The Integrated e-Learning System-RAPSODY Based on Distance Ecology Model and Its Practice

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ABSTRACT
The modern information technology society is starting to increasingly demand computer - and information communication literacy from all its members, disregarding their actual social background or working place. Our main research goal is to propose a framework for and, moreover, develop, an integrated e-Learning system, called RAPSODY. In this paper, we describe briefly the structure, function and mechanism of RAPSODY based on the Distance Ecological Model. We focus on discussing the educational meaning of this model with regard to the new learning ecology, based on multi-modality and new learning forms and situations. We also report about our experiences with the introducing of our practical program, as well as about the framework, settings, actual implementation and first results. The target objective of this program is the harmonization of university level educational research, society practice and practical business. We analyze these results and the problems we encountered, as well as offer constructive solutions.

Keywords
E-Learning, Distance Ecological Model, Learning Object Metadata (LOM), Adaptive Learning Environment

Introduction
The new information and communication technologies bring with them rich and useful opportunities, among others, for self-development (L.G. Salvador 1999, A. Chan et.al. 2001, A. Metcalfe et.al. 2001, C. Allison et. al. 2001, J. Correa 2001). On the other hand, new skills and knowledge are constantly required to keep up with the IT society. Therefore, new competencies should be fostered to actively respond to these society demands (M. Slomen 2001, M. J. Rosenberg 2001). In the e-Learning world, the various kinds of learning materials and information can be stored as digital multimedia, in form of pictures, videos and sound tracks (T. Okamoto 2000a, A. Lugmayr et.al. 2001). Moreover, by using the network environment, it is possible to make use of all resources over the net, without any constraints or restrictions of time or geographical location (G. Kimovski et. al 2001, V. Papaioannou 2001). With this premises in mind, we are developing and extending an integrated e-

In the first part of this paper, we explain the fundamental structure and the functional features of RAPSODY; the second part contains the case study of a cooperative practice between the university of Electro-Communications and some companies. During the practice sessions we have used several synchronous functions offered by RAPSODY, such as TV-conference, a chat tool and Web materials related to the teaching objectives (T. Okamoto 2000a, T. Okamoto 2001b). Via RAPSODY, students can attend an instructor’s lecture and participate in question and answer sessions from several remote sites. Afterwards, students can re-watch this lecture via the recorded archive data (with movie, sound and Web materials). Such a learning environment is set up with the help of a Guide-Script defined by a teacher or instructor. We also define the learning object, which is identified by three aspects (represented as dimensions) in RAPSODY. The system tries to set up the appropriate e-Learning environment. Each learning object metadata (LOM) is described in the “CELL” model. In this practice, we incorporated real-time TV-conference, a Chat window and Web materials as learning objects included in a “CELL”.

RAPSODY Distance Ecological Model Rationale

Figure 1 shows the conceptual framework. RAPSODY is an integrated guidance system that can logically connect individual learning units. Its principal idea is to use a “CELL” corresponding to the LOM proposed by IEEE-LTSC (IEEE-LTSC 2000), and to fulfill two main goals: to represent the educational meaning within the distance learning environment and to share digital learning materials. In RAPSODY, we approach the fulfillment of these goals by creating a model intentionally focused on three primary aspects: learning goals, learning contents and learning media. We call this conceptual scheme the Distance Ecological Model (T. Okamoto 2001a). The word “Ecological Model” in this context means multi-modal “learning environment”, as well as a closed system, representing totality or pattern of relations between actors (learners, tutors) and their environment. This concept is intended to underline the importance of free accessibility to learning goals, learning contents and learning media/environment according to a user’s need anytime and anywhere. We therefore use the term ecological model in its wider sense.

![Figure 1. Conceptual framework of RAPSODY](image-url)

Next to the attributes representing the three primary aspects, each CELL has also several other attributes (slots), e.g., material features, available tools, related CELL(s), Guide-Script, etc. (Table 1). From a learner’s point of view, this model is transparent and has the role to identify and select appropriate learning conditions according to the user’s requirements and needs (similar to the MAO – motivation, ability, opportunity - model; W.D. Hoyer and D. Machins 2001) and guide the user towards an adequate Learning Object (CELL). This system can also logically link these CELLS according to the user’s dynamic individual learning needs and conditions. The Distance Ecological Model is built on three aspects. The first one represents the learning goals in terms of the...
curriculum. The second one stands for the actual curriculum contents (subject-contents). The third aspect’s
determines the favorite learning media (form), e.g., VOD (Video on Demand), video-conference, distance
learning or education etc. By selecting a position on each of the three main (virtual) dimensions, a certain CELL
is selected. The CELL concept in the Distance Ecological Model is crucial, due to the fact that it brings into
existence the learning scenario. This contains information on how to satisfy the learner’s needs, the learning-
flow structure of subject materials and navigation guidelines for self-learning. Here it is necessary to remark that
the resulting 3-dimensionality is only emphasized for the sake of a better visual representation and that
proprieties such as, e.g., distance in 3D space, do not apply. Moreover, the model contains a hidden multi (3+)-
dimensionality, if we also consider the secondary attributes. In other words, a CELL consists of several slots,
which represent the features and characteristics of the Learning Object. The most important CELL slot is the
“Script” slot, describing the instruction guidelines of the learning contents, the self-learning procedure, and so
on.

<table>
<thead>
<tr>
<th>Frame-name:</th>
<th>Slot-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning objectives for a learner</td>
<td>Subjects which should be understood</td>
</tr>
<tr>
<td></td>
<td>Subjects which should be mastered</td>
</tr>
<tr>
<td>Subject-contents</td>
<td>The unit topic</td>
</tr>
<tr>
<td>Learning form</td>
<td>The prepared learning environment</td>
</tr>
<tr>
<td>Evaluating method</td>
<td>The learners’ evaluation method</td>
</tr>
<tr>
<td>Useful tools</td>
<td>The software used for the learning activity</td>
</tr>
<tr>
<td>Operational manual of tools</td>
<td>The software operation method used for the learning activity</td>
</tr>
<tr>
<td>Prepared media</td>
<td>Media which can be used in the learning process</td>
</tr>
<tr>
<td>Guide-Script</td>
<td>The file which specifies the dialog between learner and system</td>
</tr>
</tbody>
</table>

Table 1. Various attributes

In the following, we will explain the meaning of the prepared learning environment in more details.

The Operating Flow in RAPSODY

The system aims at supporting self-learning. Therefore, the system has to first recognize a CELL,
corresponding to the learners’ needs. Then, the system has to set up an effective learning environment, by
finding proper materials and calling the Guide-Script contained in the above CELL. Consequently, the system
presents both Retrieving and Interpreting functionality. Figure 2 shows the system architecture part related to the
guidance and learning support process.

![Figure 2. System architecture part related to the guidance and learning support process](image-url)
The system’s executing steps are as follows:

STEP 1: Record the learner’s needs.
STEP 2: Select a CELL in the Distance Ecological Model based on these needs.
STEP 3: Interpret the CELL information in the guidance WM (Working Memory).
STEP 4: Perform the interactive learning session dialog with the learner according to the Guide-Script in the guidance WM.
STEP 5: Store the log-data of the dialog. The log-data collects information on learning histories, learners’ needs and behaviors.
STEP 6: Provide the needed and useful applications for the user’s learning activities and set up an effective learning environment.
STEP 7: Give guidance-information, according to the CELL script guidelines, and decide on the proper CELL for the next learning step.

Next, we will look at the user-system dialog mechanism. We have created a special Guide-Script description language (GSDL) to support this dialogue, as well as an interpreter that reads it. This GSDL is alike the well-known Web HTML (Hypertext Markup Language) and is defined by some tags and a simple grammar for document interpretation. The interpreter understands tag meanings and interprets the contents. The GSDL description form is shown in the following:

(1) <free> ::= description of text (instruction)
(2) <slot (number)> ::= a link to a slot value in the CELL
(3) <question> ::= questions to a learner
(4) <choice> ::= branching control according to a learner’s response
(5) <exe> ::= call to relevant CELLS
(6) <app> ::= applications for learning activities (Tele-Teaching, etc.)

A Cooperative practice between University and Industry via RAPSODY

Here, we will describe a practical e-Learning session conducted via RAPSODY. The e-Learning program we designed is based on the cooperation between industry and university. The short-term objective of this program is the completion of a learning environment especially targeted at (upstanding) society members coming from various backgrounds, such as business, industry or university. For the long term, this program envisions the connection and harmonization of educational research done by universities on one side, and society practice and practical business on the other. Specifically, the program aims at offering the university student access to the practical business point of view (i.e., practical knowledge) on one hand, and at offering the industry (or company) employee a self-improvement opportunity by gaining access to higher education and knowledge. In this way, we are promoting an educational collaboration program that binds university and industry.

The goal of the educational program we present is not the creation of a new large-scale curriculum, but the expansion and enrichment of the preexisting graduate school level curriculum, by adding professional knowledge (e.g., of company employees’), with the specific target of enabling practical, efficient re-education (T. Okamoto 2000a, C. Bennett 2001).

The Japanese Ministry of Education appointed the University of Electro-Communications (UEC) with the enacting of this cooperation program between Industry and University (MEXT 2001). The target learners are industry people as well as regular students from the graduate courses of the university, who wish to learn about new Information Technology (IT) issues. The emphasis lies on advanced IT topics. The actual program execution involves the extension of the existing curriculum towards more flexibility, in contents as well as in form, in order to create adequate learning conditions that can also accommodate industry persons. Therefore, the implementation method is via long-distance Internet courses, which allow business and industry people to take courses from far sites, without leaving their working places. Moreover, the Internet method allows for flexible hours. Other three universities were appointed to start parallel projects in complementary fields.

We report about our experiences with the introducing of this program, about the framework, settings, actual implementation and first results. We analyze these results and the problems we encountered, as well as offer constructive solutions.
Subject-related matters

For the starting courses of the program we have chosen the subject of career development (aiming at acquiring experience and knowledge) in the field of information communication technology. This is an important subject for the future information communication society. The lectures were focused on information technology, large-scale information system planning and application, and network technology. For the first year, the courses involved the following topics:

- Multimedia Communication Technology
- Information Security

The appointed lecturers for the industry and university cooperation program are not only researchers and professors from our UEC Graduate School, but also company researchers and implementers. This decision was taken owing to the fact that it is important for learners to acquire knowledge about both theoretical and practical side of information systems.

The lectures are held as collaborative lectures of the type called “omnibus” (each lecturer presents only one lecture). Although this new curriculum is of a flexible nature, with many evening hours (to ensure easy participation from far sites) and a relatively concentrated information contents given over a short time period (again, to ensure that company workers, who have a stricter program, don’t have to skip too many regular working hours to follow this program), the UEC Graduate School has established a regular credit system for certification purposes. This certification level of is at Master level.

Experimental situation

Here we report an example situation of a lecture entitled “Multimedia Communication Science, Technology and Application”. The syllabus of this lecture includes: multimedia and distributed cooperation, CSCL (collaborative system collaborative learning) and collaborative memory, multimedia communication technology, ATM networks, new Internet technology, media representation form and application, data mining, multimedia and distributed cooperation learning support systems, knowledge management, standardization and new business models. The total number of learners attending the lecture was 63, among whom only 13 were curriculum students. The cooperating distance company sites were located near Tokyo, in the Kanagawa prefecture.

The remote companies were linked via Internet or ISDN, therefore establishing a real time bi-directional information transmission and reception environment (details in the next section). Figure 3 displays the geographical distribution of the distance company sites.

![Figure 3. Geographical distribution of the distance company sites](image)
The shortest (physical) round trip time for the closest site to UEC is of 2 hours by public transportation, and of about 6 hours for the furthermost. Therefore, considering the hours of time saved and the convenience of the distance education method, the system presents evident merit for students from far company sites as well as company managers.

Distance education system configuration

According to many researchers (B. Collis 1999, C. Karagiannidis 2001, N. Chen et.al. 2001, P. Nieminen 2001), it is necessary to provide a lecture environment that guarantees the distribution of lecture movie, sound and materials to the attending learners, as well as a dialogue function supporting the communication between lecturer and learners. We have implemented these functions with the help of two servers: a VOD and a WWW server (T. Okamoto 2000b). Figure 4 shows the system configuration of the distance learning system.

![System configuration of the distance learning system]

Each site has to configure their transmission server and viewer. Each distance lecture site establishes two dedicated channels: receiving-only and sending-only. By connecting respectively the lecture classroom transmission with the distance site reception and the distance site transmission with the lecture classroom reception, bi-directional communication is implemented. Below, each function is outlined.

1) Transmission function of lecture’s movie and sound: the movie and sound information of the lecture is distributed to the attending sites via the VOD server real-time transmission function. For some of the companies, their Internet access (and therefore, transmission and reception) is not free. To cope with such a network environment, we had to ensure a dedicated Proxy server that relays the distribution of lecture movie and sound between Internet sites, to ensure good data reception. Learners at far sites attend lectures by viewing the lecture movie and sound data distributed by the VOD server.

2) Lecture material presentation function: the lecture materials are formatted as HTML (Hypertext Markup Language) sources and offered to learners via the WWW server. Learners use the WWW browser to access the lecture materials and to follow the lecture progress by referring the appropriate page.

3) Dialogue (chat) function: a CGI (Common Gateway Interface) program written in Perl (Practical Extraction and Report Language) ensures the communication between lecturer and learner. Lecturer and learners access the CGI program via the WWW browser and perform a question and answer (Q&A) session via the chat terminal screen.
One problem appearing is that the data sending and receiving conditions depend on the network traffic conditions. If delays appear during reception, far site learners have difficulty in following the lecture, sometimes even failing to understand the lecture contents. Therefore we have created a bi-directional communication channel between lecture site and far sites. In this way the communication channel between lecturer and learners is guaranteed, independent on the Internet network conditions. Figure 5 shows the distance lecture environment structure (lecture site -> far sites) as well as the interfaces of both lecturer and learners. As can be seen in the figure, the lecture manager transforms the lecture materials into a HTML form and stores them into the lecture materials database.

**Figure 5.** Distance lecture environment structure and the interfaces of both lecturer and learners

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**Figure 6.** The main menu of the lecture site and the registration window of the attending sites
Figure 6 displays the main menu of the lecture site and the registration window of the attending sites. Concretely, the data recorded are: the machine name (organization name), VOD server IP address and port number, and the VOD contents stream identifier. Learners attend lectures (Fig. 6) via our distance lecture environment interface. First they have to press the lecture movie “reception” button in the main menu. The system then inquires for the movie to display.

After selecting the option “lecture site -lecture movie”, the system pops up the “lecture movie transmission” window and starts the real-time transmission (Fig. 7). Moreover, when clicking the main menu’s “lecture materials presentation” button, the system presents the lecture materials, too. Learners can browse the lecture material via the buttons “advance” and “return”. To enable the Q&A session, the lecturer has to select the dialogue tool “startup” from the main menu, action that will generate a “chat” window.

Lecturers attend lectures via a similar procedure as the learners. First they press the lecture movie “reception” button in the main menu (Fig. 6). If the learners’ far sites are equipped with VOD server, video camera, microphone and movie encoder, it is possible for lecturers to also receive image (and sound) transmitted by the learners attending the lectures. Similarly to the learners, the lecturer can access this received data by using the movie receiving function. Moreover, when multiple far sites can transmit, the lecturer can select the site from which to receive data, as well as switch between them. Q&A sessions are possible in the form of full movie and sound exchange, chat (in text format), or via the regular telephone line.

Evaluation of the Industry and University Education Cooperation Program

The evaluation of the program focuses on how many of the objectives stated in the introduction were actually achieved; evaluation was performed from 3 points of view enumerated below:
1) Science and technology aspect: Here we analyze the operations, functions and transmission and reception of lecture movie and sound data.
2) Educational aspect: Here we examine the meaning and significance of the distance education lecture in the frame of the industry and university collaboration project, via questionnaires filled-in by learners.
3) Application and organizational aspect: Here we collect information from administrators participating in the same program; the focus is on possible improvements of the distance education system; the data collection is done via work sheet analysis and interviews.

These evaluation points are meant to inform institutions and organizations trying to introduce similar educational projects about technological, scientific, educational and organizational benefits and possible problems. Some of this information therefore is of interest to educators, some to implementers or administrators. The analysis of the lectures from the above-mentioned points of view is a continuous process. In this section we report the results of points (1) and (2) above.

(1a) Science and technology aspects; evaluation 1: movie and sound data transmission and reception aspect:

We have measured the delays, time-lapses and evolution of the lecture movie and sound data transmission. For this purpose, we have analyzed a situation with 3 sites exchanging VOD data. Each site was respectively connected to the Internet via either a high speed-, or low speed dedicated circuit (maximum rate 128 kbps), or via a business provider dial-up IP link. For the analysis of the transmission, we have collected data from each site about the movie bit rate, movie frame rate and sound bit rate. The maximum real transmission values are, respectively, 48 kbps for the maximum real movie bit rate, 10 fps for the highest real movie frame rate and 13.2 kbps for the highest real sound bit rate.

We will firstly discuss the movie transmission. For movie bit rates of 40 kbps and above, the lecture transmission is stable, with little interruptions, and the frame transmission is of about 5 frames per second. However, we have experienced that for the dial-up connections, reception at the learners’ far sites is of about 1 frame per 10 to 20 seconds. At this rate, the lecture movie transmission window often freezes into a still image for several seconds. Learners attending lectures from such sites complained therefore that movie and sound reception is often asynchronous. Compared with the movie data reception, the sound reception was relatively stable for all participating sites.

The above experimental result shows clearly that for such distance lectures the limitation is given by the movie reception, and that it is recommended to implement distance lecture environments on network circuits allowing maximum transmission capacity of 128 kbps or above. If a provider IP connection cannot be avoided, the distance lecture environment can be improved with a number of adjustments. The first adjustment is related to the lecturer’s actions. The VOD system used in our distance lecture environment complies with the H.261 standard, which bases the movie distribution on information compression via a frame prediction mechanism. Namely, the transmitted/received information weight changes according to the movie data, movie complexity and details, movement intensity, etc. If the lecturer’s actions are various, the transmission data weight grows. However, if the lecturer’s actions during the lecture are moderate, the movie changes are reduced and therefore the lecture movie distribution can become a little more stable. As another adjustment, the creation of a dedicated low speed circuit for the VOD server is necessary. If these adjustments are made, all sites can reach similar bit rate, and the distribution occurs according to the different frame rates. I.e., according to the network bandwidth of the access points, the distribution to high-speed circuit learners’ far sites should be of high rate, whereas the low speed circuit far sites should receive low rate movie and sound data.

(1b) Science and technology aspects; evaluation 2: distance education system operability and functions

We have identified a few possible improvement points concerning lecturing via a distance education system, with focus on application result, operability and function. Table 2 shows the recommended improvements for the distance lecture environment. Some items in the table point to proposed solutions, others to counter - measures, and again others just present situation examinations.

<table>
<thead>
<tr>
<th>Encountered problems</th>
<th>Solutions/ Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web lecture materials are not synchronous with the lecturer indications. If the lecturer is browsing quickly through the material (as often in the second half of the lecture), the distance learners cannot keep up with the current page.</td>
<td>By using applications with a share function, the synchronous display in both lecture room and far sites is possible. One drawback is that the lecturer’s personal browsing through the material is not possible anymore.</td>
</tr>
<tr>
<td>The circuit speeds of the distance lecture sites</td>
<td>Multiple preparations are necessary for correct movie &amp; sound</td>
</tr>
</tbody>
</table>

132
During the Q&A session, the communication quality is reduced by the existent delay between lecture room and far sites. There is no fundamental replacement scheme at present. New infrastructure and communication hardware is necessary. Rehearsal prior to the actual Q&A session is useful (or guidance of session by a chair person).

The phone line Q&A sound problems:
Noise, hauling;
Speaker volume & receiver volume differ.

Noise, hauling are caused by the using of a large combination of equipment
The volume difference can be cancelled by the circuit resistance value.

Table 2. Recommended improvements for the distance lecture environment

(2) Educational aspects evaluation: questionnaire survey

After each industry and university cooperation program lecture we have asked the learners to fill in a questionnaire. The questionnaire contains 21 questions that are a combination of both free description form questions and questions with a 5 steps assessment scale. For the latter, the learners should choose the most appropriate of the following 5 gradations:

5: I strongly think so, 4: I incline to think so, 3: Neither/nor, 2: I incline not to think so, 1: I definitely don’t think so).

As our lecture cycle is not yet finished, we couldn’t aggregate all the questionnaire results yet, and therefore cannot establish conclusive results yet. However, as at present we have finished the first round of lectures, it is possible to derive some suggestions and hints. Questionnaires were anonymous and 38 questionnaires were returned from the 63 distributed.

As the questionnaire (Table 3) average is in general around 3-4, the result can be called satisfactory. Especially, questions Q 4-6 (about learners interest in the subject, the motivating effect of the lectures and about the knowledge they acquired) showed a high score.

Learners had an average of 2.8 preliminary knowledge on the subject (Question Q1). This result possibly points to the fact that learners with no prior knowledge, up to learners with some prior specialty knowledge were all interested in the lecture. As the acquisition of high-level specialty knowledge is the main object of the industry and university cooperation program, this is an extremely important pointer.
A low result was noticeable especially for questions Q10 and Q11 (regarding the far site transmission situation). Therefore, an important sub-goal and improvement point for the next lectures is the harmonization of the transmission with the far sites. As these were the results of the first lesson in the series, such problems were perhaps unavoidable, and the management and synchronization of lecturer, lecture manager, technical supporters, and teaching assistants was difficult to establish. Some of these problems have already been solved in the following lectures of the same cycle, but as the results were not yet analyzed, we present here our first experiences only, to be of use and to serve as a guide to other educators and education implementers worldwide.

Conclusions

This paper proposed the Distance Ecological Model for building an integrated distance-learning environment. This model stands for the networked virtual learning environment based on a 3 aspects -representation, which has on the axes 1) learning goals or competency, 2) subject-contents in the designated subject-matter, and 3) learning media forms). This represents a new framework for the coming networked age. We have mentioned the rationale of our system and explained the architecture of this system via the Distance Ecological Model. Furthermore, we have described a Guide-Script language. The aim of our system is to support learners’ self-learning.

RAPSODY is a platform that provides various kind of learning forms, based on the Distance Ecological Model and according to the learner’s needs, based on relationships between pre-defined Learning Objects. In this system, the function of a Tele-conference with real video/ sound and the shared window of chatting/application software are provided. Therefore, if, after a learner has finished with a certain Learning Object, he/she wants, for some reason, to change the learning media mode from an individual (self) to a collaborative (group) mode, the system will ask the respective group manager for permission to include the learner in the discussion group (and therefore to satisfy the learner’s request according to the Distance Ecological Model). As another example, the system may directly intervene to recommend a transfer to the collaborative mode, for encouraging deeper recognition and understanding for a specific learner, if such a navigation advice message is described in the Guide-Script. In this way, RAPSODY provides an integrated, free environment for distance learning that can adaptively change between self – and collaborative mode according to a user’s needs based on the Guide-Script in the Distance Ecological Model. In this sense, the Guide-Script contains the core information about the stream developed between Learning Objects by reflecting both the learner’s needs and the curriculum relationships.

We have also presented an e-Learning program of the industry and university education cooperation project at our graduate school. This program was controlled under the RAPSODY environment. In this practice, we have highlighted the following points.

1) The implementation method as well as possible problems of the distance lecture environment offering synchronous study possibility at the lecture site as well as far sites, based on bi-directional communication. In this sense we have concretely presented the lecture form, the representation and presentation technique, as well as the implementation of the questions and answers session.

2) The issue of curriculum integration and certification/ recognition of both on-site and far-site learners: learners in the graduate school as well as far site learners achieve credits according to the Master course credit system. Credits can be obtained course-based or program-based. We have also pointed to the merits of continuous learning and self-improvement for company employees, within our program.

3) Moreover, we have discussed and presented our efforts in the direction of building the infrastructure necessary to support lecturing within the industry and university education cooperation program. Specifically, we referred to the prior collection of information, which is to be sent together with the lecture movie and sound transmission. This service packet contains advice and assistance information concerning the lecture contents, the collection and classification of lecture materials, text forwarding, etc.

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