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Implementation of an Agent Based Mobile Education System

Akio Koyama,[†1] Akira Sasaki,[†2] Leonard Barolli,[†3]
Zixue Cheng[†1] and Aiguo He[†4]

The cellular phone is the most popular information terminal which anyone can use freely anywhere and anytime. The cellular phone has now become a necessary appliance for everyday life. By the spread of cellular phone, users can get more information and can use various applications. An interesting application for a cellular phone is the education system. By using cellular phone based education systems, teachers and students are able to communicate with each other anywhere and anytime. Recently, some education systems for cellular phones are proposed (e.g., i-mode). But, the i-mode system has simple functions and the communication cost is high. In this research, we propose a Mobile Education System (MES). The MES is a flexible education system and is based on agent technology. The MES can support the student's learning by downloading the Teacher Agent (TA) into the student's cellular phone. The TA plays an advising role for students, marks the student's answers, and makes communication with Management Agent (MA). The MA supports the teachers for preparing learning materials, exercises and homework. Also, it performs the student's score management. We implemented the proposed system by using Java and Perl languages. For the evaluation, we used the packet communication cost as a parameter. The system evaluation shows that MES cost is about 4 times lower than the Homepage Based System (HBS) cost. In order to investigate the proposed system performance, we prepared a questionnaire and investigated some students and teachers who used the system. The investigation evaluation shows that the proposed system is a very useful education system for students and teachers.

1.   Introduction

The cellular phone is now the most popular information terminal which anyone can use freely anywhere and anytime. In Japan about 60 million people have cellular phones and it is predicted that in 2003 there will be about 80 million. The cellular phone has become a necessary appliance for everyday life. In January 2001, NTT DoCoMo started a new service for Hyper 503i series [1] which has a K Virtual Machine (KVM) [2] and is also able to run Java applications.

By the spread of the cellular phone, users can get more information and can use various applications. An interesting application for a cellular phone is the education system. By using cellular phone based education systems, teachers and students are able to communicate with each other anywhere and anytime. Recently, some commercial based education systems that use

cellular phone are proposed [3]. These systems provide a choice type question list in the web page using Common Gateway Interface (CGI). However, these systems have simple functions and the communication cost is high. Therefore, new education systems which can support an effective education and have a low communication cost should be developed.

In this paper, we propose a Mobile Education System (MES). The MES is a flexible education system and is based on agent technology. The MES has a two way communication, which is suitable for cellular phones. It can support the student's learning by downloading the Teacher Agent (TA) into a student's cellular phone. The TA plays an advising role for students, marks the student's answers, and makes communication with Management Agent (MA). The MA supports the teacher for preparing learning materials, exercises and homework. Also, it performs the student's score management. We implemented the proposed system by using Java and Perl languages. For the evaluation, we used the packet communication cost as a parameter. The system evaluation shows that MES cost is about 4 times lower than the Homepage Based System (HBS) cost. In order to investigate the proposed system performance, we prepared a questionnaire and investigated some students

†1 Faculty of Computer Science and Engineering   The University of Aizu
†2 Graduate School of Computer Science and Engineering   The University of Aizu
†3 Faculty of Literature and Social Sciences   Yamagata University
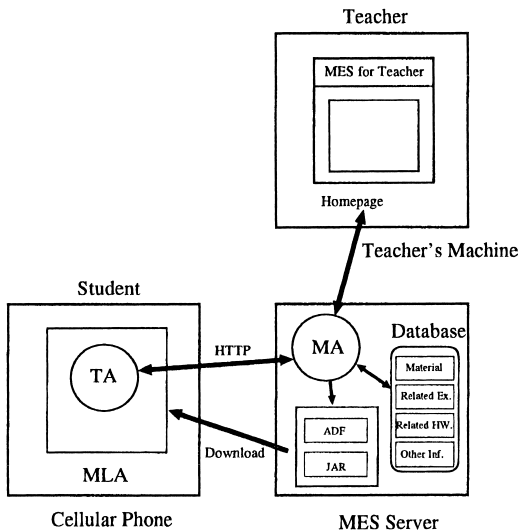†4 Core and Information Technology Center   The University of Aizu

Fig. 1　MES system.

Fig. 2　Interaction between TA and MA.

and teachers who used the system. The investigation evaluation shows that the proposed system is a very useful education system for students and teachers.

This paper is organized as follows. In Section 2, we explain the MES. In Section 3, we present system evaluation. In Section 4, we give some conclusions and future work.

2. Mobile Education System

The MES is shown in **Fig. 1**.

The MES consists of the MES Learning Application (MLA) and MES server. The MLA is coded by Java language and needs KVM [2] to run. The MLA can run on a cellular phone in which is implemented Java 2 Micro Edition (J2ME). Currently it can be executed on the cellular phones which correspond to the Limited Device Configuration (CLDC) [4] /Mobile Information Device Profile (MIDP) [5]. The MES server is implemented on Red Hat Linux 6.2J machines. The MA is coded by Perl language 5.0. The database on MES server uses the Data Base Management System (DBMS) attached in Perl.

2.1　MES Learning Application

The MLA is downloaded in a student's cellular phone and after that can be used for studying. The MES server stores the Java Archive (JAR) file which has the MLA execution program.

The student can access the MES server using the Internet Browser on the cellular phone and inputs his name and e-mail address. Using this
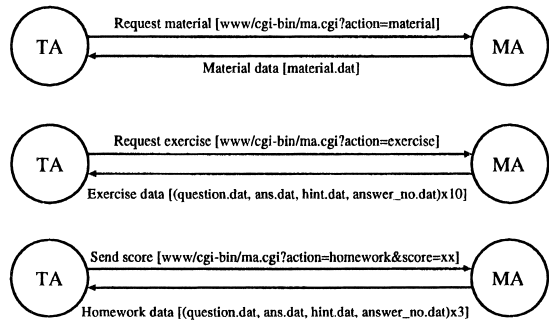
information, the MA makes an Application Description File (ADF). Next, the student clicks the hyper link to ADF made by MA and the MLA JAR file is downloaded in the flash memory of a cellular phone.

The MLA includes the TA. The TA communicates with MA to get the learning materials, exercise problems, and homework as shown in **Fig. 2**. In this figure, first, the TA makes a requests to MA to get the learning material. Next, the MA sends the learning material to the TA and the TA shows the learning material to the student. After the student finishes studying the learning material, the TA requires to MA, the exercise problems, hints, answers items and correct answer item number. The MA sends these contents to the TA, which shows the exercise problems to the student. Finally, the TA communicates with MA to get the homework. The MA judges the student score and after that sends appropriate homework to the student.

The MLA provides three main menus.
- Learning materials for the day.
- Exercises for the day.
- Homework.

The MLA menu is displayed in the cellular phone display as shown in **Fig. 3**. In this menu, when a student selects the Material item, the TA shows the learning material in the cellular phone display as shown in **Fig. 4**. When a student selects the Exercise item, the TA shows the exercise problem as shown in **Fig. 5**. While, when a student cannot answer the problem during a predetermined period of time, the TA shows a hint as shown in **Fig. 6**.

2.1.1　Teacher Agent

The TA is downloaded as a part of MLA in the flash memory of the student's cellular phone. The main role of TA is to support the student for studying and to communicate with MA of MES server using http protocol. If the
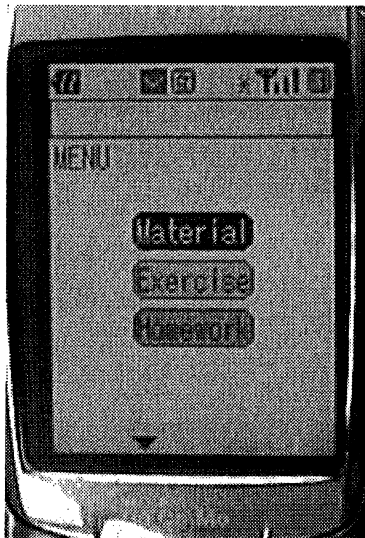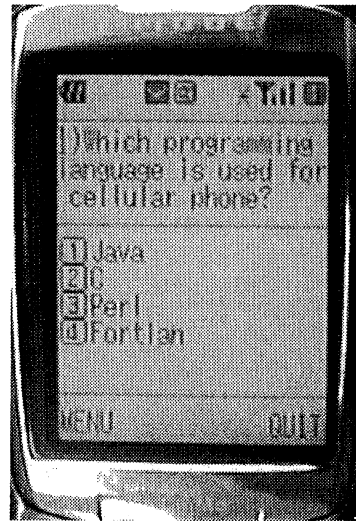
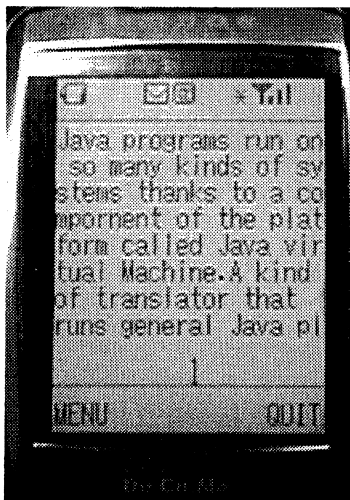**Fig. 3** MLA menu.

Fig. 5 Exercises.

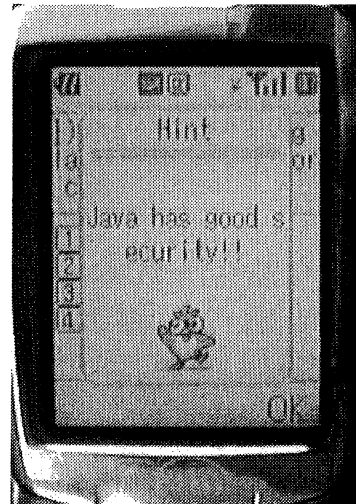**Fig. 4** Learning materials.

Fig. 6 Hint.

student does not answer the problem within a predetermined period of time, the TA sends a hint about the problem. Also, when student requests a hint, the TA shows the hint to the student even if the predetermined period of time has not yet arrived. Marking of student's answer is also carried out by the TA. The TA shows problem explanations in the cellular phone display in both cases when the student gives the wrong answer and when he needs more explanation. The TA also records how much time was needed to answer the question, whether the TA gave the student a hint or not, and it saves this data in the cellular phone memory. After the student answers all the ques-

tions, the TA and MA communicate together and the data is stored in a database managed by the MA. This data is used later by TA for the learning strategy.

2.1.2 Learning Materials

The learning materials are prepared by a teacher in the homepage provided by MA and are stored in a database of the MES server. When the student wants to study, the TA communicates with MA and displays learning materials considering the students progress.

In order to display the learning materials, we developed a simple viewer which can display only characters. In fact, the cellular phone has a micro browser. But, the Java applications

and the micro browser cannot run at the same time. By using the proposed viewer, a student is able to continue studying.

2.1.3 Exercises

The exercise problems are prepared based on the information from the learning materials. They are prepared by the teacher in the homepage provided by MA and are stored in the database of the MES server. When a student finishes studying the materials, the TA communicates with MA and the problems related with day's learning materials are sent to the cellular phone and are saved in its memory. When a student wants to start the exercises, the stored data is given as an exercise problem to the student.

During the exercises, the TA supports the student. If the student interrupts the exercise and starts studying, it is possible that he can come back again and start the exercise at the interrupted point. When a student cannot finish all the exercises within the time indicated by the teacher, the TA shows the answers and their explanations.

2.1.4 Homework

The homework is prepared by the MA considering a student's results sent by the TA. If the MA judges that the student has passed the test, the MA gives this student some application problems. Otherwise, if the MA judges that the student did not pass the test, the MA gives the student some basic problems for homework. The TA receives the homework problems and stores them in the flash memory of the student's cellular phone. The student can give the answer to the teacher when he has free time. However, the student must finish the past homework, before starting to study the day's learning materials. Otherwise, the student cannot go to study other materials.

2.1.5 Teaching Strategy

The teaching strategy is shown in **Fig. 7** and is based on a student's ability to solve the basic and application problems.

As we mentioned in the exercises section, first some basic problems are given to a student and based on his answers, the TA decides whether the student passed the test or not. If the student passed the test, then some application problems are given to him. Otherwise, in order to improve his ability, some more basic problems are given to study.

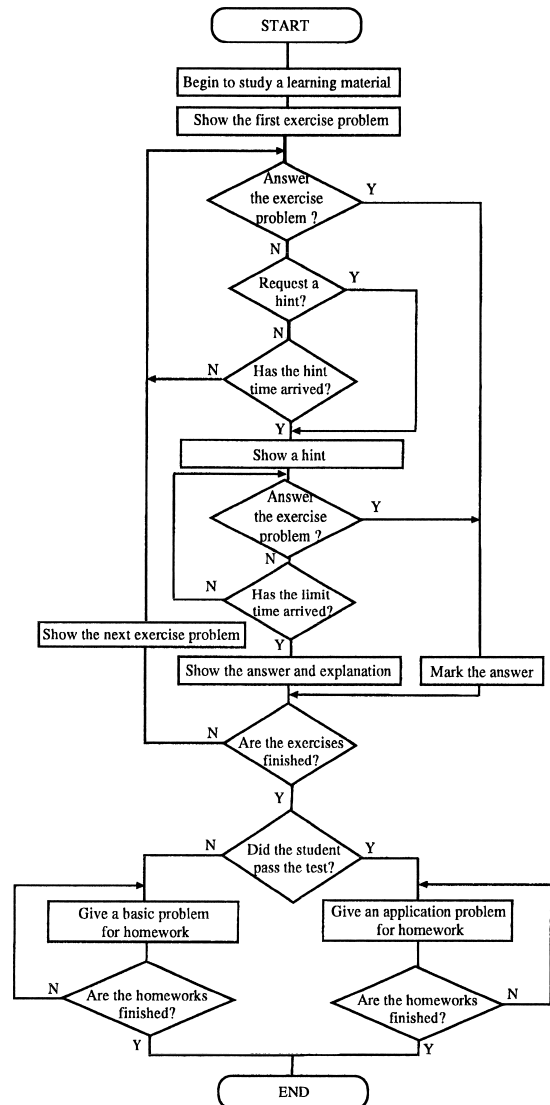### 2.2 MES Server

The MES server consists of a database and

Fig. 7 Teaching strategy.

the MA that manages it. The http server runs on the MES server. The MA receives the packet sent from MLA using the CGI.

2.2.1 Management Agent

The MA's role is to support the teacher for making learning materials, preparing exercises and homework problems, and managing the database where this data is stored. The MA uses the data sent by the TA such as the student's score and answer time, and based on these data prepares the homework which is sent to the TA. The MA communicates with the TA and sends the learning materials and the problems based on the student's progress.
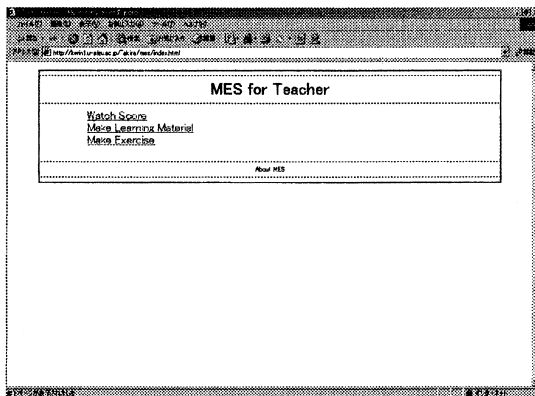
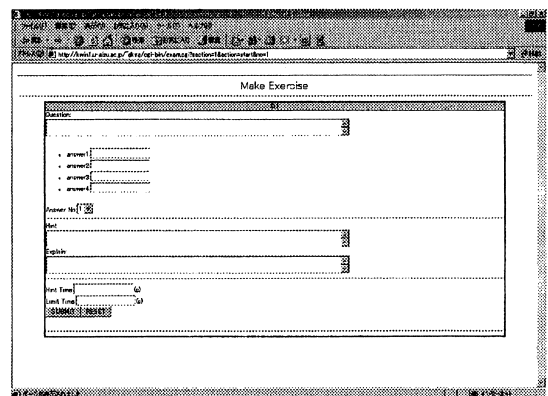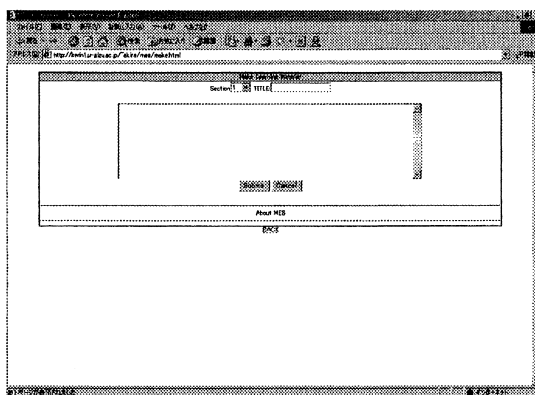**Fig. 8**   Preparation of learning materials and problems.

Fig. 9   Make learning materials.

Fig. 10   Make exercises.

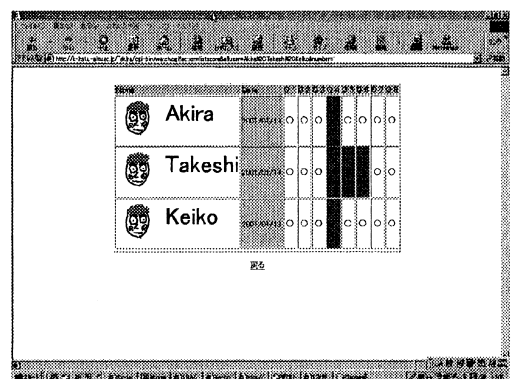**Fig. 11**   Score for all students.

Fig. 12   Score for each student.

2.2.2 Preparation of Learning Materials and Problems

The preparation of learning materials and problems is shown in **Fig. 8**, **Fig. 9**, and **Fig. 10**. The teacher prepares the learning materials and problems in the homepage provided by the MA.

The learning materials are usually text. To make the problems, the teacher should prepare for each problem the following items: the problem text, the answer sheet, problem hints, problem comments, a time value when the hints should be shown, and a time limit to answer each problem. Usually, the teacher prepares about 10–20 basic problems and 3–5 application problems. The prepared data are stored in the MES server database and are managed by the MA. The MA communicates with the TA to send this data to the student's cellular phone.

2.2.3 Score Results

The teacher can check the student's score and progress of learning using the homepage provided by the MA. It is possible to show th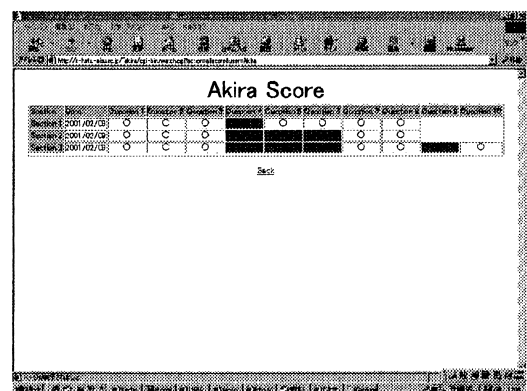e score results of all students or the score results for each student on the web page. In **Fig. 11** are shown the score results for all students in the case when they study one section of the learning materials. While, in **Fig. 12** are shown the score results of each student for three different sections of the learning materials. The marks ◯ and × inside the figures means a right an-

Table 1   Learning materials, exercises and homework.

Learning Materials	Exercises	Homework
970 characters	10 questions and hints	application problem
970 bytes	2,310 bytes	500 bytes

Table 2   Comparison of packet communication cost for exercise problems.

Method	Number of packets	Cost (Yen)
MES	19	5.7
HBS	70	21

swer and a wrong answer, respectively.

Considering the evaluation of these figures, the teacher is able to judge the students degree of understanding.

3.   System Evaluation

We implemented the proposed MES by using Java and Perl languages. For the evaluation, we used the packet communication cost as a parameter. Also, in order to investigate the proposed system performance, we prepared a questionnaire and investigated some students and teachers who used the system.

The parameters for learning materials, exercises and homework are shown in **Table 1**, while the comparison of communication cost for exercise problems is shown in **Table 2**. Considering the same learning contents, in the HBS, the exercise problems are received by browsing every page. During browsing, content (question, hint, answer) request actions and content download actions (bidirectional actions) are carried out for each exercise problem. Let's consider a case when the number of exercise problems is 10. In this case, for the HBS, 10 content request actions and 10 content download actions should be carried out. For 1 content request action and content download action, the number of packets is 7. Consequently, by increasing the number of content actions, the number of transmitted packets is increased. While, in the proposed MES, the content request action is carried out only once for all exercise problems, so the communication cost is lower than HBS. Packet interactions for exercise problems for the HBS and MES are shown in **Fig. 13**.

In the i-mode, the cost of one packet (128 byte) is 0.3 yen. Considering Table 2, in the MES are transmitted 19 packets, so the total packet cost is 5.7 yen. While, in the HBS are transmitted 70 packets and the total packet cost is 21 yen. Thus, the MES decreases the packet
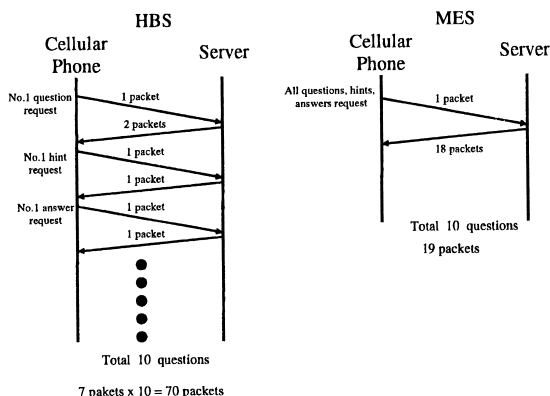
Fig. 13   Packet interactions for exercise problems.

communication cost about 4 times compared to HBS.

In the following, we compare the proposed MES with the current HBS educational applications for service and user support. The current HBS applications, which are provided by the i-mode official site, provide only a choice type question list in the web page. These services are simple, thus they are not intelligent. On the other hand, the MES is based on agent technology and shows a flexible behavior. The MES is able to provide the learning materials, exercise problems and homeworks. Furthermore, it can show the hints and explanations according to a learner's conditions. The MES also marks the student score after the student answers the question. The MES supports the teacher to make learning materials, exercise problems and homeworks. Thus, the MES supports all parts of learning and teaching. Therefore, the MES is a useful education system compared to the current HBS applications. If the current HBS applications are upgraded, they can support showing of hints and explanations by using CGI. But, in this case, the communication delay (showing time) and cost are increased, because in HBS the number of packet interactions between the server and a cellular phone is increased.

We carried out many experiments using the proposed system. Some students and teachers who used the system answered a questionnaire we prepared. The answers of the questionnaire are shown in **Table 3** and **Table 4**.

Table 3   Questionnaire for students (6 students).

Question items	Good	Average	Poor
How was the system operation?	1	0	5
How clear were the material contents?	2	4	0
How clear was the material displayed?	3	2	1
How smoothly was the learning carried out?	6	0	0
How much did the hints help you?	5	1	0
How was the timing of the hints?	2	1	3
How effective was your study using MES?	5	1	0

Table 4   Questionnaire for teachers (2 teachers).

Question items	Good	Average	Poor
How useful were the material making tools?	2	0	0
How well did the score results help you?	1	1	0
How effective was the role of agents?	2	0	0

After the questionnaire investigation we also got some comments from students and teachers. Students' comments: 1) the system operation was a little bit difficult; 2) it will be better if the system would also use multimedia contents; 3) after finishing the exercise, it would be better if the ratio of correct and wrong answers is shown. Teachers' comments: 1) it would be better if as learning materials also audio and images would be used ; 2) if the display size and memory size will be increased more interesting things can be realized.

By this investigation, we got some suggestions how the system was performing and how to improve its performance. Some teachers were satisfied that learning materials could be prepared easily and the agents could support students efficiently. However, some of them were dissatisfied that the MES can only support text contents. Many students were satisfied with the agent functions, especially, hints during exercises were very useful. Some students were not satisfied with the fact that MES provides only text contents.

4. Conclusions

In this paper, we proposed and implemented an agent based mobile education system. By downloading a TA into a cellular phone, the MES can provide an efficient study for students. Also, teachers can easily prepare the learning materials and the teacher's teaching load can be decreased by using MES.

We compared the MES with the HBS. The current HBS applications, which are provided by the i-mode official site, provide only a choice type question list on the web page. These services are simple, thus they are not intelligent. On the other hand, the MES is based on agent technology and shows a flexible behavior. The MES is able to provide learning materials, exercise problems and homeworks. Furthermore, it can show hints and explanations according to learner's conditions. The MES also marks the student score after the student answers the question. The MES supports the teacher to make learning materials, exercise problems and homeworks. Thus, the MES supports all parts of learning and teaching. Therefore, the MES is a useful education system compared to the current HBS applications.

We implemented the proposed system by using Java and Perl languages. For the evaluation, we used the packet communication cost as a parameter. In order to investigate the proposed system performance, we prepared a questionnaire and investigated some students and teachers who used the system. From the communication cost evaluation and questionnaire investigation, we conclude:

- the proposed system is a useful education system for students and teachers;
- the MES decreases the packet communication cost about 4 times compared to HBS;
- some teachers were satisfied that the learning materials could be prepared easily and agents could support students efficiently, but some of them were dissatisfied that the MES could only support text contents;
- the system operation was a little difficult;
- many students were satisfied with the agent functions, especially, the hints of exercise were very useful, but some of them were not satisfied with the fact that MES provides only text contents.

In the future, the authors plan to develop a proposed system to support multimedia contents and to have easier operations.

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Akio Koyama received the B.E. and Ph.D. degrees from Yamagata University in 1987 and 1998, respectively. Until March 1999, he was working as a technical staff at Faculty of Engineering, Yamagata University. From April 1999, he is working as an Assistant Professor at Department of Computer Software, the University of Aizu. His current research interests include network agent systems, high speed network protocols, distance learning systems, application systems for cellular phone and routing algorithms. He is a member of IEEE-CS, IPSJ and IEICE.

Akira Sasaki received the B.E. degree from the University of Aizu in 2001. He is now a graduate student of master course in the University of Aizu. His current research interests include application systems for cellular phone and network agent systems.

Leonard Barolli received the B.E. and Ph.D. degrees from Tirana University and Yamagata University, in 1989 and 1997, respectively. From April 1997 to March 1999, he was a Post Doctor Fellow Researcher of JSPS at Faculty of Engineering, Yamagata University. From April 1999, he is working as a Research Associate at Department of Public Policy and Social Studies, Yamagata University. His research interests include network traffic control, fuzzy control, genetic algorithms and agent-based systems. He is a member of SOFT and IPSJ.

Zixue Cheng received the M.E. and Ph.D. degrees from Tohoku University in 1990 and 1993, respectively. He was an assistant professor from 1993 to 1999 and has been an associate professor since Apr. 1999, at the Department of Computer Software, University of Aizu. Currently he is working on distributed algorithms, psychological agents, and distance education. Dr. Cheng is a member of IEEE, ACM, IPSJ and IEICE.

Aiguo He received the M.E. and Ph.D. degrees from Nagoya University in 1985 and 1988, respectively. He is an assistant professor of Core and Information Technology Center at University of Aizu, Japan. Currently he is working on distant education, computer science education and network. He is a member of IEICE, IPSJ, IEEJ and JDLA.