Adaptive Design Model on Heterogeneous Learning Management System (LMS) by Utilizing Multi-Agent System (MAS)

Amir Kombo Mwinyi, S.A.R Al-Haddad, Rusli bin Hj Abdullah, and Shaiful Jahari bin Hashim

Abstract— Content synchronization in LMS (Learning Management System) is a new area of research which involves the transfer of data from one machine to another. Many researchers have conducted their researches concerning synchronization in different applications on data transfer. Therefore, in this paper we introduce a new idea of synchronization in heterogeneous LMSs and to share learning contents among different learning institutions. The major contribution in this paper, is based on the integration of rsync with MAS (Multi-Agent System) in heterogeneous learning management systems (LMSs) environment using SCORM (Sharable Content Object Reference Model), so as different learning institutions in higher education (HE) can seamlessly share learning contents in the different LMSs. Hence, a new model of heterogeneous LMS (HLMS) has been presented for easily sharing of learning contents in Higher Learning Institutions (HLI).

***Keywords*—**Heterogeneous LMS, Interoperability, Multi-agent System, Synchronization, SCORM

I. Introduction

A LEARNING Management System (LMS) is a computer system that automates the administration, tracking, and delivering learning contents [1]. The system is working on multiuser environment where developers can develop, store, reuse, manage and deliver digital learning contents to their clients.

The growing number of Institutions and business organizations has embraced the idea of e-learning and m-learning [2], [3], [4] institutions due to its importance and efficiency. In that they utilize web based learning systems to facilitate their educational requirements. But, when the system expands, some sort of management system is required [5]. Therefore, when system became big, the process of updating and adding contents together with managing users become very difficult problem in LMS [6].

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Currently, many LMS systems are not allowed instructors and learners to update their files. If instructor or learner wants to update the file he/she has to replace the whole file instead of updating the existing ones. Furthermore, sharing of learning contents between multiple LMS platforms in learning institution is a challenge [7].

The proposed system therefore, based on the integration of synchronization and multi-agent system (MAS) approaches to improve communications efficiency between recipient and server, during file updating in the content distributed system (i.e. LMS). Furthermore, this paper is introduced a new learning model, in order to share learning contents in heterogeneous LMS (HLMS) by incorporate SCORM compliant standard.

II. Related Work

Synchronization is very important in every distributed system in order to reduce storage and communication overhead. As [9] described in their research paper which deals with the synchronizing between two datasets, one is outdated and another one is updated over low bandwidth network link.

In [10] carried out a research on In-Place Rsync: File Synchronization for Mobile and Wireless Devices where updating is performed on the same space used by original file (outdated). In this paper the authors mentioned the problem that rsync encountered which when it updates it uses temporary space before it replaced the outdated file. This problem makes rsync to be unqualified to be used in block devices like mobile phone and palm which have insufficient space (memory space).

In the synchronization which involves transfer of large amount of data organized in hierarchical folders [11] took a more extreme approach on their paper called Pre-Processing Directory Structure for Improved RSYNC Transfer Performance. In this paper they mentioned two main problems, first, rsync when it tries to search it checks folders and files one by one which took a long time and the checksum which is normally not the same on the sender and receiver sides. Another problem of rsync is called Delta compression.

To solve those problems they designed a framework which called Hierarchical Folder Synchronization Algorithm (HFSA) which works as a middleware that reduces the computational time required by rsync at both the sender and

the receiver nodes. The HFSA consists of two parts; the first one is HFSA at the sender node that focuses on creating the hash table and transmitting this file to the receiver. And the second one is HFSA at the receiving node that focuses on receiving the hash table, receive the information on the changes and re-construct the respective folders, before any data can be sent from sender to receiver.

In the adaptive model designed by [12] that consists of two main parts, a mechanism and an adapter. Mechanism is the interface of a mobile agent to the environment that contains sensor which senses the environment and report their findings to the mechanism. Mechanism also includes effectors that can take actions to change the environment that responds to the environmental change. Adapter is another part of the model that decides whether the adaptation is required or not, and if it is required how best to adjust with the new environment.

In the adaptive design model analyzed by [13], they investigate on how to control the amount of mobile agents in the decentralized network. They extended the model used by [12] which briefly explained above to regulate the mobile agent in the network. They implemented their adaptive model in the system which is called immune system which is capable of adapting the dynamical change of the distributed network environment.

Bakhouya and Gaber [13] explored their system by using immune system as proposed by Watanabe et al. [27], which consists of environment (percept) which identified by using interface (sensors) that works as antigen, and prepared behavior is considered as an antibody, where the communication between actions or behaviors is considered as Stimulation/Suppression chains between B-cells (antibody) [12].

In order to decide the amount of mobile agent in the network in [13] used inter-arrival time to control the agent population in the network. When inter-arrival time is small, this can be shown that, there is an extremely number of agents in the system. Therefore, the kill and move behaviors should be activated. But, if the inter-arrival time is large, it means that the number of agents in the system is reasonable small. Hence, the clone and move behaviors should be activated [12].

Kinshuk and Taiyu Lin [14] study on the benefit of using mobile agent technology to improve mobile learning environment. Due to Kinshuk and Lin the motivation for using mobile agents based on the potential benefit mobile agents have in the system.

To determine the efficiency of mobile agent [15] compared mobile agent model with client/server model in e-learning system. Hassan mentioned different requirements for an e-learning system and also described some requirements for mobile agent.

In his comparison, based on the performance between mobile agent and client/server, the author in this paper enlightened in which circumstances mobile agent solution is best compared to client/server-based solution. The author further elaborated that, due to the repetition of Remote Procedure Calls (RPC) from the client to the servers, searching for the required information the process will take much communication time between user and the servers.

But in contrary, in mobile agent-based model, the user may initialize an agent from his machine (computer) to the network, this agent will move to different servers sequentially until it obtained the require information, before it returns back to the agent host. In conclusion, the author concluded that, the performance will be increased in large distribute environments if we use the multi-agents model instead of using single agent approach as proposed by [16].

III. Synchronization

As we mentioned above that, synchronization can be used in distributed system in order to reduce storage and communication cost. For example Sirott et al. [9] described in their research paper which deals with the synchronizing between two datasets, one is outdated and another one is updated over low bandwidth network link.

In this paper, synchronization is done by engineering the rsync algorithm [19] which is famous open source algorithm used by many UNIX and Linux system. Therefore, basically we modified rsync by incorporating Multi-agent System (MAS) which work as middleware to facilitate the searching process in the client device.

Figure1 below shows the flow chat of improved file synchronization which utilizes the benefits of Multi-agent System (MAS).

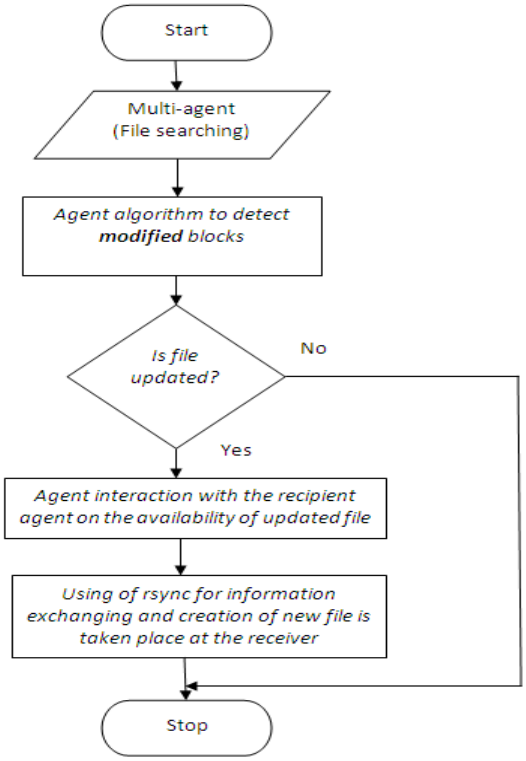


Fig. 1 File synchronization using improved rsync

Figure 1 above, shows the steps on how the improved rsync exchanges information by utilizing multi-agent (MA)

and finally file updating take place.

IV. MULTI-AGENT SYSTEM (MAS)

The study of multi-agent systems (MAS) focus on systems in which many agents are cooperate with each other [17], [18]. Their interactions can be either collaboratively or self-centered. In that, the agents can share a common goal or they can practice their own goals.

Therefore, the main intent of our paper is to see how we can integrate these two approaches together so as to improve communications between receiver and sender during file updating in the learning content distributed system (i.e. LMS) and by engineering rsync to enhance synchronization process as a whole.

V. MOBILE AGENT

Now days, many computer applications taken advantage from the mobile agent approach example, www information retrieval, data processing in graphical application, mobile computing system, etc [22].

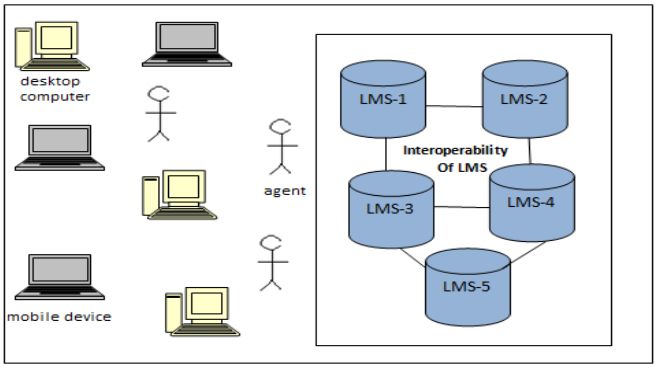
The agent characteristics [20], [21], [23] make it to be suitable in this paper where data are required to be transmitted from one device to another and to minimizing searching process, computation cost and above all to facilitate learning contents sharing and automation.

VI. HETEROGENEOUS LMS

Heterogeneous LMS system framework includes unrelated LMS with different formats and learning contents. Therefore, the contribution of this paper is based on the merging of these heterogeneous LMS so that LMS from two or more learning institutions can share courses that offered by their institutions.

This can be realized by utilizing the Multi-agent System (MAS) as the new paradigm in the communication context.

The figure 2 below shows how the Multi-agent System (MAS) can be incorporated in heterogeneous LMS.



.Fig. 2 Agent makes decision on learning contents based on course available in heterogeneous LMS

VII. INTEROPERABILITY MODEL

In this new model which is presented in this paper, is incorporated multiple disparate learning management system (LMS) so as they can collaborate in providing learning contents to the client of higher educational learning institutions.

The figure 3 below shows the design of the new model

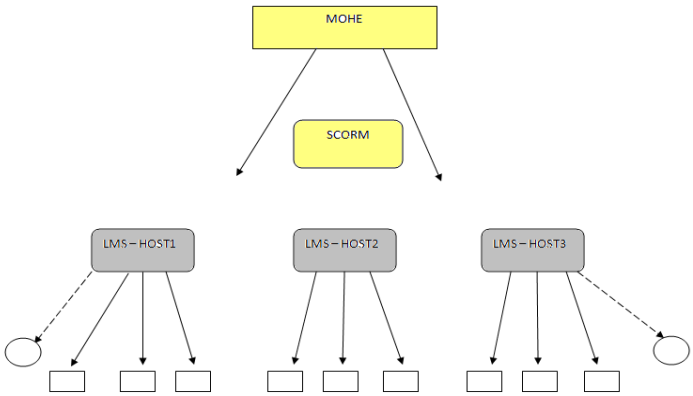


Fig. 3 Interoperability System model

Mobile devices (e.g. ipad)
Desktop computers

The figure 3 above shows the system model which comprises three layers: Higher level layer presents Ministry of Higher Education (MOHE). This level will monitor all the function of learning institutions and interoperability. Second layer presents the Heterogeneous Learning Management System (HLMS) which responsible of providing learning contents or rather sharing of learning contents from different learning institutions by compliant of SCORM standard. And the third layer represents the learning devices like mobile phones, ipad, desktop, etc.

VIII. SCORM

SCORM is defined as "the Sharable Content Object Reference Model (SCORM) that integrates a set of related technical standards, specifications, and guidelines designed to meet the high-level requirements of accessibility, reusability, interoperability, and durability of content and systems", [24]. In this paper, we incorporated the SCORM due to its importance of enabling creation of sharable learning objects.

Many researchers have embraced this standard approach to build reuse teaching materials in order to reduce cost and time [25]. The use of SCORM is also motivated by the paper of Siverkumar and Nandakumar [26] which utilized SCORM to creating learning objects that are used in personalize the learning materials based on the learning style.

IX. CONCLUSION

In conclusion, this paper is still in the system model design stage; therefore, more work is needed to be done in the implementation stage in order to realize the potential these new ideas.

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