CHAPTER 1

INTRODUCTION

The broad area is Human Computer Interaction (HCI) (Meena. K and Sivakumar. R 2014) and the specific area is Ambient Intelligence (AmI) (Aarts. E and Wichert. R 2009). The interdisciplinary area of research is Information and Communication Technology (ICT) (Silverstone.R and Haddon.L 1996). Ambient Intelligence is the new dimension of Human Computer Interaction. This research work makes its efforts in proposing methodologies for developing still smarter learning environment with Ambient Intelligent behaviour monitoring mechanisms. Following sections in this chapter introduce the basic relevant concepts.

1.1 Ambient Intelligence

Ambient Intelligence creates sensitive digital environments to supervise and control the surroundings with the help of Artificial Intelligence (AI) techniques and sensor networks. The artificial intelligence methods include Artificial Immune System, Swarm Intelligence (Abul Hasan, M. J. and Ramakrishnan, S. 2011), Artificial Neural Networks (ANN), Evolutionary Computing and Fuzzy Logic System. These AI techniques use symbolic machine learning systems, expert systems, deductive reasoning, case-based reasoning and logic systems to develop ambient smart environments. The ambient intelligent
environment is usually electronic in nature and it is highly sensitive and responsive to the users present in that environment.

An AmI environment can also be developed to control the users by using intelligent agents that are embedded in the sensor networks. It finds applications mainly in the domain of smart environments like education, health and home.

Ambient Intelligence is an emerging field of research whose environments are claimed to be among other things sensitive, caring and adaptive to their inhabitants. In the domain of education, research on application of ambient intelligence to provide solutions to understand individuals and their needs has been becoming a hot topic of research.

AmI can adopt a student-centric approach and support the education activities that are taking place adapting to the individual learner’s needs. Here, the current challenge is to propose an approach for developing an AmI educational environment to assist in identifying, monitoring, and providing adapted instruction to students.

1.1.1 **Framework of Ambient Intelligence:**

The Ambient Environment transforms conventional environment into a context aware AmI environment. It facilitates issues such as heterogeneous interoperability of AmI services, synchronous and asynchronous communication, resilience, security, orchestration and ease of use in intelligent class rooms.
In figure 1.1, the AmI environment focuses on users, who perform change of function position and processes within the environment and use the resource, which might be in remote area. Processes can be accomplished by means of services and supported by the environment. Each service consists of several small blocks, which could be represented as transitions for the application. The context is important to provide the users location, default services and running services. Ambient Intelligence is an exciting application for pervasive, wireless and embedded computing.

The notion of AmI is becoming an actual key dimension of the emerging information society, since many of the new generation industrial digital products and services are clearly shifted towards an overall intelligent computing environment.

AmI will have sound consequences on the type, content and functionality of the emerging products and services, as well as on the way people will interact with them, bringing about multiple new requirements for the development of the information society. While a wide variety of different technologies is involved, the goal of AmI is to either hide the presence of technology from users, or to smoothly integrate it within the surrounding context as enhanced environment artifacts.

AmI is often claimed to bring a significant potential in the domain of education. Information and Communication Technologies already penetrate the classroom environment in many ways and play an important role in education by
increasing students’ access to information, enriching the learning environment, allowing students’ active learning and collaboration and enhancing their motivation to learn. Figure 1.2 shows the five layer conceptual model of Ambient Intelligence.

1.1.2 Ambient Intelligence Characteristics:

Following are the various AmI characteristics:

- **Embedded**: many networked devices are integrated into the environment.
- **Context aware**: these devices can recognize users and their situational context.
- **Personalized**: system can be tailored to user’s needs.
- **Adaptive**: system can change in response to user.
- **Anticipatory**: system can anticipate user’s desires without conscious mediation.

1.1.3 AmI Contributing Technologies:

The figure 1.3 depicts important contributing technologies such as Sense, Reason, Act, Secure and HCI to the AmI environment. The vital concept in an AmI environment is intelligence. It can be achieved using sensing data from the environment through which the data can be reasoned using reasoning algorithm and based on which the system will act in a secure manner to the end user.
Fig. 1.1 AmI Environment
Fig. 1.2 AmI Five Layer Conceptual Model

Fig. 1.3 Ambient Intelligence
1.2 User Behaviour Modelling

User behaviour modeling is defined as a concept which models the characteristics of a user interacting with the system. Activity Human Behaviour recognition techniques can be divided into data-driven methods and knowledge-based approaches. Traditionally, techniques for activity human behaviour recognition have focused on the branch of pattern recognition and machine learning.

Data-Driven Approaches are for the recognition of regular human activities and the detection during their performance by the use of information provided by sensors to build, infer or calibrate a behaviour model. This approach uses any one of the following learning procedures:

- Supervised – inductive or statistical or reinforcement
- Unsupervised.

Knowledge Driven Approaches are based on learning procedures such as logic-based approaches, Ontological approach and rule-based system.

These two approaches use any one of the following mathematical models:

- Graphical models
  - Hidden Markup Model (HMM)
  - Multiple Behavioural Hidden Markup Model (MBHMM)
  - Bayesian Network
  - Clustering
Following are the possible social interactions associated with data driven approach and knowledge driven approach:

- Social Interaction / Shared Activities
- Multi-resident setting / multiuser tracking
- Concurrent activity recognition.

The various sensor infrastructures required for these approaches are listed below:

- Computer Vision techniques
- Passive sensor techniques
- Wearable sensor Techniques
- Dealing with loss of sensor data.
The scalability of these approaches is achieved through adaptability to changes in behaviour, behaviour extensibility to other users, interleaved activity recognition and publish / subscribe infrastructure.

1.3 Learning Environments

Learning environment can be classified into four categories (Ogata and Yano 2004). They are referred to as desktop-computer assisted, mobile, pervasive and ubiquitous learning environment respectively. This classification is based on the four dimensions of ubiquitous computing (Lyytinen and Yoo 2002). As far as desktop-computer assisted learning is concerned, it offers fixed learning environment. Next, mobile learning (m-learning) enables learners to learn at anytime and anywhere manner. A pervasive learning gets information through interaction between learning environment and embedded devices (Yahya. S et al. 2010). But the disadvantage here is its higher localization. Finally, ubiquitous learning (u-learning) ensures high mobility in the learning environment. It has high level of mobility of devices and embeddedness to show good impact on the learning environment. The definitions of u-learning &m-learning seem to be one and the same, thus result in misconception. Hence u-learning is referred to as “Context aware u-learning”. Following are the characteristics of u-learning identified (Chiu et al. 2008): Interactivity of Learning Process, Context awareness, situation of instructional activity, urgency of learning need, initiative of knowledge acquisition, seamless learning, self-regulated learning, adopt the subject contents, actively provides personalized services and learning community.
The concept of u-learning has been applied in different educational domains and evaluated in various dimensions like specific curriculum centered u-learning mode, ubiquitous pedagogy, faculty education for the implementation of u-learning, classroom centered u-learning mode, development of UIMS (u-learning Instructional Management System) and development of standards for u-learning resources.

On the other hand, Ambient Intelligence has also been becoming a characteristic of u-learning for the past few years. It is an emerging technology using sensitive environment and Artificial Intelligence concepts to support daily activities. It mainly does the major activities like automatic adaptation, monitor and reasoning in an intelligent manner. Hence, the concept of u-learning has been blended with ambient intelligence to enhance u-learning environment with optimized activities.

1.3.1 **Ubiquitous Learning Environment:**

Ubiquitous Learning Environment (ULE) helps learners to access the learning resources in an easier and convenient manner. Its main characteristics include context sensitivity and ubiquitous. This environment normally integrates different workshops, societies and educational institutions. It is based on three ubiquitous aspects such as learning interface, learning behaviour and learning support services. Any ubiquitous environment should have server module, communication module, mobile devices and sensors. The ULE should be mainly concentrating in providing enormous teaching resources to the teachers, multiple
modalities of learning, collaborative learning environment and user friendly interface between user environments. Thus ubiquitous learning environment is characterized by Permanency, Accessibility, Immediacy and interactivity. Following are the notable problems identified in the development of Ubiquitous Learning Framework: Construction of Resources, Resource Discovery & Interaction, Standards of Ubiquitous Learning, Security and Implementation Cost.

1.3.2 Ambient Intelligence Assisted Learning Environment:

Any ubiquitous learning environment can be extended with ambient assisted activities by using artificial intelligence and agent based techniques. The AmI assisted learning environment should ensure applications for automatic adaptation of functionalities of learners and teachers in the u-classroom environment. These activities include data capturing, personalization and collaboration.

This environment does have desk monitor agents to detect situations like off-task students, inactive students, problems faced by students during exercise solving and misusing the learning system. Hence an AmI assisted learning environment should have smart desk, smart boards and smart desk monitor systems. The AmI architecture mainly deals with data capturing using sensor technologies & middleware technologies, data management and reasoning process.
1.4 **Objective of the Thesis**

The current research challenges include the design of still smarter learning environment using advanced technologies so that users can be well monitored for effective decision making on their behaviour in that environment. Hence this thesis work aims at the proposal of a framework for the development of infrastructures for a still smarter learning environment with Internet of Things (IoT) technologies in order to monitor users’ behaviour in an unobtrusive manner using Ontologies and reasoning techniques.

1.5 **Organization of Thesis**

The remaining part of the thesis is conveniently organized with six chapters. Chapter 2 presents the literature survey of the AmI Infrastructure Facilities, Ubiquitous User Behaviour Monitoring, Ontology based User Behaviour Modelling, then, Modelling users in Ambient Assisted Living Environment and Teacher Assistance for Student Monitoring in Learning Environment with the identification of the limitations in the existing contributions. Next, chapter 3 describes the thesis relevant concepts like Ontology engineering, Ubiquitous Technology, types of learning environments, IoT devices, User Behaviour Modelling, Learning Management System, Moodle and Particle Swarm Optimization. The core of this research work is extensively described in chapter 4. It illustrates the proposed methodology of IoT learning environment development and user behaviour monitoring through Ontology reasoning and Particle Swarm Optimization clustering technique respectively.
Chapter 5 illustrates the case studies of students’ activities monitoring in IoT classroom. Chapter 6 demonstrates the analysis of the results of the user satisfactions to show the effective performance of the proposed methodology. Chapter 7 concludes the thesis with a summary of significant findings of the research work carried out with its advantages and future directions.

1.6 Chapter Summary

This chapter described the problem and its related issues, various learning environment and explained the concept of u-learning blended with the AmI environment for optimized activities.