

# A Study on Design and Implementation of the Ubiquitous Computing Environment-based Dynamic Smart On/Off-line Learner Tracking System

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**Abstract**—In order to provide a tailored education for learners within the ubiquitous environment, it is critical to undertake an analysis of the learning activities of learners. For this purpose, SCORM (Sharable Contents Object Reference Model), IMS LD (Instructional Management System Learning Design) and other standards provide learning design support functions, such as, progress checks. However, in order to apply these types of standards, contents packaging is required, and due to the complicated standard dimensions, the facilitation level is lower than the work volume when developing the contents and this requires additional work when revision becomes necessary. In addition, since the learning results are managed by the server there is the problem of the OS being unable to save data when the network is cut off.

In this study, a system is realized to manage the actions of learners through the event interception of a web-browser by using event hooking. Through this technique, all HTML-based contents can be facilitated again without additional work and saving and analysis of learning results are available to improve the problems following the application of standards. Furthermore, the ubiquitous learning environment can be supported by tracking down learning results when the network is cut off.

**Keywords**—u-Learning, e-Learning, Event Hooking, Content packing

## 1. INTRODUCTION

Since the beginning of Internet learning in the early 2000s, the e-learning industry has endeavored to improve learning efficiency while their standards for effectiveness still maintain the status quo. However, web-based e-learning through the Internet or Intranet has time-spatial, contents, and structural flexibility that provide as much freedom of choice as possible and enable self-regulated learning of contents and tools for learners, resulting in greater possibilities for advancements in tailored and individual-types education as the core value of e-learning [1]. The standard for e-learning, SCORM 2004 Sequencing & Navigation, uses identical learning objects to design and apply various interactions between particular learning objects, and by guiding the learning flow it tracks down and evaluates individual interaction between the learner and learning object to display the possibilities of individual adaptive advice learning [2].

However, e-learning has the following problems as well. The web-based courses used in one LMS (Learning Management System) cannot be used in different LMSs and web-based objects

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cannot be reused in mutually different LMSs. According to its standardization dimension, [SCORM (Sharable Content Object Reference Model), it is easy to maintain, service and re-use of the contents[3].

Second, the instructor has the fear on new medium and has no time to spare. On this matter, the system has to be easily available and able to observe the real time evaluation result[4]. Third, existing f2 is mostly learning or spray of push method that is frequently the case of the level of displaying substantial information. Accordingly, learner undertakes superficial learning and instructor is unable to measure whether learning appropriately completes the class. Lastly, learning has to facilitate various standards to undertake necessary, and activity under the various systems generates individual learner information on each system for integrated management that there is an integrated management of learner information for possible search that can be facilitated in learning in the days to come[5, 6].

In order to provide tailored and individual-types of education in accordance with the core value of e-learning, analysis of learning activity of learners is critical. Under standards like SCORM, IMS LD [7], the applicable functions are provided but it also presents certain problems of requiring contents packaging and decreased facilitation levels due to dimensional complexities. In addition, the learning results are managed on a server on which it is impossible to store the contents of learning when the network is cut off. In this context, by hooking the event of the web-browser, learner activity is managed and the HTML-based contents are re-facilitated without additional work such that learning results can be tracked down when the network is cut off.

This study is organized as follows. In Chapter 2, existing studies are described for maintaining and managing learner information, and in Chapter 3, we present the learning progress checking methods available for application using the standard and non-standard methods. In Chapter 4, we describe our conclusions and future studies.

## 2. PERTINENT STUDIES

In order to provide tailored education through learner information, there is a need for a communication method between the learner and Learning Management System (LMS), and for this purpose, various standard methods of information exchange have been studied and the SCORM Run-Time Environment (RTE) has been proposed [8, 9].

### 2.1 SCORM RTE

The management function of the SCORM RTE can basically be divided into three parts. First of all, the launching management part defines the general method that will be used to begin the content objects of the web-base using LMS. The API communication part is the communication mechanism to recognize LMS under the conceptual communication conditions between the LMS and content object(s) and it undertakes communication between LMS and SCO, data inquiry and classification functions. Lastly, the RTE Data Models are the data required to retrieve the data generated from SCO to LMS and/or save it thereto [10]. The conceptual diagram of the SCORM RTE is shown in Fig. 1.

SCORM has to contain the learning content objects of SCOs and assets. SCOs have to express an education objective and the resources required to support the objective. Launch defines the loaded contents object procedure on structuring the communication between LMS and the sup-

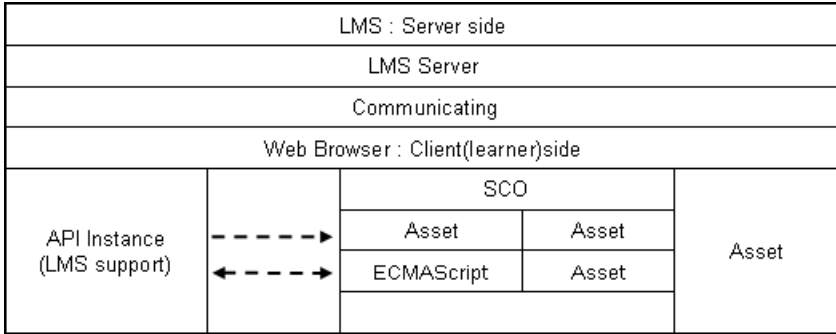


Fig. 1. Conceptual diagram SCORM RTE

ports thereof. The communication mechanisms are standardized in a common API. API informs initialization, network cut off or error and it is the communication mechanism for scores and time limitations used in data extraction and saving between LMS and SCO [4].

The Data Model is a group of standardized data model elements. It is used to define the information to track down scores using the evaluation of progress, quizzes and/or tests on an SCO. LMS has to maintain the condition of the data model element of the SCO under the learner session and the SCO has to use the data model element already defined for guaranteeing their reuse by several types of systems [3].

2.1.1 Data Model of SCORM RTE

The RTE data model includes the collection of data model elements for the SCO to track down under LMS. The data model elements can be used for the tracking lists, such as, status, scores, interaction, objective and the like. A few run time environment data model elements influence the control of other SCOs when used for the same lesson or course.

When an SCO is under the implementation status, the LMS and SCO communicate in accordance with the data model aggregation designed under IEEE LTSC CMIP1383.11. The RTE data model is divided into 24 categories and each has the element and attribute respectively.

2.1.2 Tracking Method of Learning Result

Under SCORM RTE, the data model of CMI (Computer Managed Instruction) is used to track learner activity. CMI has to use the computer to manage the learning/teaching process that it is more widely used with the term LMS (Learning Management System).

In order to exchange the CMI data model with the SCORM RTE, the CMI data related Javascript already defined under the contents has to be described. The data flow chart is shown in Fig. 2.

In order to exchange the CMI data model, the following must be within the contents.



Fig. 2. Conceptual diagram SCORM RTE

```

<script language="javascript">
storeDataValue(key, value); // CMI data Store
var value = retrieveDataValue(key); // CMI data retrieve
</javascript>
    
```

The java script of APIWrapper.js defines the functions of storeDataValue(key, value) and retrieveDataValue(key). When the applicable javascript is called from the contents, the javascript calls the applet and the applet calls LMS CMI Servlet in turn to exchange with the CMI data.

## 2.2 IMS LD (Learning Design)

IMS LD is completed through integration with the present IMS dimensions like IMS Content Packaging, Metadata, and Simple Sequencing [11]. IMS LD has expanded the IMS Content Packaging dimension to make it the basic framework, but it has not expanded Metadata and Sequencing [12].

IMS LD has the purpose of supporting group learning, cooperative learning, and mixed learning. In addition, it provides the learning design and exchange between systems, re-use of learning design and learning data, partial re-facilitation of learning design of individual learning activities, role and others, accessibility, tracking, reporting and performance for improved analysis function by facilitating the attributes of the human role and learning design [13, 14].

With the changes regarding the e-learning standardization paradigm, the data exchange between existing contents and learning platforms like LMS have been expanded with the data exchange of all systems used in the learning service, and the scope of packaging of e-learning contents has expanded into broad digital resources including the evaluation inquiries [15].

This also has the same context with the flow of e-learning and it has changed from regular education courses to irregular and ordinary learning with importance, process-orientation to learning object-orientation, cooperative work and emphasis on cooperation. For this purpose, the ‘Learning Design Summit’ held at the Open University in the Netherlands in November 2006 introduced the CopperCore(web engine), an LD engine, that supports the ‘Learning Design’ dimension [16].

### 2.2.1 CopperCore v3.2

CopperCore v3.2 does not apply standard methods like SCORM CMI, and the user has to use the Property element onto the imsmanifest.xml file that expresses the LD dimension contents for meta data, sequencing and others to define the data to track learner activity. The data flow chart is shown on Fig. 3.

In order to exchange the property data from the contents, the following definitions are given.

```

Saving the property data
Retrieving the property data
    
```

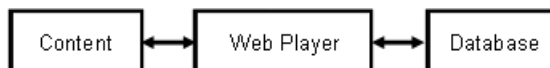


Fig. 3. The data flow chart of CopperCore

CopperCore support XHTML that the XML element defined on the contents is applied with the XSL document as designated by XML PI (Process Instruction) to convert into HTML href, Form tag and others to enable HTTP communication.

The WebPlayer servlet receives the HTTP packet by the GET method, and if the RequestID value is 3010, it parses the HTTP packet to save the property data existing in the applicable contents.

Example) WebPlayer?requestID = 3010& ...

On WebPlayer servlet, the CMI data of SCORM for the retrieveDataValue part does not exist. However, 'private static final int Get\_CONTENT = 2005;' is defined that the HTTP packet is received in the GET method to have the part defined in the '<view-property ref =“key”>' form to generate HTML dynamically by parsing from the web server to send.

### *2.2.2 Non-standard Method*

Non-standard RTE defines the data to track learner activity for each of RTE providers and the individual method exists to exchange the data. Under the non-standard method, it describes the javascript on the contents and the applicable javascript exchanges the data through the HTTP communication with the RTE engine.

## **3. DESIGN AND IMPLEMENTATION OF THE DYNAMIC SMART ON/OFF-LINE LEARNER TRACKING SYSTEM (POCKET RTE)**

Under this study, the message interception of web-browser under the on/offline condition is used to implement the system that tracks learning results and learning information of learners, and it links LMS and learner to enable the unyielding learning support by linking with the integrated system under the online condition.

The characteristics of the proposed system are shown as follows. First, tracking and saving of the learning record is possible under the offline condition, and in the event that it becomes the online condition, it is possible for ceaseless learning support through the connection with the integrated learning management system through middleware synchronization. Second, without separate revision work on the already produced contents, a basic learning record check is available for progress rate, book mark and others. And, lastly, it supports not only the HTML document but also the various formats mainly used in learning, such as, Flash, Media and others.

### **3.1 System Configuration**

#### *3.1.1 Learning management module*

The learning management module undertakes the role of importing and deleting the contents and checking the progress status of learning. The contents format used in learning is mostly HTML, Flash, Video and others that the management of contents differs depending on the format. In the event of the HTML format, it is configured in several pages to package in the Zip file format to import in principle. Under this thesis, Unlike SCORM or IMS LD, it does not require imsmanifest.xml that expresses the meta data separately and in the event of the contents id and

zip (binding HTML) through the file information with the import of contents, the core information of total number of pages is extracted to facilitate as the meta data.

### 3.1.2 Contents view built-in with the tracking module

The contents view is configured in three HTML Viewers, Flash Player, and Media Player depending on the format, and it includes the tracking module of learning record data that the tracking result of the data generated while learning through the contents view is saved on the Embedded DB.

The key method of tracking the learning record data is the message interception algorithm. The message is generated when a learner uses the web browser included in HTML Viewer and the message interception is to intercept this message to monitor the contents of use. However, it does not use the tracking of learning record data by intercepting all messages of the web-browser and it interprets only the messages requested for Navigate on already defined virtual URI as extracted for the learning record data. The web-browser reacts to the applicable message to cancel the message not to have the actual Navigate movement.

### 3.1.3 Synchronization module

Under the online condition, the learning record data saved on the embedded DB is synchronized with the integrated learning management system through the synchronization module, and it enables the ceaseless learning of the learner through it as well as possible learning through various devices. The configuration diagram of the RTE engine proposed by this thesis is shown in Fig. 4.

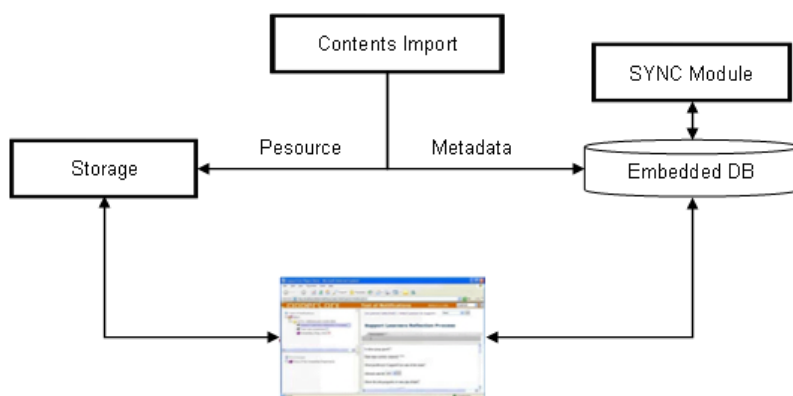


Fig. 4. RTE engine (with Viewer, Tracking module)

## 3.2 Learning record data

Under the proposed system, there is no data model for tracking the activities of learners, like CMI of SCORM. However, the learning record data basically has the required element possible for tracking without separate revision works and the selective element to additional track by processing the contents depending on the user definition.

### 3.2.1 HTML

Table 1. Essential configuration element

Element	Description
1. Rate of progress	Calculate the total pages of HTML document for the Zip packaged learning contents and how many pages of HTML document is seen from them
2. Book marking	HTML pages finally learned
3. Frequency of learning	Frequency attempted learning of the contents
4. Total learning hour	Total learning hours learned from the contents
5. Final learning hour	Final learning hours

### 3.2.2 Selected configuration elements

The HTML Tag, Javascript and others that may generate specific navigation events from the web-browser are inserted into the contents; it tracks the learning results of the learner. Under this notion, since there is no CMI like SCORM and no property that a user may define under the meta-data like IMS LD, it defines the element of the learner record upon the first request for the Set of learner record data. If the non-existing element is called to retrieve (Get) from the contents, this case also defines the learning record data and the initial value to be null.

Table 2. Flush

Element	Description
1. Rate of progress	Calculate the total number of frames for the Flash format of contents and how many formats are seen from them
2. Book marking	Frames finally learned
3. Frequency of learning	Frequency attempted learning on the contents
4. Total learning hour	Total learning hours learned from the contents
5. Final learning hour	Final learning hours

Table 3. Media

Element	Description
1. Rate of progress	Calculate the total number of duration for the Media format of contents and how many positions are seen from them
2. Book marking	Positions finally learned
3. Frequency of learning	Frequency attempted learning on the contents
4. Total learning hour	Total learning hours learned from the contents
5. Final learning hour	Final learning hours

## 3.3 Implementation of tracking the learning record data

### 3.3.1 Contents

Without separate revision work, the required configuration element can be tracked down and the selective configuration element is inserted into the contents for HTML Tag, Javascript and others that may generate a navigation request from the virtual URL of the web-browser.

Saving the learning record data

```
function SetData(identifier, value)
{
location.href="file://dummy.htm?cmd=SetData&identifier="+ identifier + &value="+ value;
}
```

Retrieving the learning record data

```
function GetData(identifier)
{
location.href="file:// dummy.htm?cmd=GetData&identifier="+ identifier;
}
```

Navigate request is the event not a function that the data cannot be retrieved, and accordingly, it is processed by the agent to call for SetDataValue.

Callback function of retrieving the learning record data

```
function SetDataValue(identifier, value)
{
// Process the retrieved learning record data
}
```

### 3.3.2 Message interception

```
CString m_strDummyPage = _T("file:///dummy.html");

void BeforeNavigate2(
IDispatch* pDisp,
VARIANT* URL,
VARIANT* Flags,
VARIANT* TargetFrameName,
VARIANT* postData,
VARIANT* Headers,
VARIANT_BOOL* Cancel)
{
if (URL->vt == VT_BSTR)
{
CString strURL = URL->bstrVal;
```



```

// Inspect the navigate request for permit on virtual URL
if (IndexOf(m_strDummyPage, strURL) == -1)
{
// In the event that it is not a navigate request on virtual URL
// Process the required configuration element in the event of URL included in the application cable con-
tents,
...
return;
}
// In the event that there is a Navigate request on virtual URL
// Process for selective configuration element by extracting the learning record data of learner, Embedded
database related work

CString strGetData;
CString strPostData;

if (IndexOf(_T("?"), strURL) == -1)return;

CString strGetData = Replace(strURL, m_strDummyPage + _T("?"), _T(""));

if (PostData->vt == (VT_BYREF|VT_VARIANT))
{
CComVariant varPostData(*PostData->pvarVal);
varPostData.ChangeType(VT_BSTR);
CString strPostData = varPostData.bstrVal;
}

...
}
}

```

The essential configuration element (progress rate, book marking, frequency of learning, total learning hours, and final learning hours) and selective configuration element (identifier, value) are used in the synchronization by inclusion onto the data structure of a 2D character arrangement ([ ][2]).

```

// Upload the learning record data
int UploadData(char *contents_id, char ***pppszData);
// Download the learning record data
char ***DownloadData(char *contents_id);

```

## 4. CONCLUSION

Under this proposal, even under the off line condition, the message of the web-browser is intercepted to realize the standard to track the learning results and learning information of the learner. The data flow chart is shown on Fig. 5.

The system proposed under this idea has the following characteristics. First, even if there is no processing done on the contents, it may track progress rate, frequency of learning, total learning hours, final learning hours and the like. Second, in the event of inserting specific code, such as, HTML Href Tag and others, that generate a message from the web-browser on the contents, it may track various learner activities. And lastly, the message interception module is saved by processing with the data to track the learning result by intercepting the Navigate message of the general web-browser and exchanging the data through this.

Through the foregoing, it is possible to ceaselessly track learner activity and confirm learning progress in order to provide tailored learning contents. When applying the standards, the existing methods require packaging with low facilitation levels since the complexity level is high, and when developing the contents, it requires additional development and requires revision when modifying the contents. In addition, even in the non-standard method, the development is easy but has low portability, and since it tracks learning results through the user defined script, it has the weakness of allowing movement only on an individual engine. The proposed thesis solves the above problems and provides high portability without requiring additional development, and it realizes the system with possible tracking of learning results when the network is cut off.

By analyzing not only the actions related to checking on the learning progress but also the behavior patterns and type for learner to undertake in its device in the future, the extract engine is realized through the learner activity to analyze the learning contents and behavior patters to undertake the study for expanding individualized and tailored education. Through this effort, the environment can be structured to heighten educational effects and level of satisfaction.

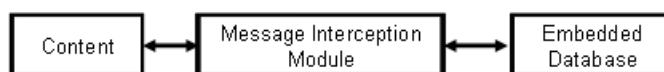


Fig. 5. The data flow chart of Pocket RTE

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