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Context Aware and Adaptive Mobile Learning: A Survey

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Abstract

Mobile becomes integral part for human life today. Technology advancements provides plenty of facilities through mobile and make the daily life simple. Peoples using mobile for communication, entertainment, banking, shopping and education. New mobile technologies, draw the attention to the researcher to enhance the learning by using the mobile technology. Mobile learning helps the user to learn the course/subject at anytime and anywhere and also provides the unique experience to the learners in terms of its flexibility. In order to provide effective learning contents to the users, both device and learner context should be considered. Unique learning experience can be possible by including adaptivity in the learning system based on learners' situation, educational needs and personal characteristics. This paper includes the detailed survey about context aware and adaptive m-learning, which serves as the base for new researches in this area. Also presents the proposed system which uses the clustering technique for generating adapted and personalized content for the user.

Keywords: context aware, adaptive, mobile learning, clustering, U-learning

1. INTRODUCTION

Technology evolve enormously and improves the human life better in every aspects in the earlier years. Mobile devices are one of the technology revolution in modern world. The mobile devices have become the type of the object with greatest index of usability today. The production of new and different mobile devices is tending to provide users with a plenty of technological features to access information through the internet. This encourages the mobile communication industry to provide new services to the users which includes internet access without place and device constraints, communication without time and location constraints, sharing digital contents in any format (text, image., audio, video), location aware information delivery and personalized assistance based on user preferences and needs [1][2].

This technology advancements and increased number of mobile users paved the way for technology enabled learning (TeL) which enhance the traditional classroom based teaching and learning experiences [3]. Mobile learning is the advancement of e-Learning. The mobile devices can (a) engage students in experiential and situated learning without place, time and device restrictions, (b) enable students to continue learning activities, initiated inside the traditional classroom, outside the classroom through their constant and contextual interaction and communication with their classmates and/or their tutors, (c) support on-demand access to educational resources regardless of students' commitments, (d) allow for new skills or knowledge to be immediately applied and (e) extend traditional teacher-led classroom scenario with informal learning activities performed outside the classroom [4]. However, the diversity of learners' characteristics as well mobile devices and networks requires personalization for different cases.

Rest of the paper is organized as follows. Section 2 presents the overview of context aware and adaptive M-Learning. Section 3 presents the literature review in this domain. Identified issues listed in section 4. In Section 5, describes the proposed system and finally we conclude the paper in section 6.

2. OVERVIEW OF CONTEXT AWARE AND ADAPTIVE M-LEANING

Mobile learning has been defined as: the process of learning and teaching that occurs with the use of mobile devices providing flexible on-demand access (without time and device constraints) to educational resources, experts, peers and services from any place [5][6]. In order to provide effective learning contents to the users, both device and learner context should be considered.

A commonly used definition of context in computer science is: ''any information that can be used to characterize the situation of an entity''[7], where the term ''entity'' is defined as anything relevant (namely, a person, a place or an object) participating in the interaction between a user and a system, and the term ''information'' is defined as any particular element or detailed piece of data that allows for the description of any condition or state of the participating entities[7]. In the field of TeL, context has been defined as: ''the current situation of a person related to a learning activity'' [8]. Context can be divided into (a) the learning context and (b) the mobile context. The learning context is defined by the learners, the educational resources, the learning activities and the specific pedagogical strategy, whereas the mobile context is defined by the learning context captured with regard to its delivery medium (i.e. the mobile devices).

Adaptivity and personalization in mobile learning systems refer to the process of enabling the system to fit its behavior and functionalities to the educational needs (such as learning goals and interests), the personal characteristics (such as learning styles and different prior knowledge) and the particular circumstances (such as the current location and movements in the environment) of the individual learner or the group of interconnected learners [9]. Adaptivity deals with taking learners' situation, educational needs and personal characteristics into consideration in generating appropriately designed learning experiences, whereas personalization is a more general term and deals with the customization of the system features, including also issues which can be adapted and specified by learners themselves, such as the system interface, the preferred language, or other issues which make the system more personal [10]. As a result, there are two main issues in the design of context-aware adaptive and personalized mobile learning systems, namely, the learner's contextual information that influence adaptations, and the type of adaptations that can be performed based on retrieved learner's contextual information [11].

3. LITERATURE REVIEW

Existing research works attempts to model learner's contextual information during the learning process. Essa [12], proposed a web-based framework, built around an ontology backbone that defines both the learning domain and support technology (device and network settings) at the semantic level. The system uses a set of ontological rules to achieve personalized context aware learning by integrating knowledge embedded in both ontologies. The reasoning process is driven by the user interaction taking into account the task at hand, learner profile, and the device-network environment. The output of the reasoning process is the extraction of metadata that will allow discovery and adaptation of learning objects.

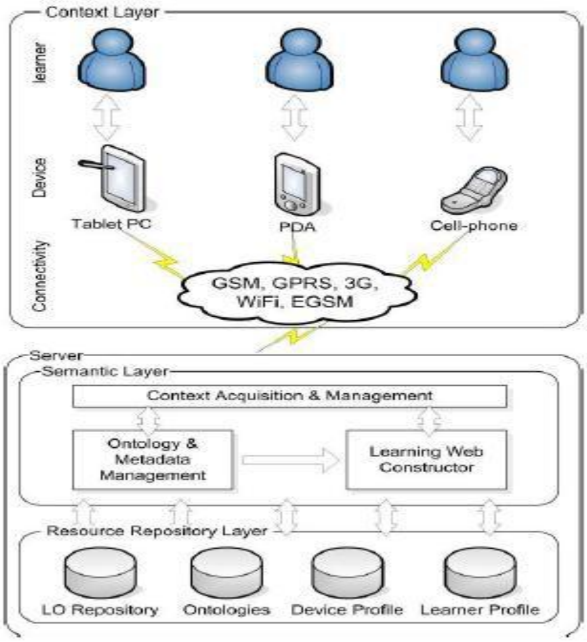

Fig 1: The three level architecture of M-Learning System

The architecture depicted in Fig. 1 exhibits three layers namely the context layer, the semantic layer, and the resource repository layer. The context layer deals with attributes related to the learner, used device, and network connectivity. The semantic layer consists mainly of an ontology reasoning component which uses the contextual information sensed by the context acquisition and management module from the user interaction to drive the reasoning process. The semantic layer uses Apache server to provide the necessary environment. In order to formulate the output, Cascading Stylesheets (CSS) are used. The learning resources repository layer includes repositories for learning objects, ontologies, learners' profile, and device profiles. This layer is implemented using MySQL (Database Management System).

Zhao et.al[13],proposed a system which includes four engines: Leaner Context Engine (LCE), Detector Engine (DE), Adaptive Content Delivery Engine (ACDE), and Transcoding Engine (TE). The architecture is shown in Fig 2.

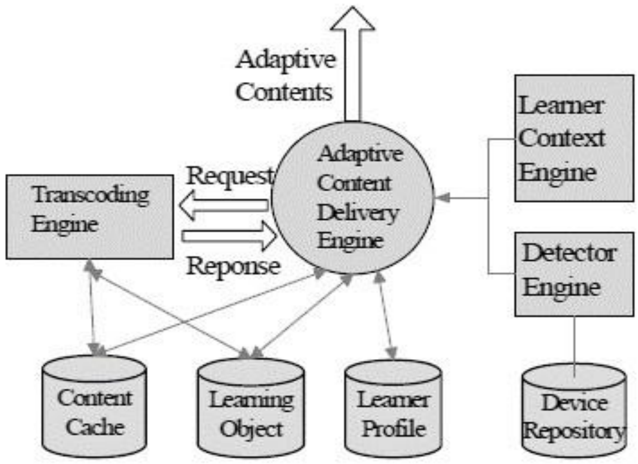

Fig 2: Adaptation Content Architecture

After ACDE receives the context data and features of device, it creates adaptive contents for mobile learners. Detector Engine takes responsibility for detecting all capabilities (memory, screen size …) using the WURFL (Wireless Universal Resource File) model to define the features of devices and mobile browsers.

Learner Context Engine detects the contextual information of learners, such as location, time, network performance, schedule, weather etc. Transcoding Engine (TE) contains many different conversion engines for media, such as text, image, standard document, audio, and video. After TE parses transcoding request (XML) from adaptive content delivery engine (ACDE), it choose a conversion engine to transform contents into adaptive content and responses the transcoding result (XML) to ACDE. ACDE is a most important component in adaptive system. It recommends the adaptive Top-N contents based on learner's contextual data: content features, device capabilities, and learner's preference and experience. The recommended contents are adapted to learner, also to mobile device. A big size video, for example, will not be recommended because it is impossible to display on a mobile phone.

When one of the recommended contents is accessed by a learner, ACDE judges whether it can be displayed on user's device correctly after ACDE analyzes the features of all parts from content. If not, ACDE negotiates the content and sends a request job (contains some parts of content not displayed) to transcoding engine for adaptation.

Zhao et al [14], proposed an adaptive contents delivery model for context-aware u-learning according to three-level service models proposed, which create the adaptive contents for learners to get a seamless access in learning according to learners' interest and contexts.

The adaptive process includes three steps: adaptive to context, content adaptation and content delivery. The adaptive process to context creates suitable content for learners according to contextual data and situational data. Secondly, content adaptation process recodes original content into adapted contents according to the adaptive suggestion, from adaptive process.

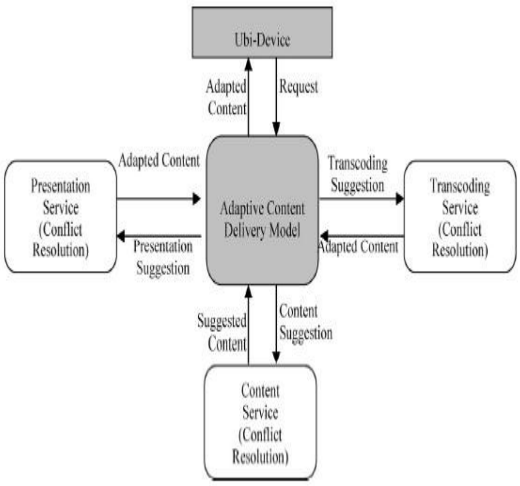

Fig 3: Adaptive Content Delivery

Adaptive process is made of three steps: adaptive to learning context, content adaptation and adaptive content delivery as shown in Fig 3. The three steps complete adaptive process together. The adaptive learning model recommends the adaptive contents according learners' preference and context. Then content adaptation model creates adaptive content based on learning environment. At last, the content delivery model delivers adapted content embedded with suitable markup.

Martin and Carro proposed a system called "CoMoLE"[10], which aims to support the generation and recommendation of different types of adaptive learning activities, which can have associated multimedia contents as well as collaborative tools to support the interaction between learners.

Hwang et al., proposed a context-aware mobile learning system [15][16][17], which automatically constructs a navigation path to perform certain learning activities in a university campus based on the learner's location. In order to emphasize the effectiveness of the system, different experiments were conducted in different students levels and courses. For Example “Identification of Plants” unit in the Natural Science course of an elementary school as shown in Fig 4, the context-aware u-learning environment with RFID sensors and wireless networks. Each target plant has an RFID tag attached to it which records the identification data of the plant, and each student is equipped with a PDA with an RFID reader which can read the data from the tag if the student is close enough. Once the u-learning system identifies the plant, relevant information can be read from the plant database in the server via wireless communications.

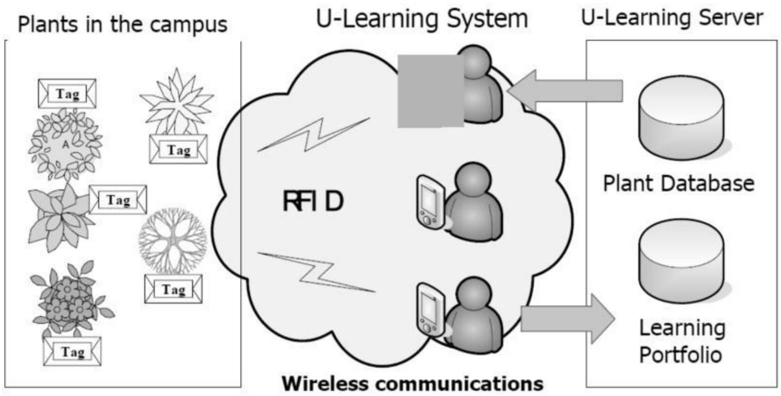

Fig 4: Context-aware u-learning environment with RFID sensors and wireless networks

This paper also highlights the basic criteria, strategies, issues and limitations of context-aware ubiquitous learning.

Potential criteria of a context-aware u-learning environment

1. A context-aware u-learning environment is context-aware; that is, the learner’s situation or the situation of the real-world environment in which the learner is located can be sensed, implying that the system is able to conduct the learning activities in the real world.
2. A context-aware u-learning environment is able to offer more adaptive supports to the learners by taking into account their learning behaviors and contexts in both the cyber world and the real world.
3. A context-aware u-learning environment can actively provide personalized supports or hints to the learners in the right way, in the right place, and at the right time, based on the personal and environmental contexts in the real world, as well as the profile and learning portfolio of the learner.
4. A context-aware ubiquitous learning environment enables seamless learning from place to place within the predefined area.
5. A context-aware ubiquitous learning environment is able to adapt the subject content to meet the functions of various mobile devices.

Strategies of Learning Activity Design for Context-Aware U-Learning

To conduct learning activities in a context-aware u-learning environment, it is necessary to define the situation parameters taken into account. For a learning activity conducted in the real world, there are five types of situation parameters, as shown in the following:

- Personal contexts sensed by the system: includes the learner's location and time of arrival, temperature, level of perspiration, heartbeat, blood pressure, etc.
- Environmental contexts sensed by the system: includes the sensor's ID and location, the temperature, humidity, air ingredients, and other parameters of the environment around the sensor, and the objects that are approaching the sensor.
- Feedback from the learner via the mobile learning device: includes the observed or sensed data of the target items (such as environmental temperature and acid value of water, air pollution, shape and color of a tree, machine status after performing an operation), acquired photos or interactions with the learning system (e.g., the answers to the test items or the log for operating the system).
- Personal data retrieved from databases: includes the learner's profile and learning portfolio, such as the predefined schedule of the learner, expected starting time of a learning activity, the longest and shortest acceptable time period of a learning activity, the learning place, the learning paths or sequences of a course, the constraints or prohibitions of a course of learning activity, etc.
- Environmental data retrieved from databases: includes the detailed information of the learning site, such as the schedule of learning activities arranged at the site, the constraints or management rules of the site, notes for using the site, the equipment located at the site, the persons who use or manage the site, etc.

PERKAM (PERsonalized Knowledge Awareness Map), which allows the learners to share knowledge, interact, collaborate, and exchange individual experiences presented by El-Bishouty et al [18]. It utilizes the RFID ubiquities technology to detect the learner's environmental objects and location, then recommends the best matched educational materials and peer helpers in accordance with the detected objects and the current location. This environment provides the learner with *Knowledge Awareness Map*, which visualizes the space of the environmental objects that surround the learner, the educational materials space, and the peer helpers' space.

The system model consists of the following items

Environmental Object

It represents the available real objects that may surround the learner. It may be computers, electronic parts, chemicals…etc.

Learner

The learner is the actor in this system. The learner's interest is obtained from his profile and his educational materials folder.

Location

The location of the learners is represented by one dimension in the knowledge space. The system can detect the learner's physical location using RFID tags.

Environmental Objects Map

The role of Environmental Objects Map is to map the physical space into the digital space, where each object in the physical space is detected, recognized and presented graphically by this system. The learner can forward this digital space to the peer helper in order to facilitate easy understanding of his environment, which augments the collaboration between them.

Peer Helpers Map

This map displays a two dimensions knowledge space of the recommended learners who are using the system and have enough knowledge about the learner's request. This map represents the level of recommendation of each learner based on his interests.

Educational Materials Map

This map displays a two dimensions knowledge space of the suggested materials. It represents the strength of the relation between the suggested materials and the learner's request in one dimension, and how far their physical locations are from the learner's location in the other dimension. Therefore the learner can get information about the appropriate material that satisfies his need.

PERKAM system consists of the following modules as shown in Fig 5:

- Learner model: It contains the learner's information such as personal data, past actions, interests, folder…etc.
- Object model: It contains information about the physical educational objects that may be used by the learner.
- Location model: It contains information about the places (buildings and rooms) and the distances between them.
- Material model: It contains information about the education material as its title, author, type and keywords.
- Message system: It provides the learner with an easy tool to exchange messages with the other learners.
- Detection manager: It detects the location and the objects that surround the learner.
- Search engine: It matches between the learner's request, the available education materials and the peer learners.
- Map generator: It represents the surrounding environmental objects, the educational materials, and the recommended peer helpers' information according to the learner's need.

- Map visualization: It prepares the enough information to graphically visualize the KA (*Knowledge Awareness)* maps.

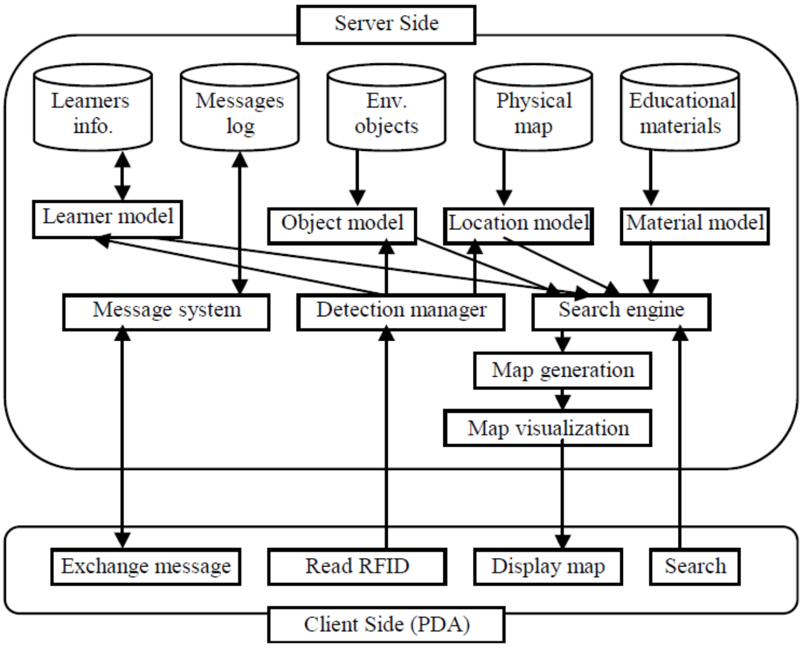

Fig 5: PERKAM System Architecture

A context-aware mobile learning system has been proposed by Martin et al[19], which give information about people who are close to the learner by exploiting learner's location during the execution of learning activities in a university campus.

Tan et al.[20] described a context-aware mobile learning system that automatically constructs a navigation path to perform certain learning activities in a university campus according to learners' previous knowledge and learner's location. A location-based dynamic grouping algorithm creates learning groups by identifying the individual mobile learners' geographic locations and other learning factors. This algorithm will eventually generate online Mobile Virtual Campus where mobile learners are grouped based on their geographic location, learning profiles and learning styles, or learning interests in the mobile learning environment as shown in fig 6.

- The Learner Agent's goal can be divided into three sub-tasks: 1) Monitoring the change of the folder; 2) Attaching the location information and time stamp to a new incoming authentic example, and then uploading it to the server; 3) Periodically reporting student's location to the Location-aware Agent
- The Learner Agent can automatically adjust the GPS receiving interval and the location reporting interval to prevent power drop.
- The Learner Agent will interact with the Location-aware Agent and the Resource Agent while exchanging data

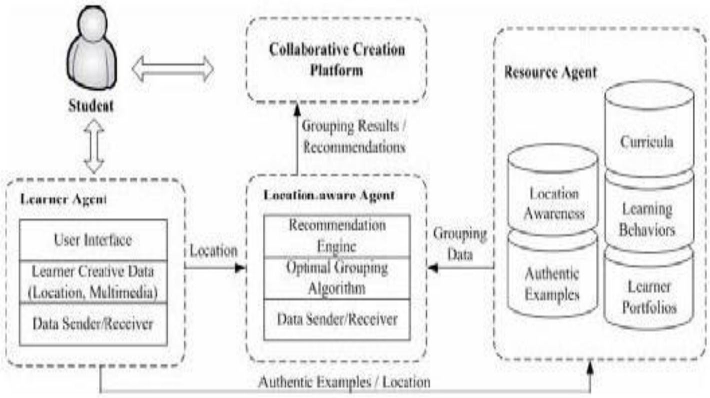

Fig 6: Multi-Agent System Architecture

A context-aware mobile learning system has been proposed by Economides [21], which automatically selects appropriate communication and collaboration tools by exploiting learners' preferences and needs.

Another context-aware mobile learning system is CMMCUL is presented by Hwang et al., 2011[21], which with the help of the RFID technology, is able to detect the location of the students and guide them with a procedural learning tasks flow and related learning materials so as they can find target objects of study during the learning process.

Wang and Wu[22], context-aware mobile learning system is presented by, which aims to provide context-aware navigation recommendations for learning tasks and adaptive courseware in real-world situations based on the learner's location, learning behavior and personal preferences.

Chiou and Tseng[23] presented the PNSS system which aims to support a personalized navigation strategy for learning activities so as to guide learners in context-aware ubiquitous learning environments.

Gomez [4] presented a context-aware adaptive and personalized mobile learning system, namely the Units of Learning mobile Player (UoLmP), which aims to support semi-automatic adaptation of learning activities, that is: (a) adaptations to the interconnection of the learning activities (namely, the learning flow) and (b) adaptations to the educational resources, tools and services that support the learning activities.

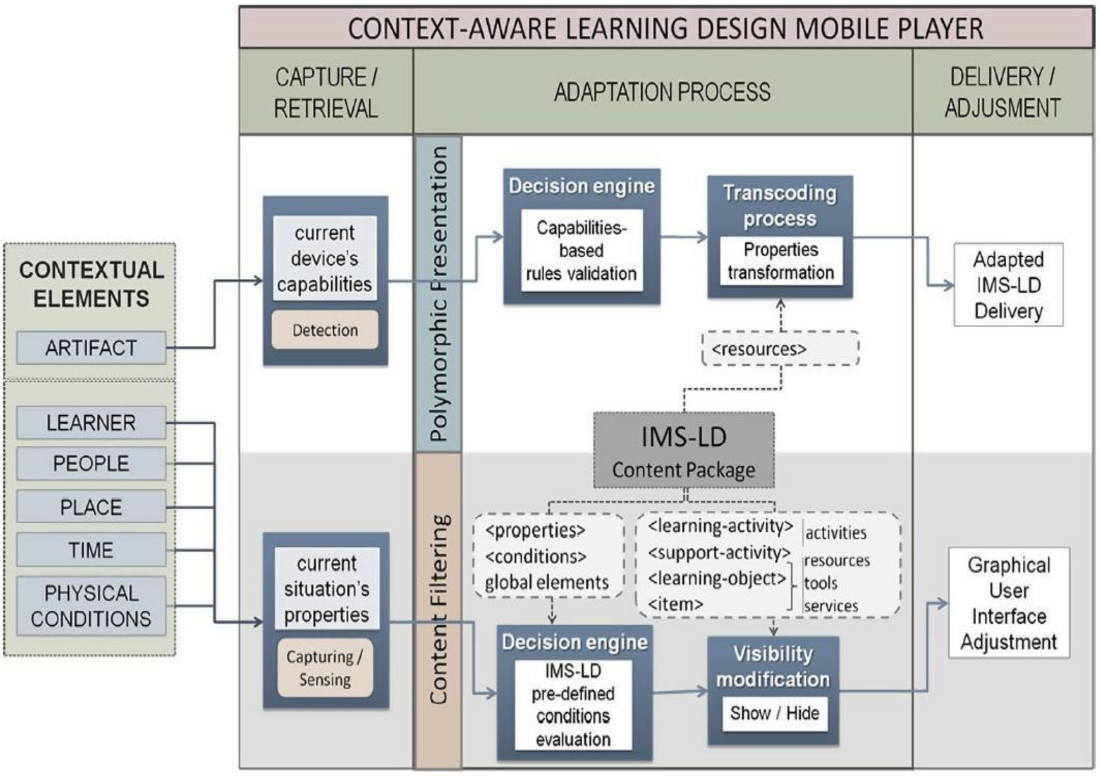

Fig 7: Architecture of UoLmP

The system in fig 7, is developed based on IMS Learning Design Specification (IMS-LD) (Global Learning Consortium). IMS-LD is a standard notation language for the description of educational scenarios. In IMS-LD, an educational scenario can be built at three different levels (level A, level B and level C). At level A, educational scenarios include: a series of learning activities, performed by one or more actors/roles, in an environment consisting of tools and services. Level B adds properties (storing information about a person or group), and conditions (placing constraints upon flow) and level C adds notifications based on run-time events.

Initially, the system interface for capturing contextual information from learner's current situation, based on learner's input. Using forms or checklists can be an easy and efficient way to capture learner's inputs about their actual contexts.

Polymorphic presentation mechanism, which is based on educational resources transformation. This process consists of a set of steps to transcode/recode the properties (format, type, size, quality, etc.) of one or more resources (that populate an IMS-LD package) considering the digital and physical capabilities of the learner's device.

Filtering mechanism, consists of making decisions based on the evaluation of a pre-defined structured decision tree that considers contextual elements. More specifically, IMS-LD conditional structures are considered for making decision processes. That is, to assess learner's contextual information in order to show or hide learning activities, educational content and tools and services. Conditional structures are predefined at design-time and consist of IF/THEN/ELSE statements that form a decision tree to select and deliver the learning activities, the educational content and tools and services that best suit to the learners' situation. Adaptation results for educational content, tools and services obtained from the decision making process according to the captured contextual information

4. ISSUES.

General Issues:

- Mobile and ubiquitous computing devices are transforming the way that learners study. But most of learning contents, designed for desktop platforms, are not suitable for handheld devices , whose capabilities are usually limited in terms of network bandwidth, processing power, storage capability, markup language, screen sizes, etc.
- Massive amount of contents, irrelevant to learners' preferences or contextual environment, will make learners feel frustrated and dissatisfied. Also, these make learners overload during learning and also increase the communication costs.
- The mobile or u-computing system makes judgments on possible mistakes or faults based on the detected information and the feedback from the learners; therefore, if the learners' feedback is incorrect or incomplete, the system will not be able to provide useful suggestions.
- The range and diversity of devices on the market today presents a challenge to provide contents on mobile device for users.

Content based Issues:

- New modes of learning will involve new pedagogies.
- The tutoring strategies may be revised according to the learning system.
- The system must be designed to guide the learners to learn. In case that the learners do not follow the instructions given by the system, the effects of the system will be reduced.
- The assessment is critical and it is a part of teaching. Context-aware M-learning environments will require more alternative ways of assessment. The assessment strategies for situated learning, adaptive learning and cooperative learning involved in context-aware u-learning need more research.

5. PROPOSED SYSTEM:

The proposed system as shown in fig 8, consist of the parts such repository, adaptation engine, context sensing & acquisition and content delivery. The repository part consist of learner profile, device profile, environment profile, content and assessment. Based on the environment, user and device profile system will cluster the context group. Based on the context group the personalized content will be generated and it will be deliver to the user.

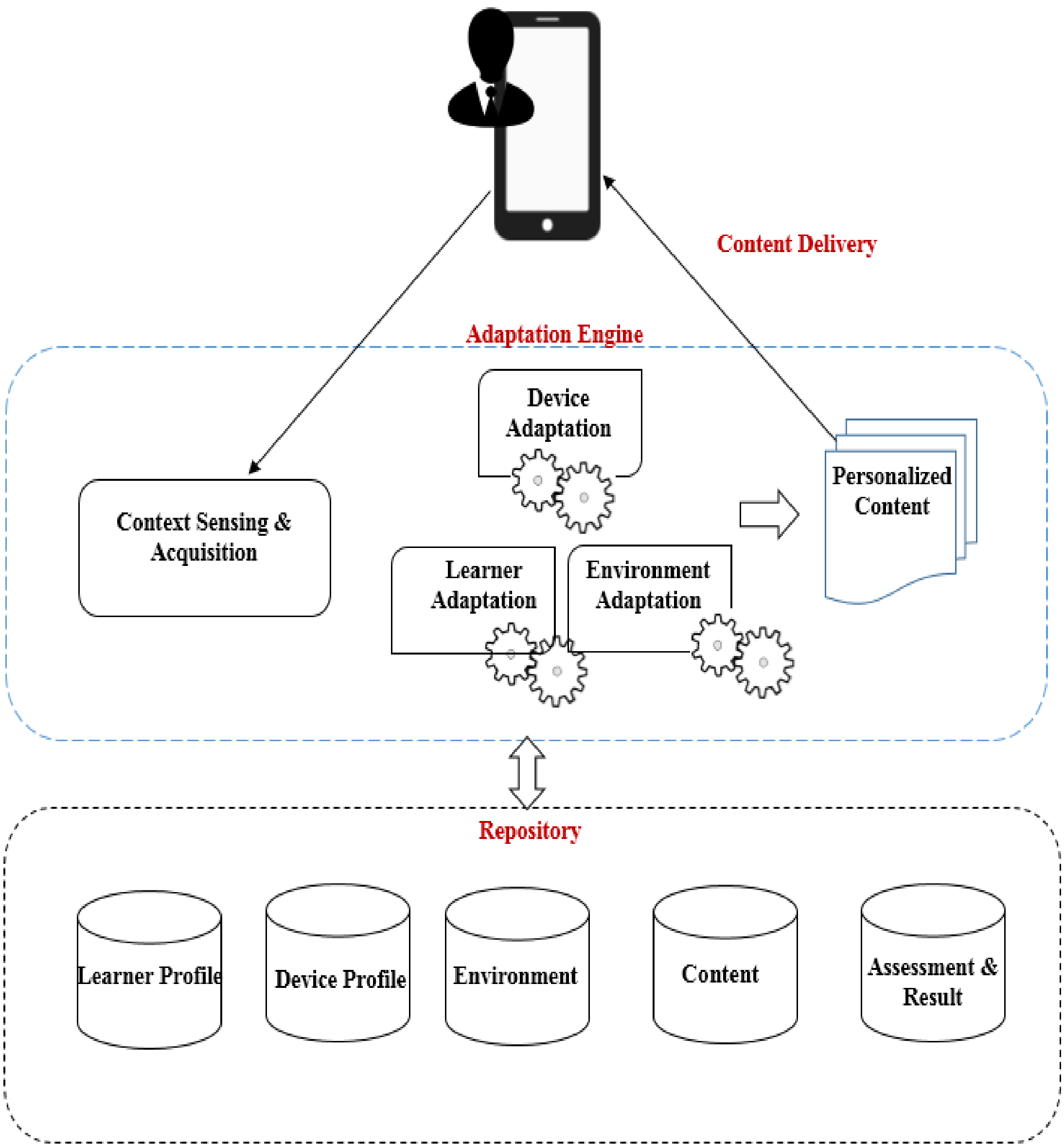

Fig 8: System Architecture

6. CONCLUSION

Mobile or ubiquitous learning is defined as learning the educational content through mobile devices without time and device constraints. In this paper, we present the overview of mobile learning and importance of context aware and adaptive. Also presents the existing works in this domain and point out the issues. Finally presents the proposed system. The proposed system, form the context cluster group, which will help to generate the personalized content. The detail implementation of the system will be published in upcoming paper.

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