Context Aware Human Computer Interaction for Ubiquitous Learning*

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Abstract. In the past year, the majority of conventional learning schemes have been transformed offline, gradually adapting E-Learning and M-Learning through the evolution of IT technology. In order to achieve effective learning, existing static schemes of learning must be transformed in all domains, to deliver true personalized learning depending on various user characteristics. Offering a conceptual background that supports this environment is the foundation of ubiquitous learning. Ubiquitous learning exists in the physical space of everyday life. It is possible to compose learning components existing in the activity space of an intelligent network. Adaptive learning in such ubiquitous environments is a significant learning step. In a general sense, our aim regard Ubiquitous computing is pursuit in the same light with Human Computer Interaction is pursuit by related works. However, in order to achieve sufficient improvement, ubiquitous learning requires 1) learning system has to provide learner centered learning contents what learner wants, 2) and through consideration of learner's learning device and learning environment, it has to offer learning contents. In this paper, a system supporting the dynamic configuration of user optimized learning objects, and the transmission of learning content irrespective of the learner device used, is designed and implemented. In addition, through the development of an effective learning model, the effect on learning is maximized.

1 Introduction

Recently, IT technology and internet improvement bring to various change in our society. These growths are made close to human and computer, so called name of the "Ubiquitous Computing", and is developed that our society enable to what is computing through anytime, anywhere and each device. There are features in Ubiquitous Computing as follows. Firstly, real space of computer is connected by communication net between wire and wireless. Secondly, these environment are simulated, it is provided user-oriented information and service. Finally, ubiquitous environment is

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composed with computer resources. In a general sense, our aim regard Ubiquitous computing is pursuit in the same light with Human Computer Interaction is pursuit by related works.

This recently changes of technical circumstances have led a lot of changes in educational domain. The existing studying system is going to Ubiquitous Learning through E-Learning and M-Learning. Ubiquitous Learning which surpassed physical and cyber space after Ubiquitous environment applied to education makes that people can learn into customized courses in their life regardless of time and place. It will be able to be accomplished by using the computing environment for ubiquitous learning, smooth interaction between learners, and offering of learner centered learning contents. To achieve this, 1) learning system has to provide learner centered learning contents what learner wants, 2) and through consideration of learner's learning device and learning environment, it has to offer learning contents.

Existing Learning Systems based on Ubiquitous environment have used the method to construct various learning contents in advance or the method using the exclusive software developed for the learner's device. At the same time, the research, relevant to learning system based on HCI technology, is focused on the management system for instructor not learner. When we define the user of learning system as learner and instructor, it is important to research the system focused on instructor. But, if we see that the number of learner is much more than that of instructor, we can understand the research focused on learner is more important.

In this paper, we described following three techniques for learning based on HCI.

1) 'Context Aware Learning Contents Delivery Engine' providing learning contents focused on each learner. 2) "HCI-based Dynamic Interface for U-Learning' to support the smooth interaction between learner and learning system and to provide learner with optimized use of the system. 3) Lastly, the method to effectively evaluate the two techniques stated, based on HCI technology.

In this paper, we present concrete methodologies for designing and implementing mentioned above. In the 'Context Aware Learning Contents Delivery Engine' where provides learner-centered learning context, in order to provide composition of learning for learners properly, it's required to consider the Contexts as follows: Learners' learning taste information and learners' situation information. Learners' learning taste information is basic learning profiles, including basic information for mastering learners, learners' capability for considering learners' learning level, and History Data that learner received currently. Learners' situation information is information which decides alterative learning situation along with learners' position; it contains learners' position and Device Control actions. This paper consists of the following. "Related Work" presents related U-Learning research in the 3rd chapter, a description for the proposed system is presented, the 4th chapter presents an experiment, and evaluation of the proposed system. Finally, in the 5th chapter, this research is concluded, with a note regarding future work.

2 Related Works

Presently, at home and abroad, research on E-Learning and M-Learning using mobile devices is being widely pursued, and greater than 100 universities in Korea confirm the possibility of constructing and managing a Wireless LAN. However, as men-

tioned, the three core technologies stated above are indispensable for efficient U-Learning and no solution has been achieved that uses all of these technologies.

- Dynamic reconfiguration of learning objects is a technology offering exact, personalized, and well-organized learning contents to learners in various learning environments. However, well-organized research is not being conducted, although much research and standardization has been performed to compose a learning object, such as SCORM [2].

- The technology to inter-transmit learning content among heterogeneous devices and networks is indispensable in satisfying ubiquitous environments. Although much research, has been undertaken, it is limited in application to U-Learning.

- Though existing E/M-Learning emphasizes self centered leading learning and learner centered educational concepts is a fixed idea. The thought that the teacher is the informer and learner is the consumer, is a common thought, and the system for quality of resources for learning is at an early level. Furthermore, devices for education are demanded, and flexibility is insufficient, because learning content is fixed in devices.

Table 1 presents related research and associated problems.

Table 1. Related research and associated problems

Organization	Technique	Research and Problem
Dalhousie Univ. (Canada)	Composition of Learning Objects	● Proposal of information architecture which can reuse learning objects. ● the learning object should be revised for composition.
Virginia Univ.(USA)	Event based Middleware (DsWare)	● supports integration of real time service of data. ● provides various real time events.
Stanford Univ. (USA)	Collaboration Service Technique	● Absence of collaboration technique which provides real-time service and understands real time attributes among agents.
OMG(USA)	The technique of real time Channel processing of Middleware	● Absence of technique and analysis, creating a real time event channel mechanism.
IBM(USA)	Self-Configuring	● Self-Recognize and auto configuration ● problem of learning the content delivery technique

In this paper, the above problems are overcome, and a ubiquitous learning system is proposed for a learner centered ubiquitous learning system appropriate for new ubiquitous environments.

3 Proposed System

The learner centered ubiquitous learning system proposed in this paper, is applied to the multi-aspect modeling technique of learners and the dynamic reconfiguration of learning object.

3.1 Context Aware Learning Contents Delivery Engine and HCI-Based Dynamic Interface

Context Aware Learning Contents Delivery Engine and HCI-based Dynamic Interface technique consists of:

1) A technique to correctly understand and analyze various learning situations of learners. 2) A technique to dynamically reconfigure different learning objects in a distributed environment.

These techniques are based on a modeling technique to perfectly analyze learner's location, device, learning, and environment information, in order to formulate optimized learning contents specifically for the learner's situation. In addition, these techniques consist of integration, permitting distributed learning objects on the Internet to be dynamically reconfigured. The ability to provide optimized learning content for each learner is based on research relating to location, device, learning and environment information. The overall architecture is as follows.

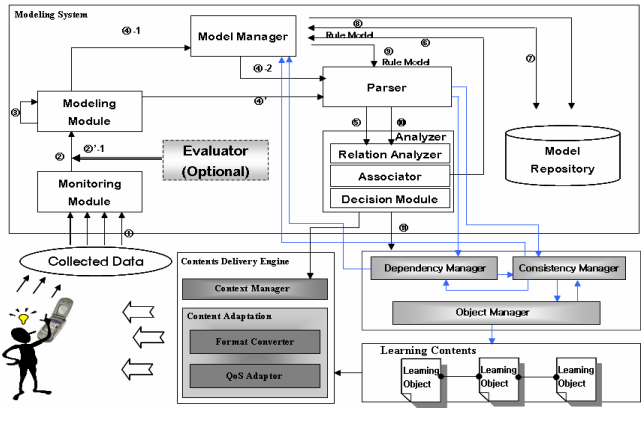

Fig. 1. Overall architecture

The modeling system monitors the learner's location, learning device, learning information, and environment information, modeling this data for effective use. The modeling system initially collects information relating to the learner's location, through a ubiquitous sensor network. The Learner's device information includes learning device type, CPU of device, memory of device, and display size of device. The learning environment includes network status, type of protocol, location of gateway and proxy server, and executing external system. Therefore, this information is analyzed and refined in the Model Analyzer.

The Modeling Module models the specification of leaner's device architecture, operational resources, behavior of learner, and environmental information in terms of

network bandwidth. The modeling data generated in this module are separated using the three aspect models.

-Resource Model

The Resource Model represents platform independent elements which have an effect on system operation. It consists of static and dynamic aspects of resources, as in the following example.

Table 2. Example of resource model

	Pre-defined elements	Collecting element in runtime	Real collected data
Static	Device (Type)	Device(Type)	MobileDevide(PDA)
	Os(Type)	Os(Type)	PPC(Pocket PC)
	Display (Size, Resolution)	Display (Size, Resolution)	320*240
Dynamic	Port(Number)	Port(Number)	2000
	CPU(type,Total_size)	CPU(Type, Current_Usage)	(Intel Xscale, 640Mhz)
	Memory (Total_size)	Memory (Current_Usage)	(512M, 140M)
	Power (Total Size)	Power(MaxUpTime, remainUpTime, Battery Level)	(240mins 144mins, 60%)

Static aspects include resource information that have less dynamism, such as device type, and operating system. These data do not change during runtime. The dynamic aspect includes resource information such as CPU and Memory usage that is able to have an effect on the system, because these change continuously. The Deployment diagram is used to model these data.

-Behavior Model

The Behavior Model represents the dynamic behavior of learner, to validate that the learner's preference. The sequence diagram and activity diagram are used to model this dynamic behavior. The activity and sequence diagram is one of the UML diagrams modeling the dynamic aspects, and representing scenarios.

- Environment Model

The Environment Model represents platform independent elements which have an effect on system operation. The model includes network bandwidth, available protocol, and location address of accessible device.

The Architecture of the Model Analyzer and execution mechanism is as follows.

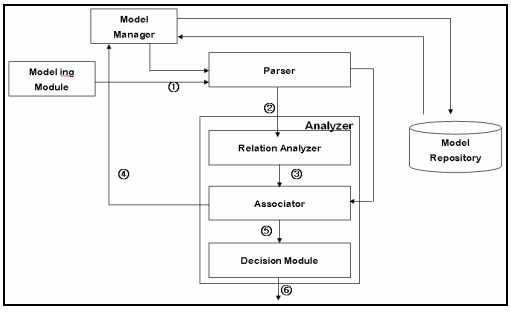

Fig. 2. Architecture of model analyzer

1. Transport the XML description, which includes the modeling data, to the Parser
2. Transmit parsed modeling type, element information, and modeled data to the Relation Analyzer.
3. The Relation Analyzer analyzes the relationship between parsed modeling data and each element and mapping rule. This information is transmitted to the Associator
4. The Relation analysis is completed, and the Associator request association model is transmitted to the Model Manager.
5. Associator constructs model information and the set is received from the Model Manager, generating the mapping rule.
6. The Decision Module decides on the reconfiguration type, information or learning object, and action information for reconfiguration.

An example of the Rule Model using an Associator is presented below.

```
- Rule 1
If(Bandwidth<=MaximUM)Associate(ResourceModel.CPU);
else(Bandwidth>Minimum)Associate(EnvirtModel.Usersatisfication);
……..
- Rule 2
If(currentUsageCPU>80%)TransformReformatinge(GCIF);
If(currentUsageCPU>30%)TransformResolution(HIGH);
```

The dynamic learning object reconfiguration system is a module provided to learners to reconfigure learning content, according to learning object, learner's location, learner's device information, learning information, and environment information gained by the learning object in the modeling system.

Our system is composed to the Modeling System, Adaptive Interface, Object Manager, reconfiguration Manager, and Content Delivery Engine, which dynamically creates learning content. The dynamic learning objects should be composed to SCORM standards, in order to compose learning content to the learning object. Also, learning object is consisted assets. Asset is an atomic element for learning, as video clip, image, voice, and etc.

The Reconfiguration Manager is a module which uses each individual learning object, and composes of learning content, fitted to the various contexts of the learner. The learning object is created from SCORM standardization, and specification regarding the information exists. The necessary learning objects for the learner are detected,

and the learning object is connected by the learning content based on this specification. Conceptual architecture of SCORM based learning objects and Content package is as follows.

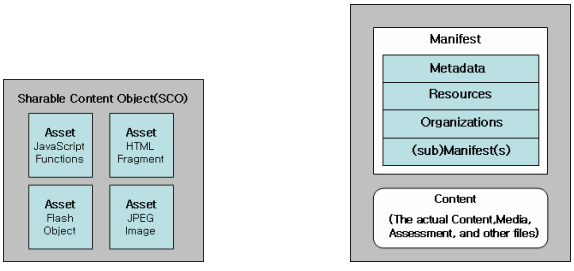

Fig. 3. Conceptual architecture of SCO and Content Package

Contents Delivery Engine consists of Context Manager and Content Adaptation. Content Adaptation consists of the Format Converter and QoS Adaptor. The Format Converter is a module transforming the format of learning content according to software type like that of the user's browser and media viewer. QoS Adaptor is a module that adapts the QoS(Quality of Service) of asset to environment modeling data in the network environment. As mentioned above, asset is an atomic element of learning contents. This table presents monitoring information and a formula used to decide the QoS of the asset.

Table 3. Information collected from Monitor module

Type	Monitoring Elements
Video	Video X Size, Video Y Size, Chrominance, Luminance, Frame rate
Audio	Audio Channels, Audio Codex, Audio Frequency
Platform	Port, CPU rate, CPU rate when Max Bandwidth, CPU rate when min Bandwidth
Network	Max Bandwidth, Available Bandwidth

'HCI based on Dynamic Interface for U-Learning' supports smooth interaction between learners and learning system and the use of optimum learning system for learners, and provides smooth and optimum learning system environment for learners under considering learners and learning system. Context consists of learners' learning machine information and learners' situation information here. Learners' learning machine information contains the Display Size of learning machine and usable Applications, and information about learners' positions information and present using application is included in learners' situation information. Learners' learning machine information is needful information in order to provide suitable form of learning context for learners' learning machine. However, learners' situation information is information for controlling alterative application information along with changing learners' positions. We can consider the information as indispensable information that the learners use learning system smoothly and it provides efficient learning opportunity

sufficiently, and it can be seen that it is approaching the goal that HCI is about to pursuing. We use the same context to make possibility of dynamic interface implementation for learners. For this, we combine Decorator pattern of GOF Design Pattern and the function of dynamic reconfiguration in executing time of component-based application. This figure shows the composition of Decorator pattern and reconfiguration

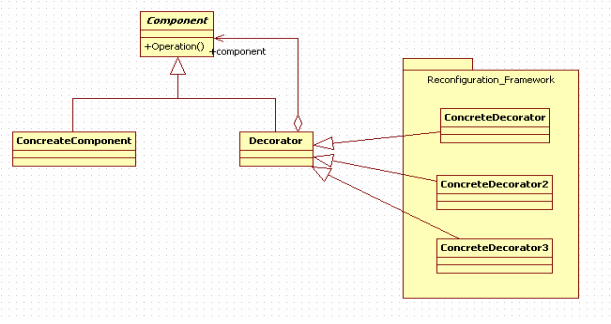

Fig. 4. Dynamic Interface architecture based on Decorator Pattern

4 Evaluation

The proposed designed and developed system can provide learning content to learners without awareness of the learner's characteristics. In this section, experiments where the system provides a more effective service for each three different type of device are achieved. The degree of satisfaction for receiving video data from local education broadcasting is evaluated. The experimental environment is as follows

1) Three learners are provided learning content from Education Server. 2) First learner's learning device is PDA using 802.11a in a wireless network environment. 3) Second learner's learning device is Desktop PC in a wired network environment. 4) Third learner's learning device is a Notebook computer using 802.11a/b/g.

When each of the three learners have accessed the education server, the latency rate for PDA user and packet loss rate for Notebook user are evaluated. In addition, in comparison with Desktop Users, the identified degree of satisfaction for PDA and Notebook users is much lower for E-Learning.

Fig.5 presents PDA user's latency rate and packet loss rate.

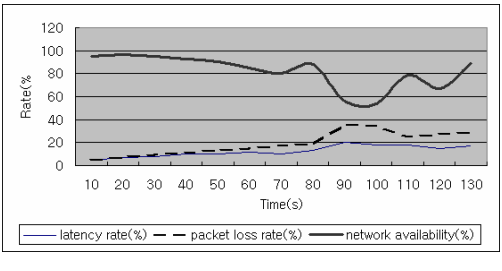

Fig. 5. First Learner's latency rate and packet loss rate

In fig.4, PDA user's network availability is unstable. However, the PDA user who received optimized-content demonstrated stable network availability.

Fig.5,6 presents desktop and notebook user's latency rate and packet loss rate.

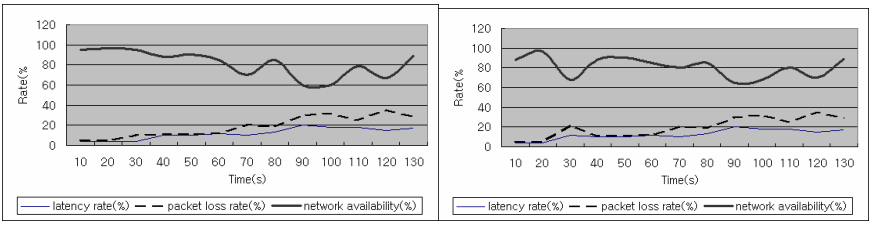

Fig. 6. Second and Third Learner's latency rate and packet loss rate

As presented in Fig 4,5,6, it can be confirmed that the same learning content is used, even though different learning devices are used, and different environments exist. Table 3 presents adapted video data for each device.

Table 4. Adapted video data for each device

	Video Stream Size(kbps)	Buffering Time
PDA(802.11a, 320*240, 64Mbyte RAM, X scale-400 Mhz) – Wireless	128Kbps	15sec
NoteBook (802.11a/b/g, 1024*768, 256Mb, Pentium M 1ghz) - Wireless	192kbps	12sec
Desktop Pc (100M bps, 1024*768, 512Mb, Pentium 2.0Ghz)	500kbps	5sec

Table 5. Evaluation Results

Effectiveness	Efficiency	Satisfaction
Effectiveness is evaluated about the ability of successful execution of given test by users.	Efficiency is about the use of physical and mental resources which users consume to achieve specific objectives.	Satisfaction expresses the degree of user's satisfaction with offered tool, application and service.
Achieved Learning : 100%	Attempt Num : 50 Achieved ratio : Mobile : 87% Desktop : 100%	Mobile : 85% Desktop : 83%

Though the proposed system, learning content is adapted to various devices, and learner received optimized learning content from distributed Education servers.

Finally, in order to confirm whether two functions as stated above deliver the learning data which learners wish through learner-centered methodology, we evaluate it based on the following evaluation factors. 1) Effectiveness: in the relevant definition of usability of ISO 9241, Effectiveness is evaluated about the ability of

successful execution of given test by users. 2) Efficiency: Efficiency is about the use of physical and mental resources which users consume to achieve specific objectives. 3) Satisfaction: Satisfaction expresses the degree of user's satisfaction with offered tool, application and service. 4) User Feedback: it's a sincere discussion about evaluation of service after user receives offered service. This table shows evaluation results. (Candidate Num : 100, Mobile:80%, Desktop: 20%)

5 Conclusion

In this paper, a learner modeling mechanism for a ubiquitous learning environment is proposed, and the dynamic reconfiguration mechanism of the learning object is presented. The contribution of this paper is as follows.

1. Correct judgment of learning situation, making use of a variable model
2. Reuse of distributed learning objects
3. Delivery of learning content without learning device awareness
4. Adaptation of learning content by considering the learning environment
5. Reflection of systematic learning model for ubiquitous learning environment

Through this merit, learning technology suited to a Ubiquitous environment is developed and, using this, learner centered learning can be effectively delivered. However, although this effective learning model is applied, the system is still in the evaluation stage of development.

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