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Ambient Learning - Knowledge as a Service Model: Towards the Achievement of Sustainable Development Goal Four

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Abstract: Studies show that United Nations Sustainable Development Goal Four is yet to be achieved. This paper presents an artefact named "Ambient learning-Knowledge as a Service model" for describing how actionable knowledge can be extracted from ambient learning systems to support improvement and consequently facilitate the achievement of Sustainable Development Goal Four. A creative process was adopted to guide the development of the model. The process involved carrying out problem analysis through literature review, designing the model by combining ambient learning and Knowledge as a Service concepts and demonstrating its application by developing a prototype. Evaluation results revealed that C4.5 algorithm that is implemented in Waikato Environment for Knowledge Analysis *(WEKA)* software is suitable for extracting knowledge from ambient learning systems while Swi-prolog software can be applied to create a tool for knowledge delivery.

Keywords: Knowledge as Service, knowledge extraction, ambient learning, knowledge consumers.

1. Introduction

The 2030 agenda for Sustainable Development which was adopted by the United Nations General Assembly on 25 September 2015 seeks to leave no one behind as it aspires to transform the world we live in [1]. Among the 17 goals that were specified in the agenda, Goal four seeks to ensure inclusive and quality education for all and to promote lifelong learning. However, studies reveal that this goal is yet to be fully realized. For instance, results from Kenya National Adult Literacy Survey show that only 61.5% of the adult and out-of-school youth above 15 years have attained minimum literacy level leaving 38.5% (7.8 million) adults illiterate. A majority of these are individuals from less fortunate backgrounds who have a limited chance of attaining quality education owing to lack of reading material and other resources. There also exists gender disparity in literacy levels with men rated at 64.1% and women at 58.9%[2].

Ambient learning promises to bridge this gap by allowing personalized access to high quality learning content from anywhere, anytime and anyhow[3]. Nevertheless, the existing ambient learning models do not describe how knowledge from ambient learning systems can be extracted to support improvement of such systems. Therefore, there is need to initiate new mechanisms and paradigms for describing how knowledge can be retrieved and applied to enhance ambient learning systems.

Knowledge as a Service (KaaS) has been hailed as the new paradigm for acquiring knowledge through the cloud to support knowledge management [4]. Old knowledge management technology cannot cut it in this new age of open data and big data environments. The potential capability of KaaS paradigm presents a unique opportunity for combining it with ambient approaches to continuously improve quality of education services offered by ambient learning systems. Despite such an opportunity, little or no research has been undertaken to

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explore appropriate model(s) that can be derived from both KaaS and ambient learning concepts in order to enhance the achievement of sustainable development goal four (SDG 4).

2. Objectives

The main purpose of our study was to establish an appropriate model that describes how knowledge can be extracted from ambient learning systems and be used for improving such systems towards achieving SDG 4. Specific objectives of this work included the following:

1. To establish an appropriate algorithm for extracting knowledge from a typical ambient learning system.
2. To demonstrate how extracted knowledge can be delivered to the relevant knowledge consumers.

3. Research Methodology

To achieve the main objective of our study, the "creative process" [5] was adopted. This process is characterized by a sequence of five cognitive activities that can lead to novel, yet appropriate, productions in a given problem context [5]. The first activity was *problem analysis* that entailed to exploring literature in ambient learning and KaaS areas articles to find existing knowledge gaps. By the end of that activity, twelve (12) publications were purposively selected and reviewed. The second activity was *ideation,* which involved deriving the proposed model using combination strategy [5] to integrate KaaS and ambient learning concepts. The third activity was *Evaluation* that entailed assessing the validity of the model using *investigators triangulation method*. During this activity, the proposed model was iteratively submitted to information technology lecturers at KCA University for the purpose of gathering their opinions until a consensus was reached. The feedback received from the lecturers was then used to enhance the proposed model. *Implementation* activity was the last activity and it involved demonstrating how the model can be implemented by developing a *proof of concept* using WEKA data mining tool and Swi-prolog software.

4. Technology Description

4.1 Ambient Learning Overview

According to [6], there are three ambient learning approaches that can be implemented in different contexts depending on the availability of information technology infrastructure. These are (i) Mobile Interface Ambient Learning (MIAL) that utilizes mobile devices only, (ii) Fixed Interface Ambient Learning (FIAL) that utilizes location dependent devices only, and (iii) Hybrid Interface Ambient Learning (HIAL) that utilizes both location dependent devices and mobile devices.

Open Mobile Ambient Learning (OMAL) [3] is an example of MIAL that combines characteristics of ambient intelligence (AMI) with mobile learning, open education resources (OERs) and cloud computing services. This is shown in Figure 1 below.

As indicated in Figure 1, OMAL system consists of the following features [3,7]:

1. Cloud services: provides help in managing and overcoming storage limitations of mobile devices.
2. Content manager: retrieves relevant online learning material (videos, audios and text)
3. Context manager: collects, evaluates and stores learner's details i.e. identity, education level and preferences.
4. Multimodal access: allows internet access to different data or content representation modes like audio, video and text.

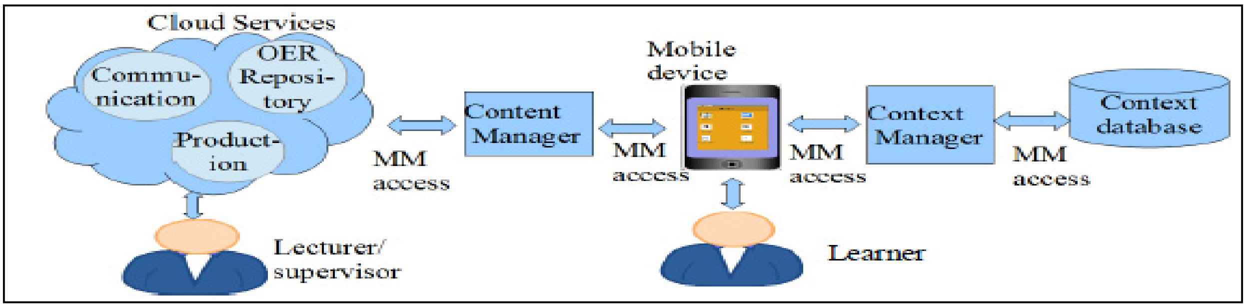

Figure 1: The OMAL system architectue. Adopted from [7]

However, there are two knowledge gaps in the reviewed literature. First, system architectures for illustrating how FIAL and HIAL can be implemented are lacking. Second, OMAL system architecture does not describe how knowledge can be extracted from the context database for the purpose of continuous improvement of ambient learning system. Therefore, there is need for innovative models that can be used to address the two gaps.

4.2 Knowledge as a Service (KaaS) Paradigm.

Traditional stand-alone platforms of client and server architecture are too rigid to keep pace with changes in knowledge management but cloud computing solves this challenge efficiently and effectively[8] . Cloud computing by definition is a three layer model of distributed computing. That is, (i) Software as a Service (SaaS) which provides the interface and top-level functionality, (ii) Platform as a Service (PaaS) which handles the processing necessary for applications to work and, (iii) Infrastructure as a Service (IaaS) layer that handles low level services like database administration [9]. KaaS on the other hand refers to a platform for providing the best knowledge, leveraging it from anywhere, anything and anyone in a distributed computing model [10]. Figure 2 illustrates the basic KaaS paradigm.

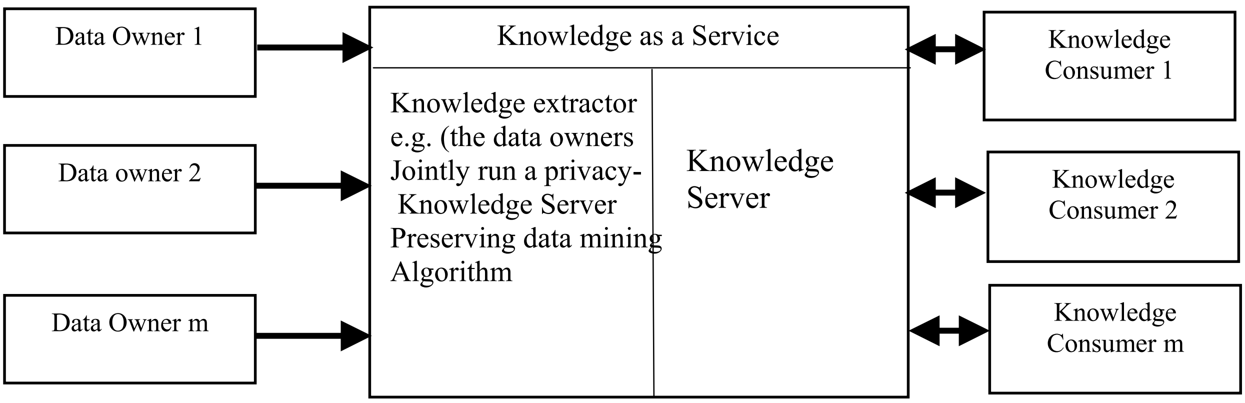

Figure 2: KaaS paradigm. Adopted from [10]

As described in Figure 2, KaaS paradigm consists of three main interacting components. That is, (i) Data owners who collect data from their daily system usage logs, (ii) Knowledge service providers who deliver extracted knowledge from datasets through an appropriate knowledge extractor and, (iii) Knowledge consumers who access a knowledge server in their decision making procedures [10].

4.3 Knowledge Extraction Algorithms

In recent years, many algorithms in the literature have been created for extracting knowledge in the data. Examples are 10 artificial intelligence algorithms that have been identified that have been identified by the IEEE International Conference on Data Mining

(ICDM) as among the most influential algorithms for classification, statistical learning, association analysis, clustering and link mining [11]. They include (1) C4.5 and beyond, (2) K-means, (3) support vector machines, (4)Apriori algorithm, (5)The Expectation–Maximization algorithm, (6) PageRank, (7) AdaBoost, (8) Knn-Nearest Neighbor, (9) Naive Bayes and finally (10) Classification and Regression Trees (CART). All these algorithms are applied effectively in various areas of applications such as technology enhanced learning to overcome knowledge extraction challenges.

5. Developments

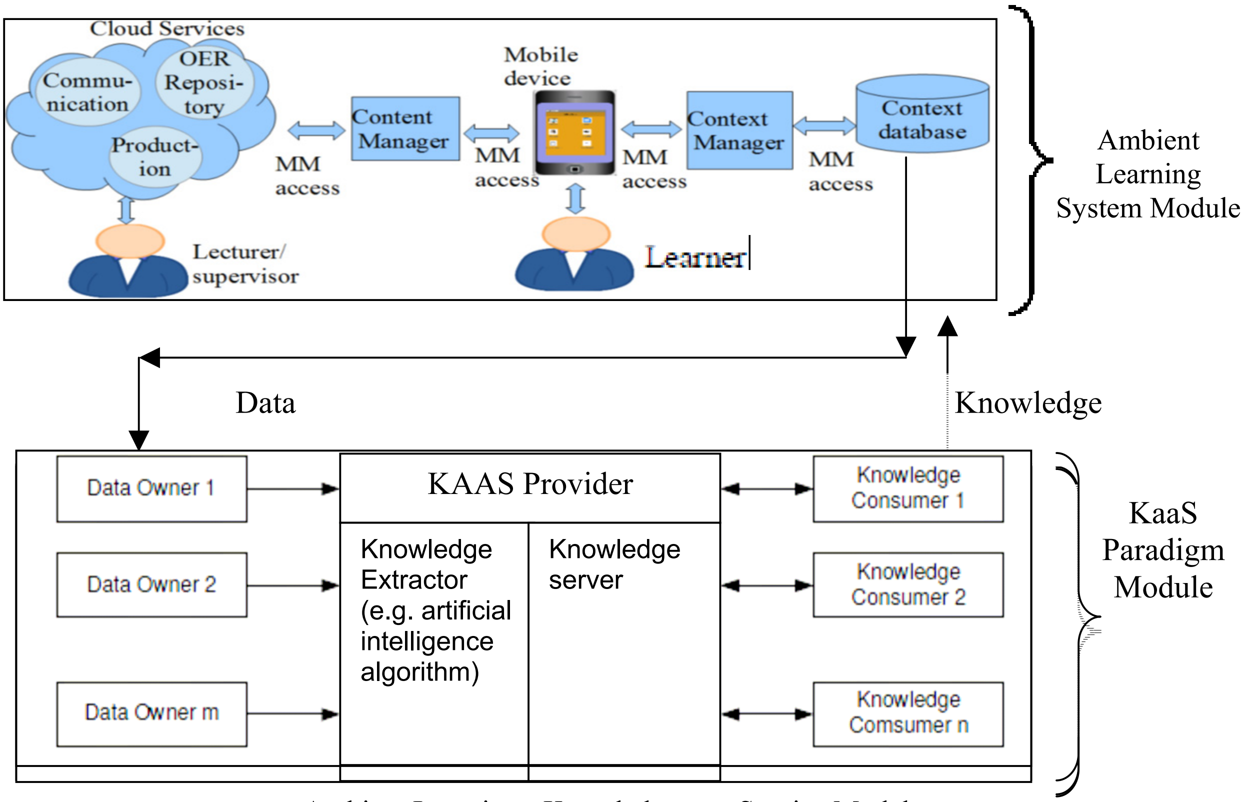

Figure 3: Ambient Learning - Knowledge as a Service Model.

The main objective of KaaS is to generate knowledge from heterogeneous data located in a cloud environment and make it available as a knowledge service[12]. This objective provides a potential solution for addressing knowledge management limitation of OMAL system architecture. Nevertheless, little or no research has been conducted to explore how the KaaS can be merged with ambient learning approaches to enhance knowledge management in ambient learning systems.

To address this gap, we propose an ambient learning-KaaS model that can be used to continually enhance ambient learning systems. The framework is derived from[7] and [10] models. This is shown in Figure 3.

As illustrated in Figure 3, the proposed architecture consists of the following components:

- Ambient learning system module: Allows learners to access open education resources and other cloud related service in different contexts as is relevant to the learners.
- KaaS Paradigm module has three main components that can be summarized as follows:
  - (a) Data owners access data from ambient learning system through context database. They can freely utilize the data and are responsible for ensuring its security. An example is the learning institution that provides the data storage infrastructure.
  - (b) KaaS provider is made up of two sub-components. First, a knowledge extractor in the form of a data mining algorithm that processes and transforms the data from the

ambient learning system context database and finds the patterns hidden in the data. Second, a knowledge server that is used to deliver knowledge to knowledge consumers e.g. knowledge based systems (KBS).

(c) Knowledge consumer is any entity that consumes the services offered by the KaaS provider under specific service level agreements (SLA).

In order to demonstrate feasibility of ambient learning-KaaS model, proof of concept was developed. KCA University, which acted as data owner provided data collected from ambient learning system that was piloted in 2014 by [3, 7]. Decision tree algorithm named C4.5 was then applied to extract knowledge from the already collected data. Finally, Swi-prolog software was adopted to develop a knowledge server prototype for delivering knowledge to ambient learning experts that represented knowledge consumers. These included the authors of open mobile ambient learning (OMAL) system in KCA University [3]. The results of this proof of concept are presented and analyzed in the results section below.

6. Results

Among the identified 10 ten data mining algorithms, C4.5 constructs decision trees that can readily be grasped by non-specialists like some of the knowledge consumers in ambient learning environment [11]. Therefore, the algorithm was adopted to build decision tree using OMAL system. This is shown in Figure 4.

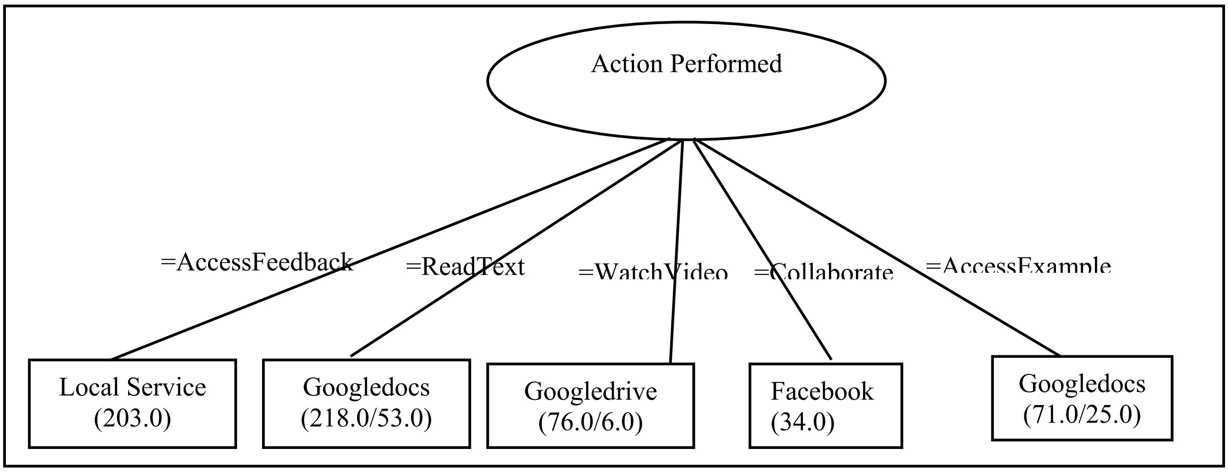

Figure 4: C4.5 Decision Tree

As illustrated in Figure 4, the following knowledge was extracted from the data:

1. Ambient learning system can allow learners to access feedback, read text materials, watch videos, collaborate and access examples. Using a test data of 602 cases, cross validation results indicated that, the decision tree model was 84.4% accurate. That is, 508 instances were correctly classified instances while 94 instances were incorrectly classified instances.
2. Learners can access feedback through local service (local database server).Findings indicated that course work results were accessed from locally available database instead of cloud-based repository. Cross validation test results showed that out of 203 cases covered by this rule, none of them was misclassified.
3. Ambient learning system enables learners to access text-based materials through Google docs. Cross validation test results revealed that out of 218 instances covered by this rule, 53 of them were incorrectly classified.
4. Ambient learning system can allow access to video materials stored in a Google drive. 10-fold cross-validation test results showed that out of 76 cases covered by this rule, only 6 of them were incorrectly classified.

5. Ambient learning system can allow learners to collaborate through Facebook. Evaluation results showed that, out of 34 instances covered by this rule, none of them was misclassified.

Having extracted knowledge from ambient learning system, the next step was to create knowledge server (KS) for delivering knowledge to knowledge consumers. For the purpose of our study, prolog was used to demonstrate how stand alone knowledge server can be implemented. The server was made up of the following three main components:

1. Inference engine that is already inbuilt within prolog.
2. Knowledgebase component that was used for storing rules and facts extracted from ambient learning system. Figure 5 shows a sample of knowledge stored in the knowledgebase.

```
knowledgebase_cloud - Notepad
File  Edit  Format  View  Help
action(readtext).
action(watchvideo).
action(collaboration).
action(accessfeedback).


cloud_service(googledocs).
cloud_service(googledrive).
cloud_service(facebook).
feedback_service(local_web_server).

cloud_based_production_service :- cloud_service(googledocs),write("use googledocs").
action(readtext):- cloud_based_production_service.
cloud_based_repository_service :- cloud_service(googledrive),write("use googledrive").
action(watchvideo):- cloud_based_repository_service.
cloud_based_communication_service :- cloud_service(facebook),write("use facebook").
action(collaboration):- cloud_based_communication_service.
local_service :- feedback_service(local_web_server),write("use local_web_server").
action(accessfeedback):- local_service.

feedback_provision :- action(accessfeedback).
cloud_service_provision :- action(readtext), action(watchvideo), action(collaboration).
```

Figure 5: Sample of Knowledge Stored in the Knowledgebase.

3. User interface component, which was created to support interaction between knowledge consumers (KC) and the server. This shown in figure 6.

```
SWI-Prolog -- f:/Data mining/knowledgebase_cloud.pl
File  Edit  Settings  Run  Debug  Help
Welcome to SWI-Prolog (threaded, 64 bits, version 7.5.11)
SWI-Prolog comes with ABSOLUTELY NO WARRANTY. This is free software.
Please run ?- license. for legal details.

For online help and background, visit http://www.swi-prolog.org
For built-in help, use ?- help(Topic). or ?- apropos(Word).

?- start.
Welcome to the Ambient Learning Expert System.
Type "menu" to display the menu and "end" to end the program.
true.

?- menu.

1- for readtext.
2- for watchvideo.
3- for collaboration.
4- for accessfeedback.
Enter e to end>>
Make your selection:

|: 1.

To enable readtext
use googledocs
```

Figure 6: User Interface for Enabling Interaction between KC and the Server.

As illustrated in Figure 6, knowledge consumers could be an ambient learning expert, inquiring which cloud-based tools that can be integrated in ambient learning system for enabling certain actions. For example, when the knowledge consumer (KC) starts the server he/she types “menu” on the prolog prompt and gets a reply of the cloud based services and local service available. Upon keying in the relevant number for either a cloud or local service, KC receives action knowledge regarding tools that can be incorporated in an ambient learning system to enhance its effectiveness.

7. Benefits

The adoption of the proposed model is expected to support continuous enhancement of existing ambient learning systems towards the realization of SDG goal 4. Therefore, the model will not only help revolutionize learning but also bring ambient learning to the forefront as one of the most efficient tools for providing inclusive and quality education for all. Additionally, incorporating an interactive component in KAAS can help to crowd source knowledge that may be useful in size or time units to knowledge consumers in ambient learning environments.

8. Conclusions and Future Work

This study proposed a new model that was derived from a combination of ambient learning concept and KaaS with an aim of supporting the achievement of United Nations SDG 4. Results revealed that the model can be implemented using an appropriate data mining tool to extract knowledge from ambient learning system and using swi-prolog to create stand knowledge server. The extracted knowledge can then be used by the ambient learning system experts to improve an existing or new ambient learning system.

However, the study has three limitations. First, the proposed model was evaluated using only data collected from a case of MIAL approach. That is, the OMAL system that was piloted in KCA University. Second, among the identified top ten knowledge extraction algorithms, only C4.5 was used to demonstrate the application of the proposed model. Third, implementation of knowledge server was demonstrated using only one artificial intelligence tool. That is, swi-prolog that use predicate logic to represent knowledge.

Therefore, future research activities that are aimed to extend ate extending this work can focus on three main areas. That is, (i) Evaluating the model using data from instantiations FIAL and HIAL, (ii) Exploring other data mining algorithms that can handle different sets of data for faster and easier dissemination of knowledge, and (iii) Explore other programming tools in the field of artificial intelligence that can facilitate implementation of a knowledge server with a more user friendly interface.

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