# INTEROPERABILITY OF MULTI-AGENT SYSTEM IN HETEROGENEOUS LEARNING MANAGEMENT SYSTEM (HLMS) BY DEPLOYING WIRELESS SENSOR NETWORKS (WSNS)

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**ABSTRACT**. User detection in Heterogeneous Learning Management System (HLMS) using sensors which are attached with the Multi-Agent System (MAS) is a new area of research. The integration of sensors with the Multi-Agent system improved the efficiency of LMS by reducing the work load on the LMS servers to the dedicated sensors which are deployed in the domains. In order to explore the potential of sensors and agents, the authors of these papers have integrated these two components so that the efficiency and security of learning management system are realized. In this paper we have introduced the sensors in the web learning system so that the administrators can be aware of the presence of each and every user once connected to the system. The interoperability of Multi-Agent Systems in this learning system is facilitating the retrieval of information from the sensors and sends them to the HLMS servers (Sinks). Furthermore, the information which are gathered and manipulated by the MAS is including measured signal strength of the learning devices and user profile. This information will enable the administrators to know the location of the user in the learning domain and also to notify students on their learning status, based on their profiles which are stored in the database. Hence, a new system model of Multi-Agent System (MAS) with sensor network, in Heterogeneous Learning Management System is presented for improving overall system performance.

**Keywords**: Deployment, Multi-Agent System, Interoperability, HLMS, Protocols, Wireless Sensor Networks

## INTRODUCTION

Learning Management System (LMS) is a web based system application that automates the system administration, tracking, and reporting of training events (Ryann, 2009). The system is working on multiuser environment where designer can create, store, reuse, manage and deliver digital learning contents from a database.

Each and every new evolves technology emphasis speed and enhanced performance of the system operations. Collaboration and integration are very useful concepts which are used to design enterprise system (Sardis et.al, 2011) for sharing resources and reducing production time. A distributed sensor networks are devices which are deployed in a domain or arena for sensing the environment (Patel et al., 2009). The increasing number of sensor networks

application is the one of the motivation of utilizing them in this paper. Other motivation of using sensor networks (SNs) in this paper is based on the emergency of small and inexpensive sensors in the market (Vinyals et al., 2011).

In the current Learning Management System, the literature shows that, no researcher has introduced the use of MAS that contains sensor node (device) to solve the problem of identifying the location of the system user (i.e. student or instructor), once the user reaches to the HLMS domain coverage. Therefore, one of the major issues in this paper is to deal with identifying and detecting the location of the e-learning user in the HLMS domains, in order to improve system security and efficiency.

The aim of introducing and integrating sensor networks and multi-agent system is to increasing efficiency of HLMS and detecting user of the learning system domain. Efficiency of HLMS can be attained by utilizing mobile agents which contains sensors to sense the users of the HLMS. Hence this operation can be done by sensors and mobile agents' integration, instead of HLMS server. Therefore, the work load of servers will be reduced and hence increase the learning system efficiency. Further, the sensors will perform the overall monitoring activity in the system to control the users' of the HLMS.

Instead of user monitoring for location identification, another parameter which will be tested in this paper, is to identify the system user status (i.e. in terms of what percentage cover in his studies so far) based on the features collected during sensing session. Among the features which will be collected include: user name, password, IP address, device type, signal strength, operating system, browser name, protocol, etc.

The proposed system model therefore, will increase the overall performance and accessibility of HLMS, by decreasing server work load and ensuring the identification of the HLMS users.

## RELATED WORK

Multi-Agent System has been used in different applications to solve a variety of problems with different complexities. (Guruprasad & Ghose, 2009) for example, to address the heterogeneity in sensor networks and solving heterogeneous multi-agent searching problem, they incorporated multi-agent systems with sensor devices which equipped with various capabilities (i.e. in terms of strength and range) in order to solve uncertainty problem caused by the sensors. In this, Guruprasad and Ghose have presented two types of strategies to gather information about the target. The first strategy was called heterogeneous sequential deploy and search, and the second one was heterogeneous combined deploy and search. In their contribution, they presented a generalized form of the standard Voronoi partition, to address the heterogeneity in sensor networks and solving a heterogeneous multi-agent search problem.

Multi-agent system also can be used in the services like tracking object, security, fault-tolerance, power management and so on. In the paper presented by Patel and Jain (Patel, 2009), they encompassed mobile agents (MAs) in the distributed sensor networks which generate an intelligent framework for deploying application in distributed sensor networks. In this, the authors have tried to minimize the trip time by incorporate Mobile Agents (MAs) (i.e. Multi-agent Systems) and improve the overall network traffic.

To improve security of the critical rooms and very sensitive buildings, like banks, data warehouse, etc. Multi-agent System (MAS) can play very crucial role to secure buildings and other critical areas. Alkhateeb et al. (2010) have conducted a research to incorporating Multi-agents in order to securing and monitoring Faculties buildings in the University campus. In

addition, for achieving this goal, the authors have integrated the Multi-agent System and wireless sensor networks. In this, MAS sensors architecture the authors have introduced three types of agents, namely, alarm management agent, building position agent, and security guard call agent. Basically, this system signals alarm to security guard when the campus agents detect any attack or invade in any of the critical rooms in the University campus.

## SENSOR NETWORKS

The sensor networks (SNs) consist of low cost sensor nodes with computational capabilities, wireless communication, sensing and power devices (usually battery) (Akyildiz et al., 2002). As mentioned earlier the advancement of these devices is due to advances of miniaturization. These devices have been extensively used and deployed in sensing of physical phenomenon and due to their size; they can be easily deployed into whether, outside or inside physical environments.

To route data to the desired end, hundred or many as thousands sensor nodes need to work in a cooperative manner under selected routing protocols. Moreover, the routing protocols used in traditional network (fixed networks) cannot be directly applied to WSN, because WSN not only working under unreliable wireless links but also have less or no infrastructure to route data. Therefore, for the past years many routing protocols have been developed to drive the WSN networks. The researchers have classified the WSN routing protocols in different forms and categories (Singh et al., 2010, Goyal et al., 2012, & Biradar et al., 2009) based on their network structure.

The flat based routing protocol consists of sensor nodes which have the same role and function (Karkaziss et al., 2012), on the other hand, hierarchical based routing protocol consists of sensor nodes in which each one has a role to play inside and outside the formed clustered such as LEACH (Heinzelman et al., 2000). Location-based routing protocol comprises of sensor nodes which have knowledge of locations or mechanisms to address their positions so as to route data (Wood et al., 2002, & Blum et al., 2003). This work is preparing to implement the MAS in the location based routing protocol of geographic position type.

The decision of encompassing the sensor networks in this paper was made based on the advantages of sensor technology (as monitoring technology) over other technology (Vinyals et al., 2011). Table 1 below shows the comparison of sensor networks as compared with other monitoring technologies

**Table 1. Comparison of SNs with other monitoring technologies (Vinyals et al., 2011)**

| Feature | Sensor network | Alternative technologies |
|---|---|---|
| Sensor | Low cost, low power | Expensive, power consuming |
| Coverage | Wide area | Small-size areas |
| Monitoring environment | Remote and/or hostile environment | Highly controlled |
| Robustness | Fault-tolerant and robust to node failure | Non-robust |
| Invasiveness | Non-invasive | Invasive |
| Data acquisition | Irregularly sampled datasets | Regularly sampled datasets |
| Architecture | Distributed | Centralistic |

## MULTI-AGENT SYSTEM (MAS)

Multi-Agent System (MAS) is the interoperability and collaboration of more than one agent to accomplish a certain goal(s). Basically, MAS is a compromising software paradigm

that comprises autonomous, intelligence, proactive agents which can be used in software engineering strategy for developing multi-purpose applications (Zambonelli et al., 2003).

In order to widen the use of MAS, Talib et al., (2012) have presented the security issue by introducing the MAS in cloud computing for securing cloud data. In this, they introduced a new security access control formula called Formula-Based Cloud Data Access Control (FBCDA). Multi-Agent System (MAS) architecture is presented that comprises of two types of agents. Cloud Service Provider Agent (CSPA) which concerning of providing access to the cloud resources and Cloud Data Confidentiality Agent (CDConA) which responsible of formulating new access control to Cloud Data Storage (CDS).

Furthermore, in the knowledge sharing environment, multi-agents have to work together in collaborative way in order to give solution or solve social or business problem. This is because, individual agent has incomplete capabilities to solve complex problem (like software maintenance environment (Nor et al., 2009). Therefore, there is a need for MAS to work together and to sharing knowledge among them so that, to maximize the performance of the system. In this new technology, software engineers can develop and design a very complex software system by introducing these flexible agents to attain their objectives.

As for the purpose of this paper, the Multi-Agent Systems (MAS) has been presented by integrating with Sensor nodes to attain the flexibility and enhance the interaction of the learning system (i.e. HLMS). MAS comprise different agents with different capabilities that can be used to predict the location of the system users based on their device profiles

## METHODOLOGY

In this section, the previous literatures metrics concerning the importance of integrating SNs and MAS is analyzed. The analysis of the multivalent system integrated with WSN has been carried out in different literatures to measure different types of performance metrics. Each literature uses different methodology to perform analysis of the models. (Marsh et.al, 2004) conducted an experiment to compare the performance of two agent-based schemes i.e. intelligent agent-based transmission schemes with manipulation of their sample time to report the events in detecting intruders to the based station. Table 2 below illustrates the results of the analysis.

It was observed that, in reducing number of transmission using good sampling rate, the power is saved and the accuracy of the detection is increased by boosting the number of frequency of detection. (Sardis et.al, 2011) came up with architecture of sensor cameras and multi agents modules to control and manipulate workflows in industry production lines. For system performance perspective, they provide the system performance needed based on computing power demand by sensor agents to perform their allocated job i.e. light recognition etc. The results of system performance indicate the viability of the system in industry production line. Table 2 also illustrates the memory needed for the number of agent sensors in average, as demonstrated by Sardis et al. (2011).

**Table 2. Performance Analysis by Using Different Agent platforms**

| Measurement Unit | Value | Agent model |
|---|---|---|
| Transmission Frequency (Hz) | Number of transmissions = 153, and events detected = 17 per second | Platform 3 (sample every 2s) |
| Transmission Frequency (Hz) | Number of transmissions = 64, and events detected = 20 per second | Platform 3 (sample every 8s,if ROC <50,or 0.5s if ROC >50) |
| Storage (MB) | Average of 615.25 of RAM for average of 7 sensor agents | Sensor Networks and Multi-Agents in Industrial Workflows |

*ROC: Rate of Change of light level over time*

## SYSTEM MODEL AND IMPLEMENTATION

The network comprises of group of sensor nodes within communication range among each other. All nodes make use of location identification such as triangulation or GPS devices to have knowledge of their locations. Using wireless communication links, the nodes form connected graph between themselves as well as the base station. The base station is the sensor node with additional power, memory and processing features contrasted to other members of the network nodes. The node may use different types of protocols to form a communication pattern between each other. In this case we prefer to use the geographic routing protocol to provide routing functionality between nodes in the network, to the base station to the sink end, Heterogeneous Learning Management System (HLMS) servers in our case. Location based routing protocol of geographic types are preferable as having the ability to support mobility and scalability with the least routing overhead (Karkaziss et al., 2012). The information agents in the sensor nodes have to answer the queries from base station about the data that have been observed and identified (i.e. tracking both the position of the devices the user of LMS) in vicinity. Nowadays, there are a number of technologies specific to develop

### Multi-agents as well as sensor nodes

In most cases the wireless sensor network is deployed for monitoring and detection of environmental events, detecting user (student) in our case. This can be achieved by measuring the signal strength of the user device, and therefore the agents will make a decision in less than 0.5s to identify the user's location. In addition, the agents will also involve in answering the query on the status of the user (student) based on the information read by the sensor in user device upon connection to the LMS. Hence, the agent will notify the student on what percentages of his/her study have already been covered so far.

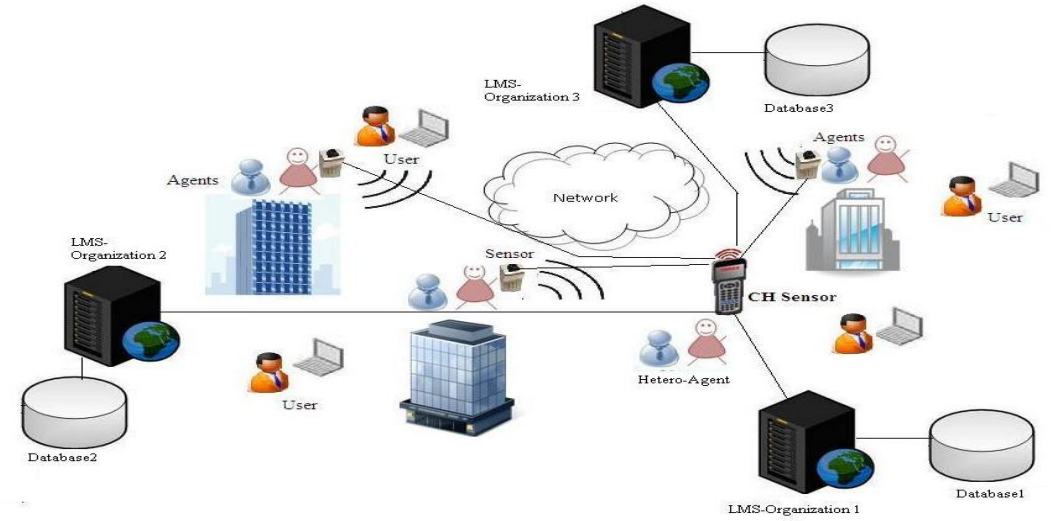


**Figure 1. System Model for Interoperability MAS with Sensors in HLMS**

Figure 1 above shows the University buildings that attached with MAS contains sensor nodes. In this system model, sensors are sensing the incoming devices to the University domains and report this information to the MAS which in terns are interacting with each other in order to reach consensus on the location of the device in the domain.

Again, another task of the agents is to answer the query from the HLMS servers, which are required to know the features of the device in order to notify the user on the status of the study.

## RESULTS AND DISCUSSION

Since this research project is still in the preliminary stage we have not yet analyzed the real world data using this new system model. However, based on the results from the number of literatures, this integration of MAS with sensor networks in HLMS is a promising technique to enhance the efficiency of the HLMS system by introducing a new functionality for detecting students during classes or training session.

The graph below shows the predicted results for this new system model where number of agents which contains sensors are compared by the number of users' (students) detected.

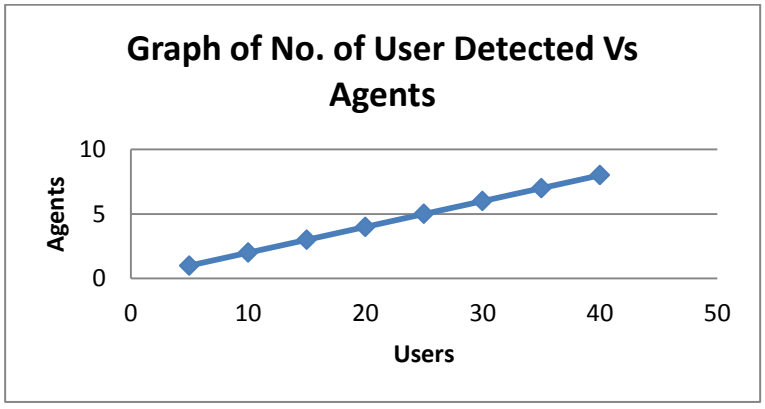


**Figure 2. User detected vs. agents**

As we can observe from the graph, the numbers of students detected and identified are improved as the number of agents increased.

## CONCLUSION AND FUTURE WORK

Intelligent discovery of students' activities (events/behaviors) in Heterogeneous LMS is critical in maximizing the overall performance and increase the deployment of such network successful in the near future. The life spanning of the network is maintained while the discovery of sensory data is aggregated, preserved by sink (CH sensor) sensor before transmitted to HLMS databases for further processing. As sensor nodes are deployed in distributed fashion, the multi-agent themselves performed detection autonomously. More work is needed for designing a prototype and realizing the benefits of this new architecture in real world scenario.

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