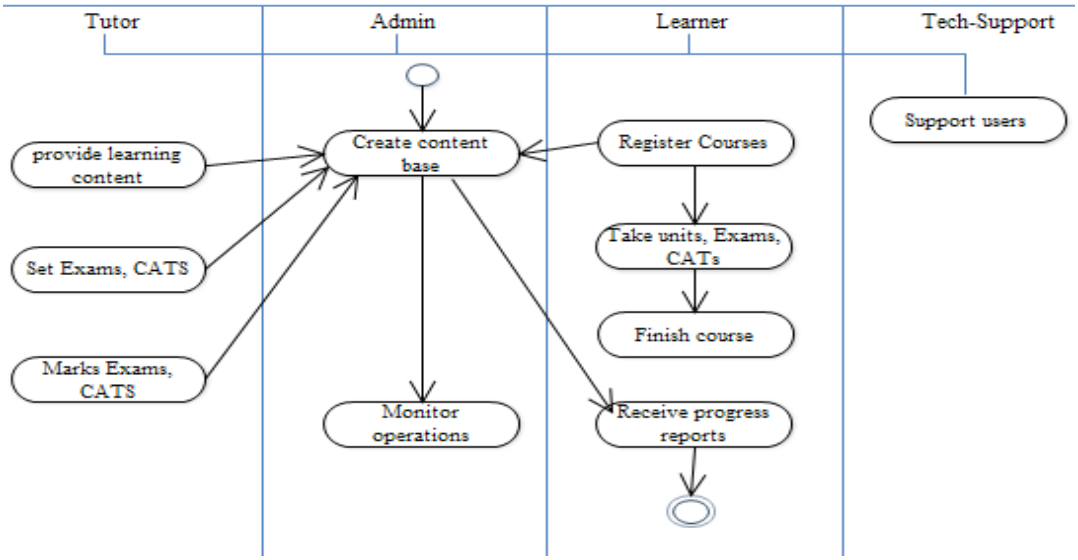

Figure 12: Task Identification diagram

4.4.2 Agent Society Model

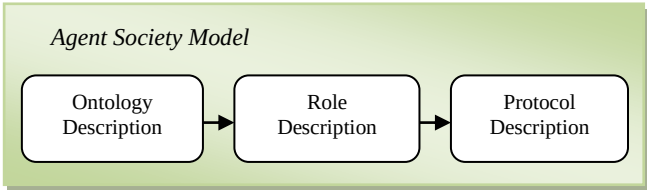

Figure 13: Agent society model

i) Ontology Description

This is where the ontology design is done using class diagrams. Example the learner agent class diagrams.

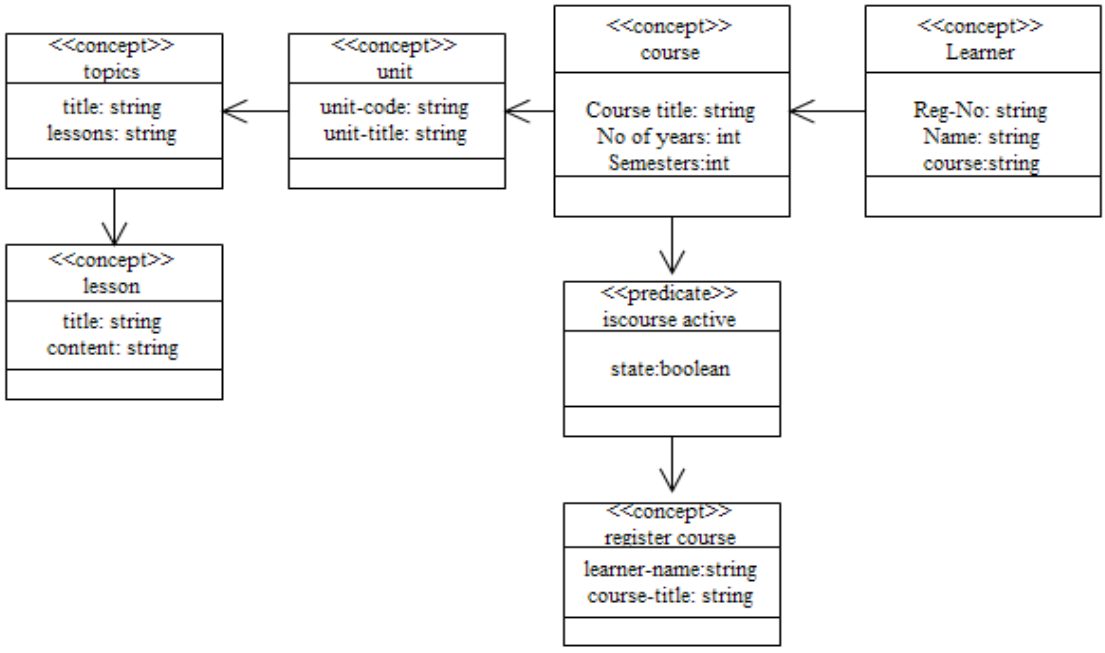

Figure 14: Ontology description diagram

ii) *Role Description*

This phase models the lifecycle of each agent taking into account its role. Role description looks at collaborations the agents need and the conversations they will be involved in. The roles are represented using class diagrams where each agent is symbolized by a package containing its roles. Each role is obtained by composing several tasks to compose the desired behavior. Each task is related to an action or a set of actions, and therefore the list of tasks describes what a role is able to do; it can also be helpful in the identification of reusable patterns. A roles description also shows connections between roles of the same agent.

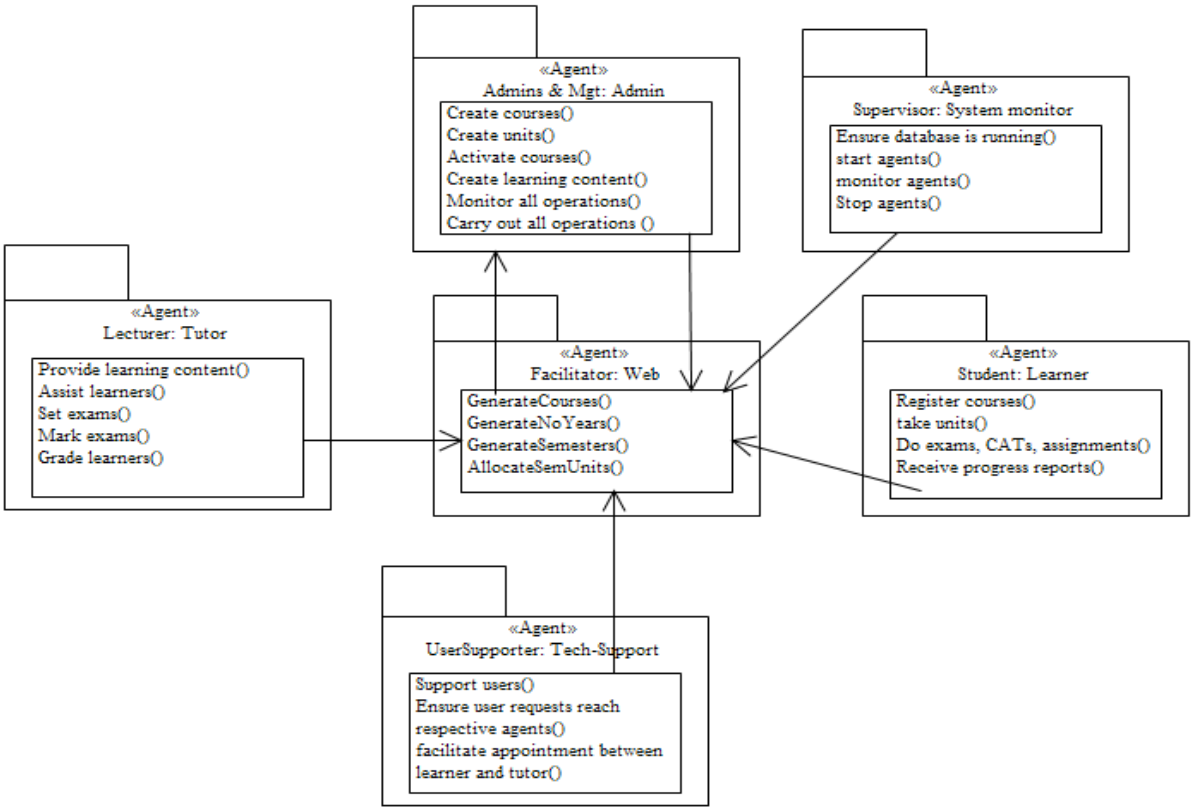

Figure 15: Role description diagram

iii) Protocol Description

Agent interaction protocol has been used for communication which is one of the FIPA standard protocols

4.4.3 Agent Implementation Model

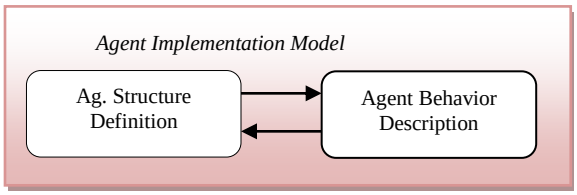

Figure 16: Agent Implementation Model

i) Agent Structure Definition

This phase defines the agents are and it is represented using class diagrams showing the agent's interactions with the environment. Operations are included to signify the agent's tasks.

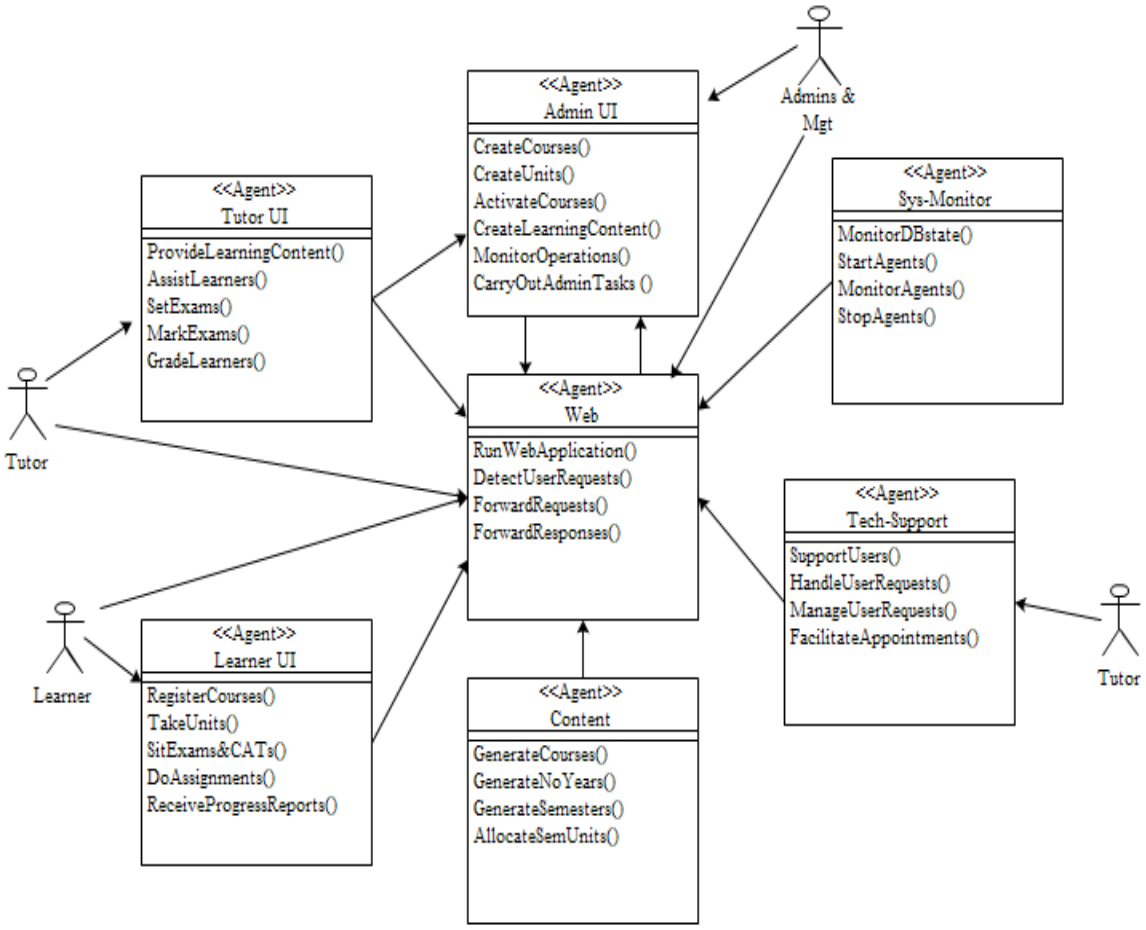

Figure 17: Agent Structure definition diagram

ii) Agent Behavior Description

In this phase more than one activity diagrams are used to show the flow of events between and within agent classes. This is depicted using one swinlane for each agent. Activities inside the swimlanes indicate methods of the related class.

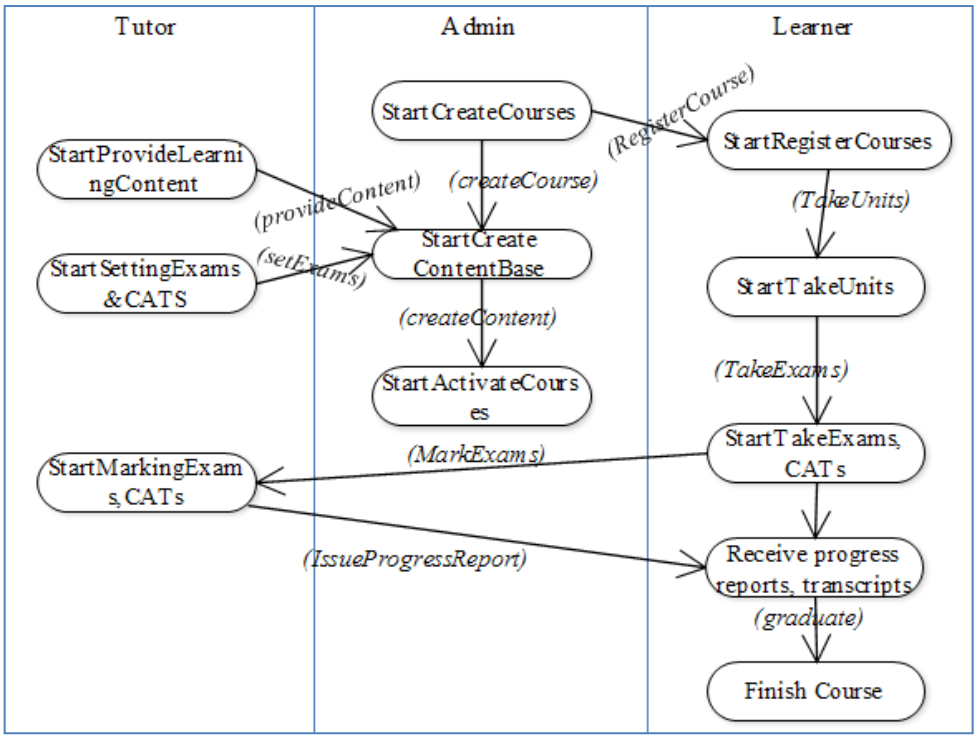

Figure 18: Agent behavior description diagram

4.4.4 Code Model

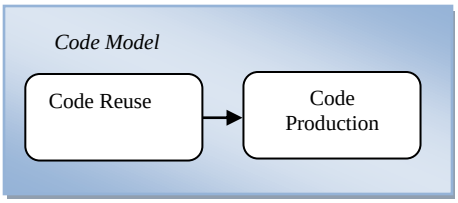

Figure 19: Code model

In this phase code and predefined design diagrams are used to implement the Agent-based self study system. Implementation has been done using two applications which are the Multi-agent systems and the web application through which users interact with the system. The following are the implementation tools:-

4.4.4.1 Development

i) *Java Development Kit 7:* - This kit provides tools such as the compilers and debuggers necessary for developing the Agent-based self study system. It also provides the libraries, the JavaVirtual Machine (JVM) and other components necessary to run Java applications.

ii) *Netbeans IDE 8.0:* - It has an integrated development environment which provided the code editors, code analyzers, HTML5, Java Script for developing the system.

4.4.4.2 Multi-agent Application

Java Agent DEvelopment Framework (JADE) Framework: - It is software implemented in Java language which simplifies the implementation of multi-agent system through a middle-ware that complies with the FIPA specification and through a set of graphical tools to support debugging and deployment of agent-based systems.

4.4.4.3 Web application

i) Java script: - Used in the web application for client-side scripts basically for validating user inputs. It is also used for server side programming.

ii) Java Server Faces (JSF):- it's a framework that establishes the standard for building server-side user interfaces. It is also used to process data entered by the user on the server and outputting the response to the client's browsers.

iii) Primefaces v5.0:- It is a JSF user interface framework for developing web applications

iv) Jetty:- a java based HTTP web server for handling HTTP requests over computer networks

4.4.4.4 Database

i) MySQL:- an open source database for creating the learning content

ii) MySQL connector :- It provides the JDBC drivers for connecting the application to the database

iii) Java persistence API 2 (JPA2): - used object-relational mapping to bridge the gap between the object model and the relational model

iv) PhpMyAdmin :- It is a PHP tool for handling the administration of MySQL over the web

4.4.5 Testing

Testing was done in two steps. The single agent testing to verify the behavior of each agent meets the original requirements. The society testing was done after integrating the agents to ensure they are interacting as required to achieve their objectives as shown in the figure below:-

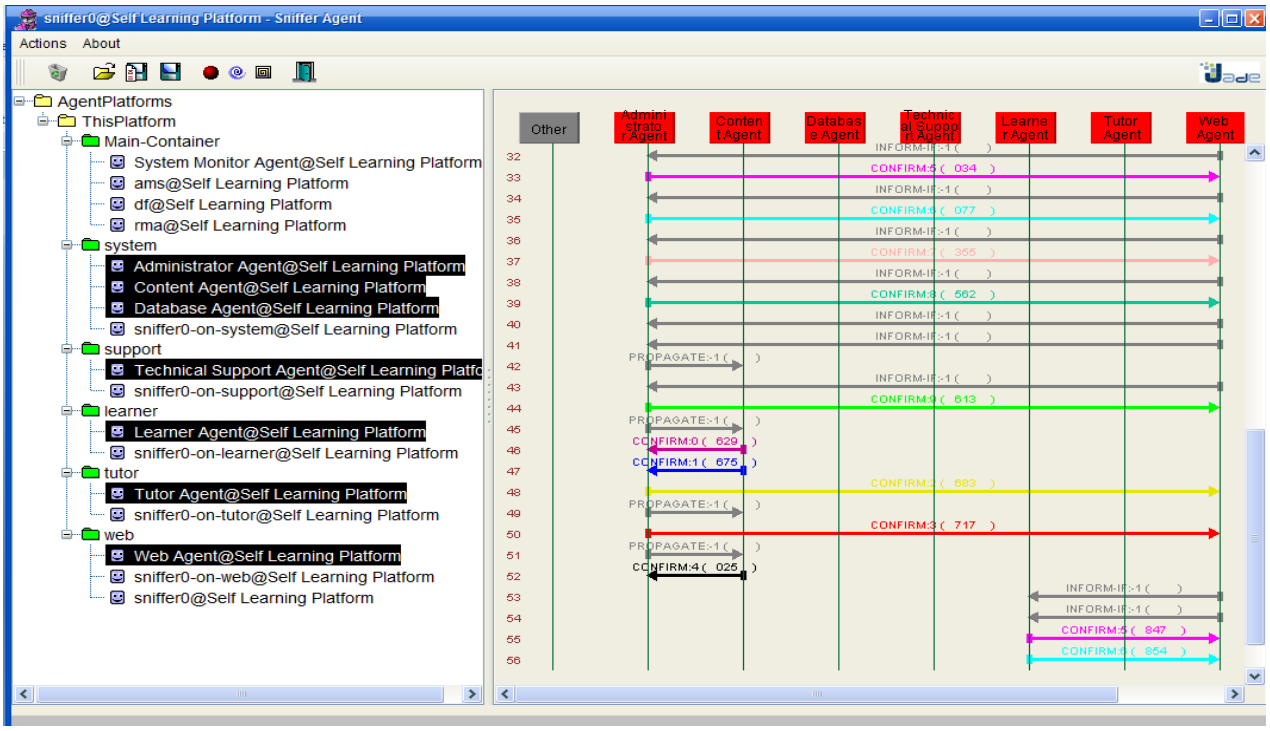

Figure 20: Agent interaction testing diagram

4.4.5 Deployment Model

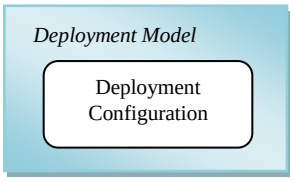

Figure 21: Deployment model

This model focuses on distribution of the system modules across hardware processing units. The agent-based self study system was hosted in the School of Computing and Information Technologies, Technical University of Kenya intranet where users could easily access the system. The users were then trained on the system and given a chance to carry out a few tasks to evaluate the system. Performance testing was done by allowing the students to register several courses units and observations were made on the usability of the system and if they were able to accomplish all the tasks involved with ease. Stress testing was done by allowing several students register and use the system at the same time and observations system response time was note. User acceptance testing was also done by assessing the students' satisfaction.

CHAPTER 5: PROTOTYPE EVALUATION AND DISCUSSION OF RESULTS

5.1 Introduction

The Agent based self-study system was evaluated by a team of fifteen (15) evaluators which composed of students, lecturers, one ICT officer, one director of School and one faculty Dean. The school is made up of three departments therefore; three students and one lecturer from each department were selected for the exercise.

5.2 Prototype Evaluation

The prototype is composed of several modules namely:-

i) System Access Control

To access the system all the users' require a user name and a password where authentication is done and access granted as shown below:-

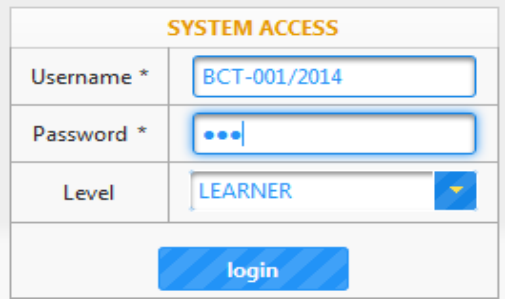

Figure 22: System access

ii) Administrator Module

Using the Administrator's module an administrator of the system sets and manages the system variables such as the academic year, number of semesters in an academic year, the course units to be offered in a given semester among others. Below is the administrator user interface with all the system variables.

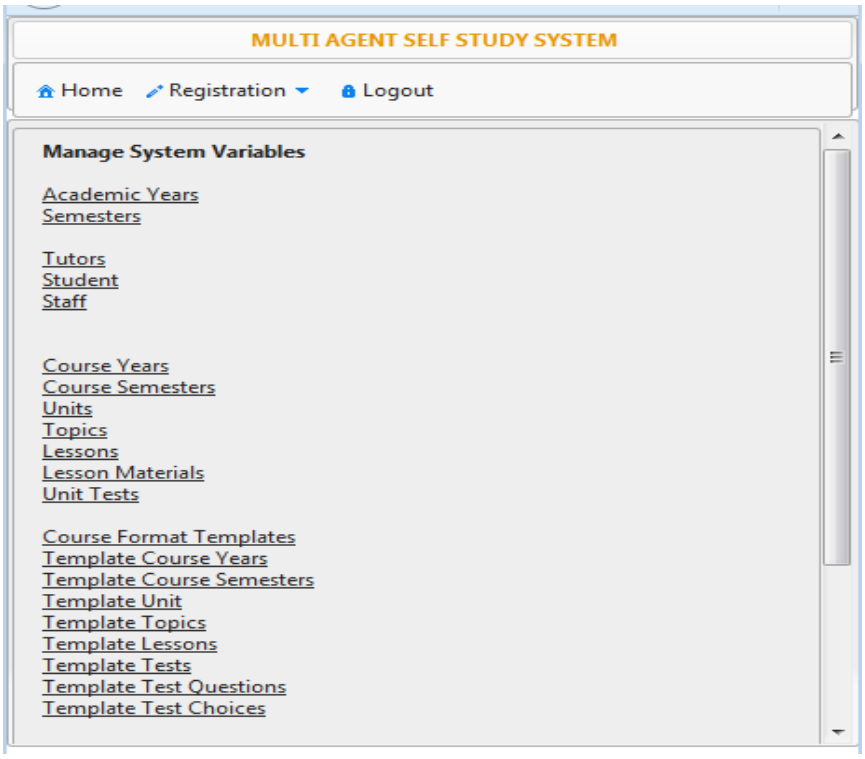

Figure 23: Manage system variables

Administrators can also view the status a given course such as number of registered students as shown below:-

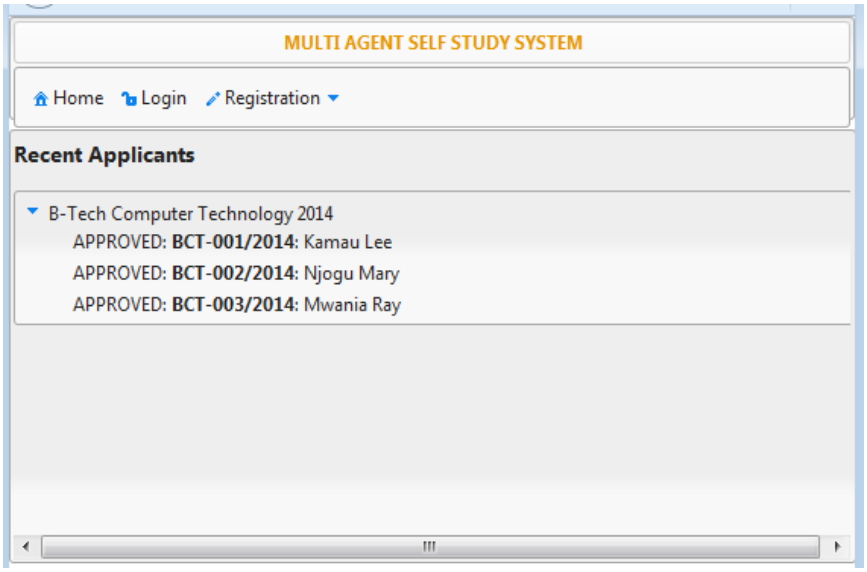

Figure 24: Registration status report

iii) Learner Module

When all the system variables are set learners can register for courses for available courses as shown below:-

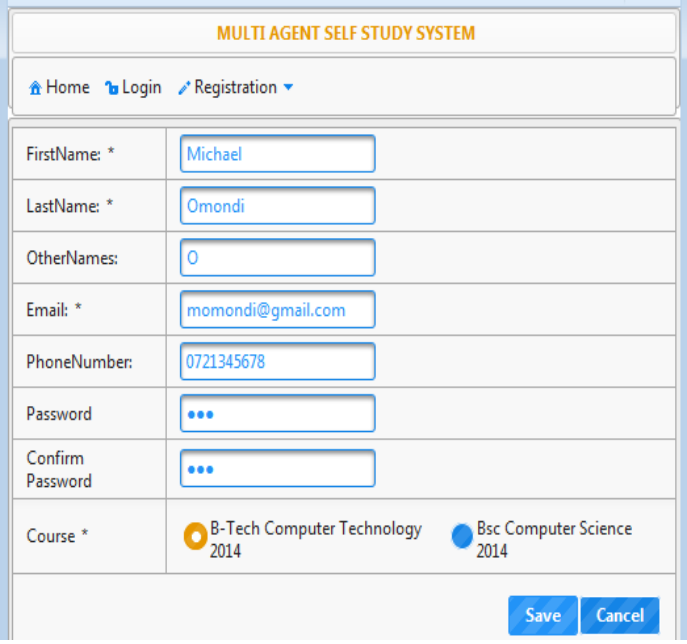

Figure 25: Learner registration user interface

Once learners have registered they can log in to the system and access their portals where they are able to study units, access learning materials and take exams as shown in the figures below:-

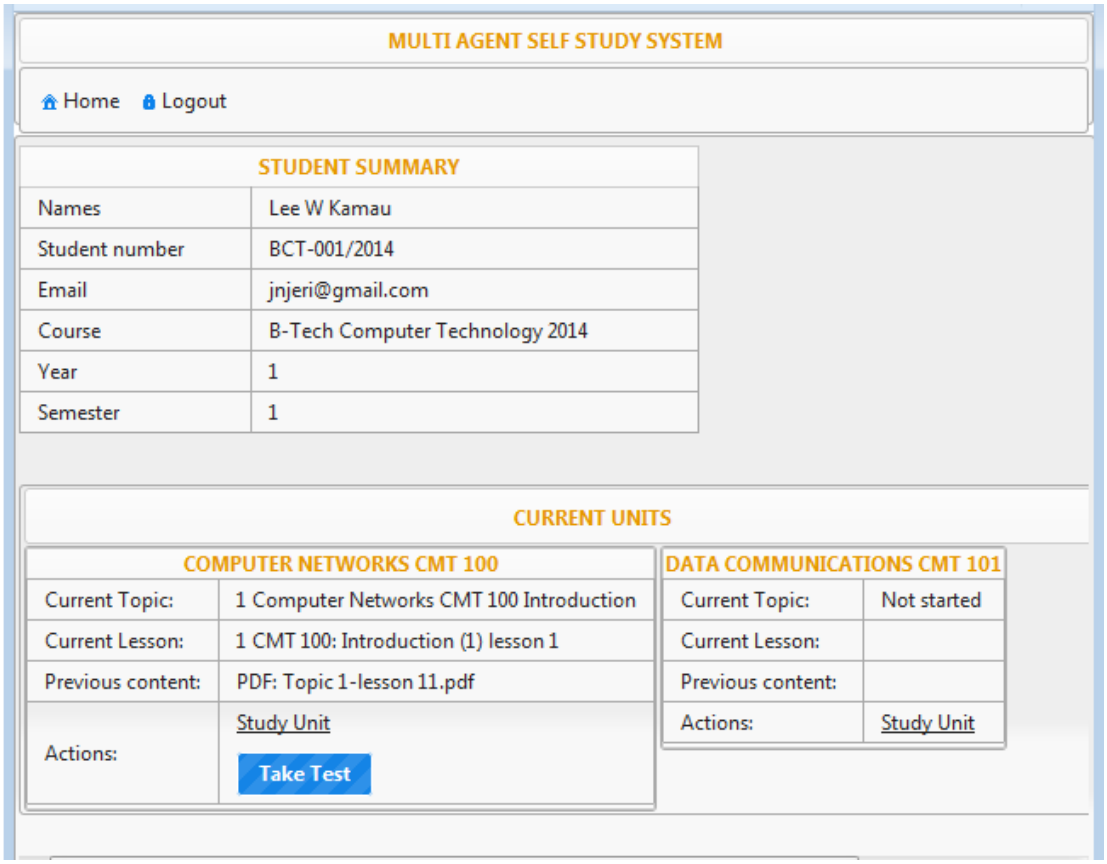

Figure 26: Learner's portal user interface

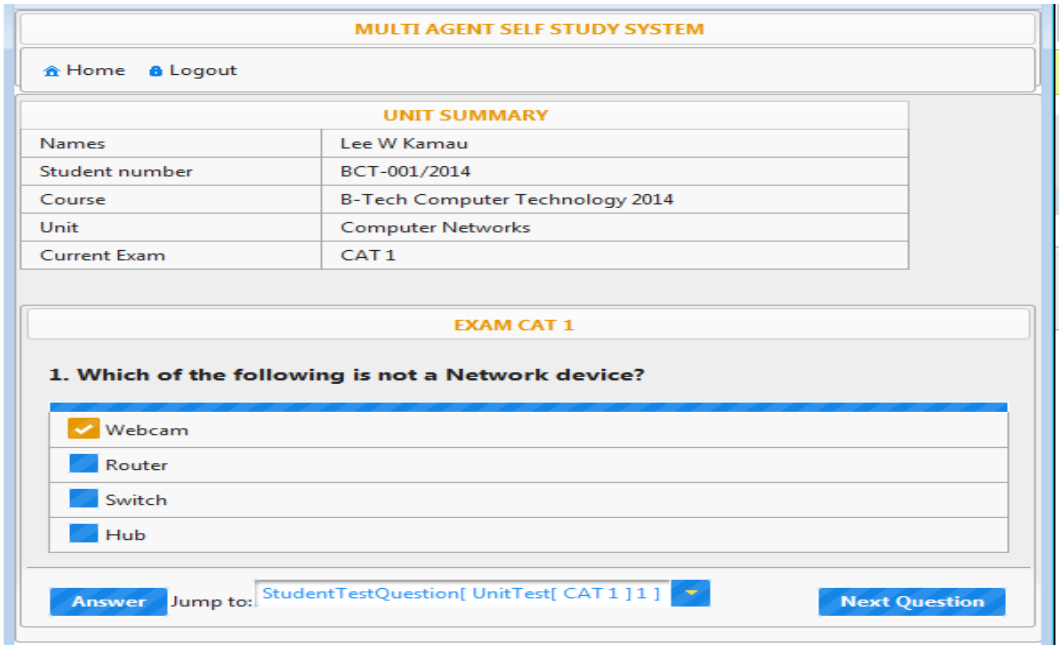

Figure 27: Exams User Interface

Once the learners have completed an Exam or a CAT it is marked by the tutor agent and they are able to view their score as shown below:-

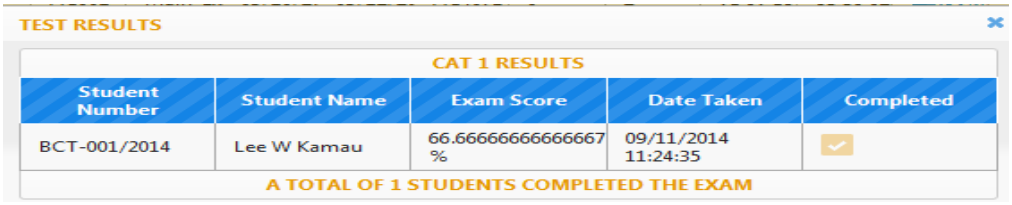

Figure 28: Exam Results

Tutor Module

This module enables the tutors to select course units they will support by providing learning materials, manage exams and tests and also offer support to learners.

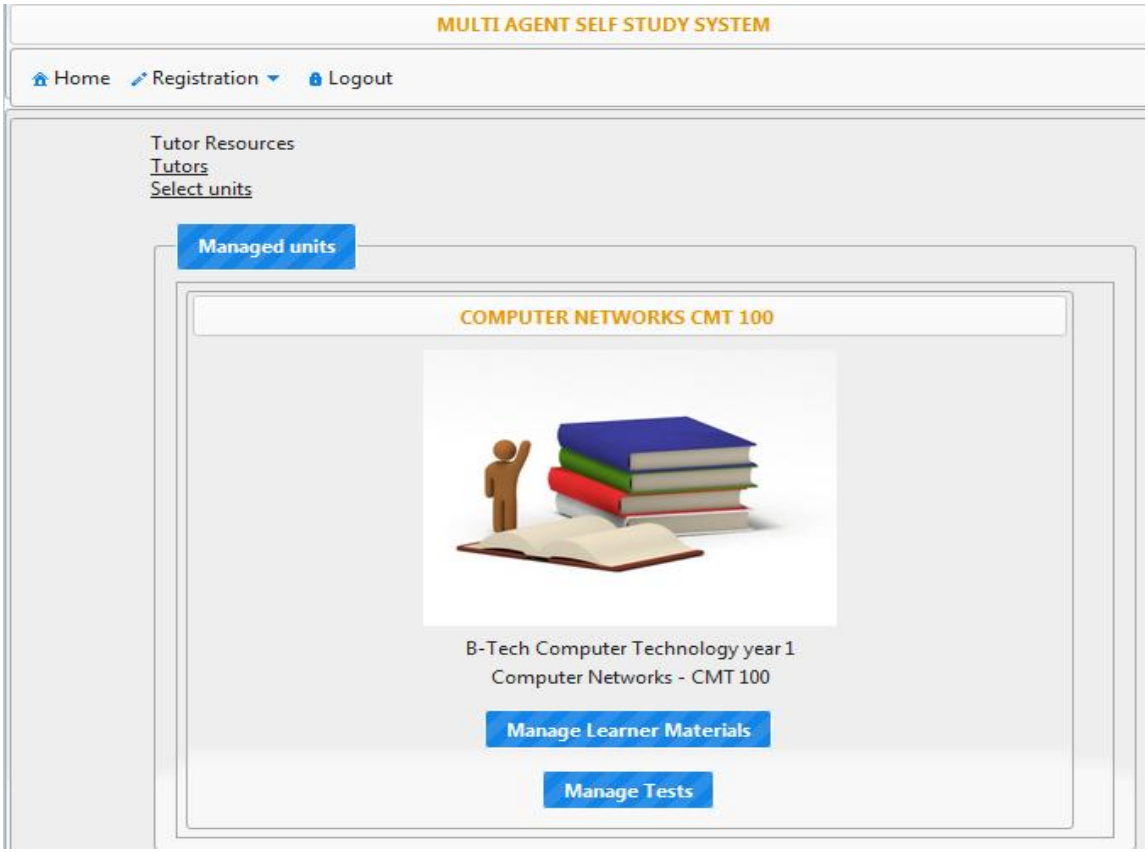

Figure 29: Tutor's User Interface

5.3 Discussions and results

During the evaluation exercise an evaluation form was issued to the users to evaluate the Agent-based self study system. Below are the evaluation results based on the following criteria:-

i) System Usability
ii) System functionality
iii) System Performance

Table 1: System usability

System Usability	Excellent	Good	Moderate	Fair	Poor
How is the system navigation		7	6	2	
Subjective Satisfaction		10	3	2	
Ease of learning	5	8	1	1	
Efficiency of Use		9	5	1	
How users recover from errors		4	10	1	

Table 2: System functionality

System Functionality	Excellent	Good	Moderate	Fair	Poor
Working of system functions	2	10	2	1	
if the system meets the user requirements	3	10	2		
Handling of validations in the system		7	8		

Table 3: System performance

System Performance	Excellent	Good	Moderate	Fair	Poor
How is the system response over the network	3	10		2	
How is the reliability of the systems	4	11			

5.4 Comparison of the Agent Based Self-Study systems with the other systems in use

Most universities use Learning Management Systems (LMS) such as Moodle and Blackboard with which it is not easy to monitor the progress of the learners. With the Agent-based self study administrators can monitor the learners' progress and as a result they are able to make informed decisions on how to improve the system to serve the learners' better.

Another challenge reported with the existing LMS such as Moodle is they do not work efficiently with very large numbers. Agent based systems are scalable and they are able to grow as need arises especially with the growing number of students enrolments unlike the existing LMS systems. The agent-based self study system is interactive and empowers learners to be in control of their studies making it more flexible and convenient and at the same time ensure quality of education and training.

Based on the evaluation outcome most users are comfortable with the usability of the system. On the functionality a good percentage of the users were able to accomplish all the tasks with ease. However the Agent based system is hosted in the university's intranet, so there is need to explore the possibility of hosting it in the clouds to improve on availability and reliability.

CHAPTER 6: CONCLUSIONS AND FUTURE WORK

6.1 Conclusions

The education sector is charged with the responsibility of creating a knowledge based society but it is also faced by several challenges. Competition is also on the rise with many universities coming up and to remain competitive modern learning techniques have to be adopted to offer flexibility and at the same time maintain quality of education and training.

This study has seen that the agent-based self-study system will provide a solution to the challenges of the education sector for example where expertise is distributed like resource persons in education. Multi agent systems also offer enhanced performance due to parallelism.

6.2 Recommendation for Future Work

Based on the learners, tutor and administrators feedback, further study needs to be done to cater for practical lessons, examinations and assessments such as simulations and technical drawing. They also recommended exploring the possibility of marking different types of exam questions other than multiple choice questions and structured answer questions. Currently the agent-based Self-study system is installed locally in the School of Computing and Information Technologies. To make this system fault tolerant there is need to host the system and publish the resources to make them accessible off campus network. As the number of users increases we can also consider hosting in the clouds to increase availability and reliability.

Further research also needs to be done to explore the possibility of integrating the Agent-Based Self study system with other applications like AutoCAD and simulators for instance packet tracer to take care of practical units such as Technical drawing, Routing and Switching.

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Appendix I: Installation Manual

Requirements

The following applications should be running in the computer systems before installing or running the application

1. Java runtime environment version 7 or latest
2. MySQL database that is the Wampserver

Installing

---

1. Copy the contents of the provided DVD in a directory of your choice. The DVD contains all the libraries required to run the application
2. Set up the MySQL Database as shown below:-
    - Host: localhost:3306
    - Username: root
    - Password: “ ”

Running the Application

---

1. In the directory created earlier click the **run** batch file to launch the application on systems running windows operating systems
2. On other operating systems double click the MAS_Self Learning jar file to launch the application
3. On the browser enter the following URL http://localhost:8080/index.xhtml to launch the web application

Appendix II: Prototype Evaluation Form

Different users were selected to evaluate the prototype based on the following criteria:-

A: Background Information

1. Name of Institution ……
2. Name of the School ……
3. Address…… Postal Code …….
4. E-mail Address……..**...**

B: System Usability

1. How is the Agent-based self study system navigation?

   Excellent [1] Good [2] Moderate [3] Fair [4] Poor [5]

2. How is the subjective satisfaction of the Agent-based self study system?

   Excellent [1] Good [2] Moderate [3] Fair [4] Poor [5]

3. How easily are you able to learn the Agent-based self study system?

   Excellent [1] Good [2] Moderate [3] Fair [4] Poor [5]

4. How efficient is the Agent-based self study system?

   Excellent [1] Good [2] Moderate [3] Fair [4] Poor [5]

5. How easy do you recover from errors when they occur?

   Excellent [1] Good [2] Moderate [3] Fair [4] Poor [5]

C: System Functionality

1. How is the working of the Agent-based self study system?

   Excellent [1] Good [2] Moderate [3] Fair [4] Poor [5]

2. Does the Agent-based self study system meet the user requirements?

   Yes [1] No [2]

3. How do you rate the validation of the Agent-based self study system?

Excellent [1] Good [2] Moderate [3] Fair [4] Poor [5]

D: System Performance

1. How is the Agent-based self study system response over the network?

Excellent [1] Good [2] Moderate [3] Fair [4] Poor [5]

2. How do you rate the reliability of the Agent-based self study system?

Excellent [1] Good [2] Moderate [3] Fair [4] Poor [5]