Application of Adaptivity in Quiz Systems

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ABSTRACT

Web-based assessment has been a major research area in recent years, but none of the efforts have yet been directed towards providing *adaptive features (either adaptivity or adaptability)* for the learner. 'Adaptivity' requires the system to automatically adapt to the learners' current level of domain competence and other similar attributes, whereas 'adaptability' requires the system to provide suitable interfaces by which the user can customise the system according to his/her own preferences. This research explores the potential of adaptivity in the Web-based assessment environments and develops a framework that adapts selection of questions within pre-defined contextual boundaries and tolerances and revises granularity in the presentation of questions at varying degree of complexity.

Based on the framework, an adaptive Web-based quiz system is designed and implemented for a first year course at the Massey University. The system is divided into two areas: exercise area and self assessment area. The system uses a student model to monitor and record each student's exercise and assessment profile. Based on the individual profile, the system presents to the student the suitable exercises at appropriate level of complexity. For example, if the student selects to take an assessment, the system provides the suitable level of questions to the student, based on his or her profile. When the student submits the answers, the system analyses the results according to the marking rules defined by the quiz designer, and gives proper feedback to the student. The feedback includes the correct answers and next recommended step, e.g. system recommends the student to go to the next level if the student gets the satisfying results. Otherwise, the system recommends the user to either try the exercises again or go to revise the relevant learning material. With this system, students are able to take the individualized assessment, and know their own level of competence and the learning progress. Currently, the system is being used by about 150 students. An evaluation is underway to ascertain the effectiveness of the system. Anecdotal comments from the students at this early stage suggest that the students are finding the system as very useful and helpful.

INTRODUCTION

As an increasing number of higher education institutions look to computers to solve some of the problems associated with the burden of expanded student numbers, advances in technology are increasingly impacting the way in which the curriculum is delivered and assessed; Web-based assessment has been a major research area in recent years (Hartley et al, 1999). Comparing to Web-based learning, Web-based assessment is a relatively new development (Stephens et al, 1998). None of the efforts have yet been directed towards providing adaptive features (either adaptivity or adaptability) for the learner (HEFCE, 1998; Pritchett and Zakrzewski, 1996; Zakrzewski and Bull, 1998; Sutcliffe et al, 1999; Ricketts and Wilks, 2001; Ricketts and Wilks, 2002).

This paper explores the potential of adaptivity in the Web-based assessment environments and develops a framework that adapts automatically to the learners' current level of domain competence and revises granularity in the presentation of questions at varying degree of complexity. Following the framework, an adaptive Web-based quiz system is designed and implemented for a first year course at the Massey University. The system is being used by about 150 extramural students and about 150 internal students.

Student Adaptivity features in Computer-based Intelligent Learning Systems

The student adaptivity is a core research topic in intelligent learning environments (Nikov et al., 1999). The student adaptivity enables the systems to tailor themselves based on individual student's performance and background. The goal of student adaptivity is that not only "every one should be computer literate" but also that "computers should be user literate" (Browne et al., 1990). It also makes the learning systems more effective and efficient.

The main reasons that student adaptivity is so important in intelligent learning systems are as follows:

- A wide student spectrum: the student spectrum may be from one extreme (naïve) to another extreme (advanced), that means that students may have very different backgrounds, learning styles, individual preferences, and knowledge levels. The systems with student adaptivity are able to improve the effectiveness and efficiency of learning.

- The intelligent systems focus more on student centred learning. Theses systems are usually are used by the students of different places and in different contexts. The student adaptivity in these systems concerns about

individual student's preference and knowledge level, with aim to make the learning more efficient and effective.

The level of adaptivity within intelligent learning environments varies from system to system. On one hand, systems can be adaptable – allowing the users to change certain system parameters and adapt systems behavior accordingly. On other hand, systems can be adaptive – changing their behaviour automatically based on the system's assumptions about the user needs.

Oppermann et al. (1997) summarized the complete spectrum of adaptivity that exist in learning systems (Figure 1).

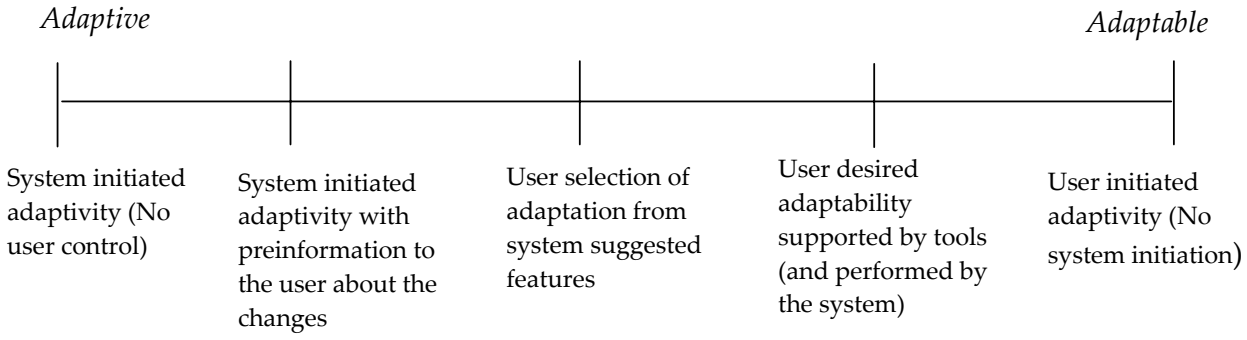

Figure 1: the whole spectrum of the concept of adaptation (Oppermann et al., 1999)

To implement the student adaptivity in intelligent educational systems, the mechanism (Figure 2) has been developed advance in this research area. From Figure 2, the tutoring module can be seen as the engine to accomplish the adaptive processes, and student model is the key information for adaptation. From figure 2, it is clear that the tutoring module is the brain of the system and the window to interact with the students. It captures the student's performance and communicates with student model, then considers the student's personal situation and other related information to draw the suitable adaptivity decisions for the specific student.

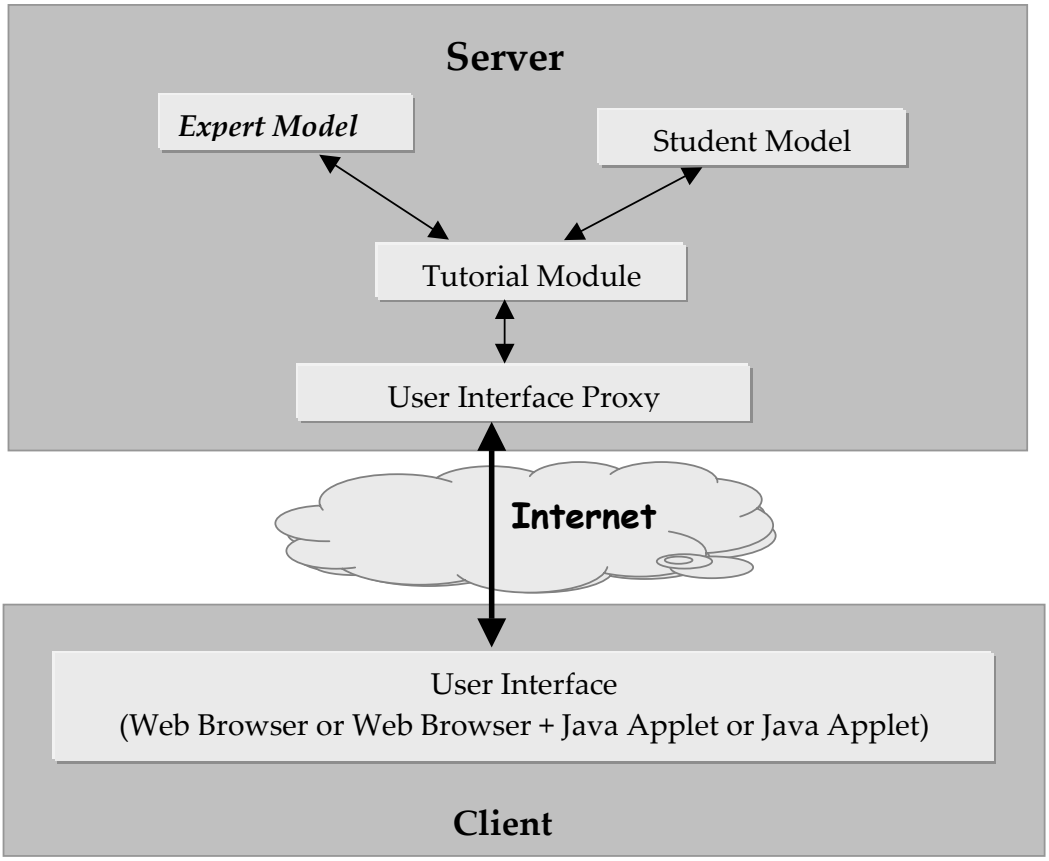

Figure 2: Basic high level Web-based architecture for ITSs

The Architecture of the Quiz System

Figure 3 shows the high level architecture of this quiz system. Based on the architecture of the web-based intelligent educational systems, the question base module is introduced into this architecture.

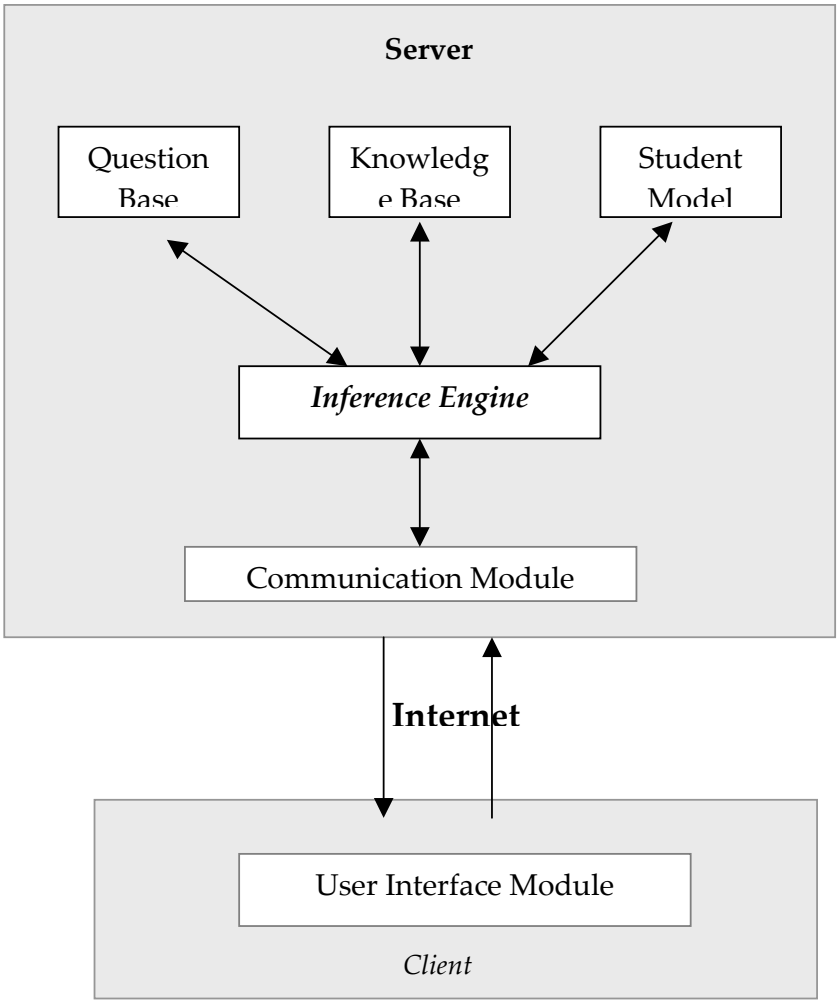

Figure 3: The high-level architecture of the quiz systems

As shown in the figure 3, the basic architecture of the system is a typical three-tier, client-server structure. The client has the presentation interfaces that are implemented as HTML frames and run in a web browser. The application programs for performing adaptation reside in the middle layer, and they communicate directly with the backend database: question base, knowledge base, and student model. The web server as the communication channel also resides in the middle tier. Figure 4 shows the three-tier architecture of the system, and the main functions of the components.

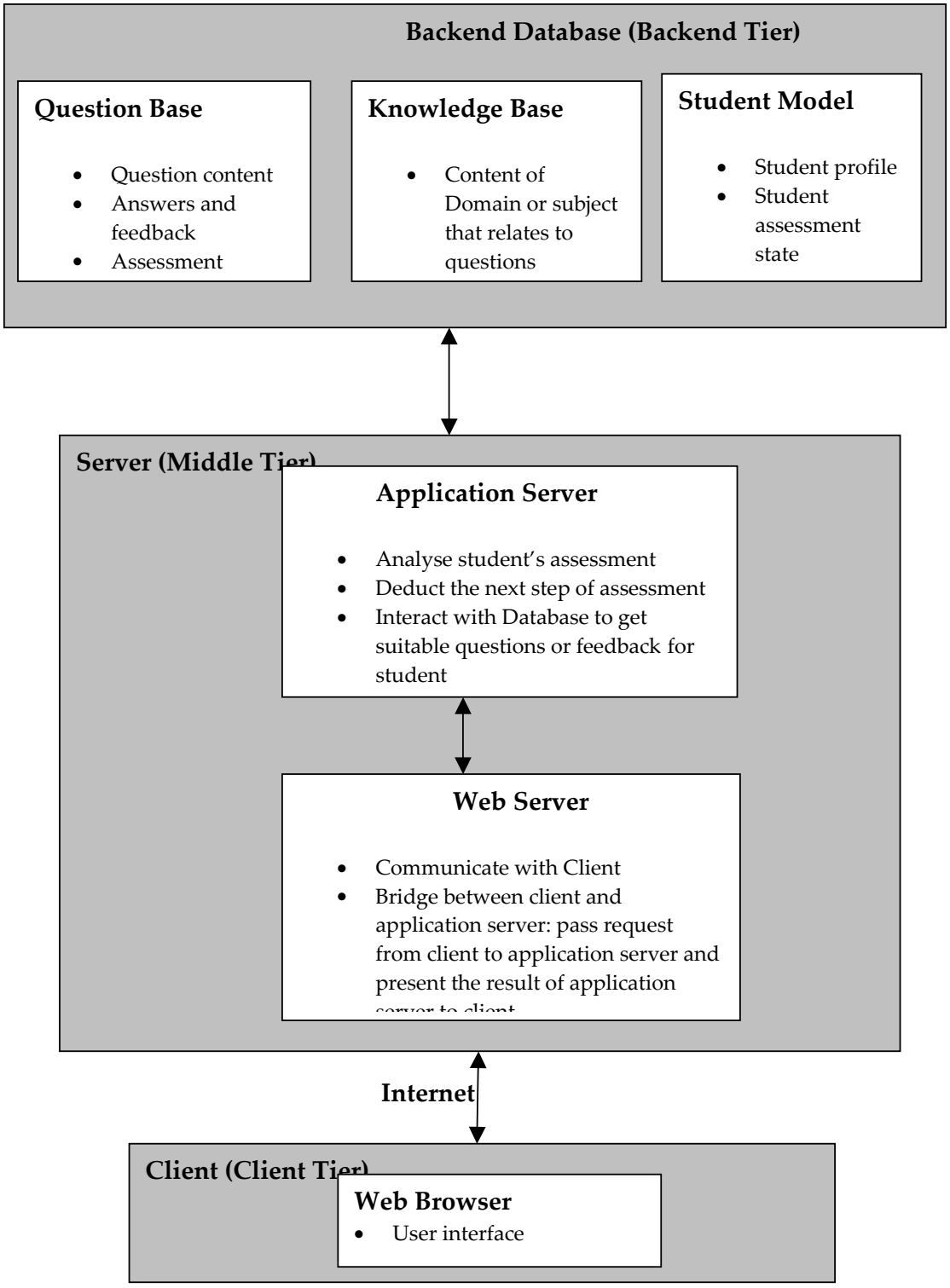

Figure 4: The three-tier architecture of the quiz system and the main functional components

- Backend tier: basically it is a database management system (DBMS) that stores and manages the data required by the middle tier's application program. It

also resides on the server side, and physically may reside on the same or different machine. In this system, it is implemented in MySQL.

- Middle tier: the middle tier that resides in the server side is the engine of the system. This layer usually consists of web server and application server.

- The web server, we use Apache in this system, communicates with client to get requests from the client and passes the requests to application server if they need to be processed. Then the web server also is responsible for sending the information back to client, normally they are web pages.

- The application server receives client requests transferred by the web server, processes the data contained in the requests. In this system, the application server will analyse the student assessment contained in the client requests, and refer to the question base stored in the backend tier (database) to assess the student's performance, then deduct the next step the student must take. Finally, it will generate a client response based on the deducted results and may refer to knowledge base stored in the backend tier (database), then send it back to the client through web server. The application server also handles the student model initialisation and update processes. In implementation level of this system, the application server consists of a set of PHP programs.

- Client tier: this is thin client which is a web browser running on the student computer. The client works as the user interface of the system. It mainly handles presentation of questions or other information that comes from the server. The information or question presented in the web browser in this system are HTML pages.

Implementation of the Quiz System

Based on the above framework, an adaptive Web-based quiz system is designed and implemented for a first year course at the Massey University. The process detail of inferring student's results and its algorithm are discussed as below.

System working processes

Figure 5 outlines the process flow of this system. From figure 5, after student logins successfully, the system presents the selection page that provides two options: go to exercise area or self assessment area (figure 6).

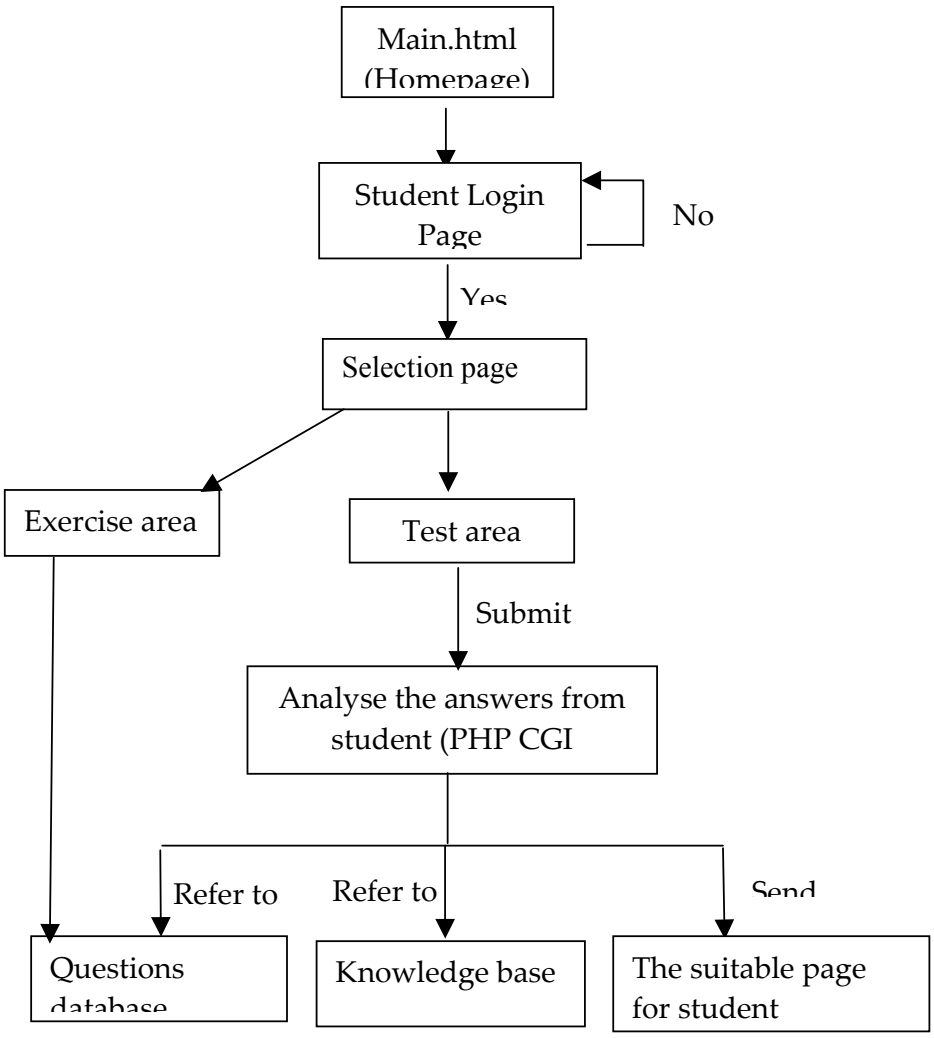

Figure 5: The main flow of the system

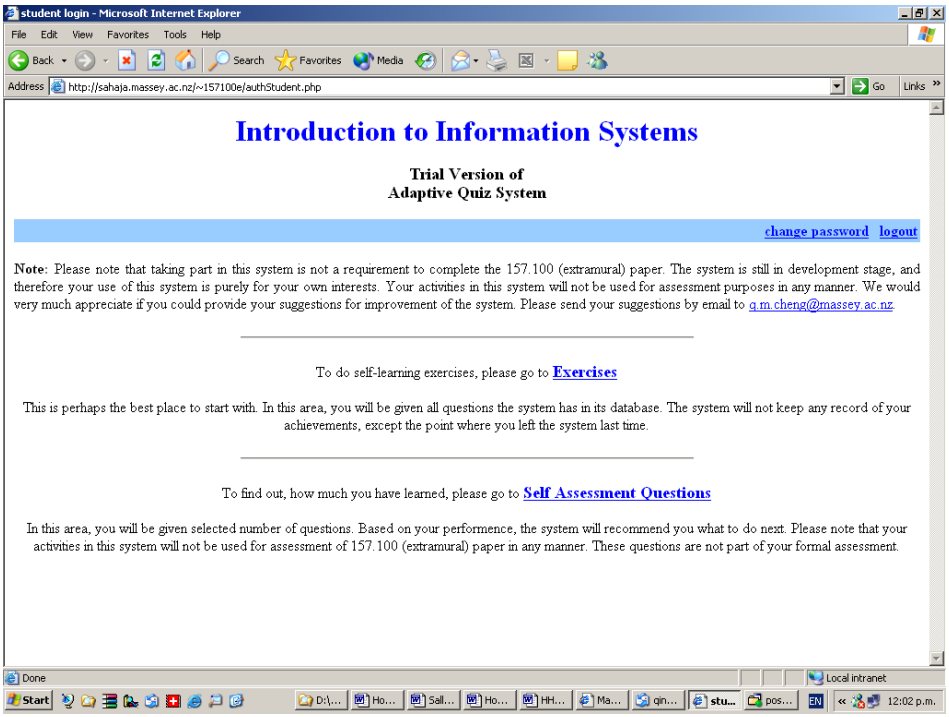

Figure 6: the selection page

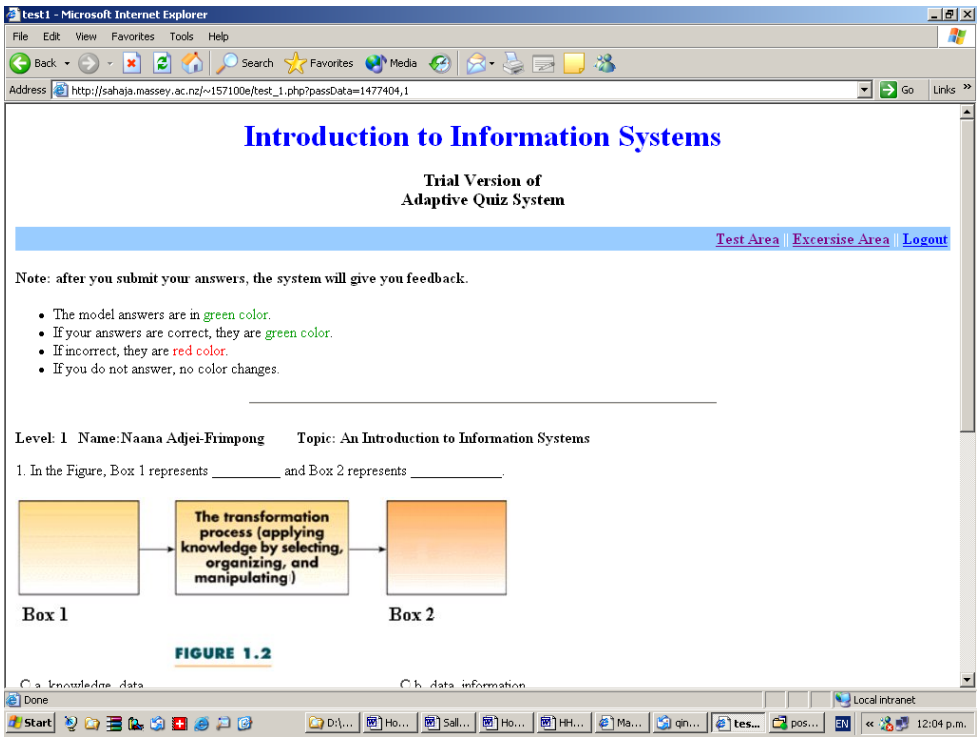

Figure 7: Example of one set of questions for student

If the student selects to take an assessment, the system provides the suitable level of questions to the student, based on his or her profile (figure 7). When the student submits the answers, the system analyses the results according to the marking rules defined by the quiz designer, and gives proper feedback to the student. The feedback includes the correct answers and next recommended step, e.g. system recommends the student to go to the next level if the student gets the satisfying results (figure 8).

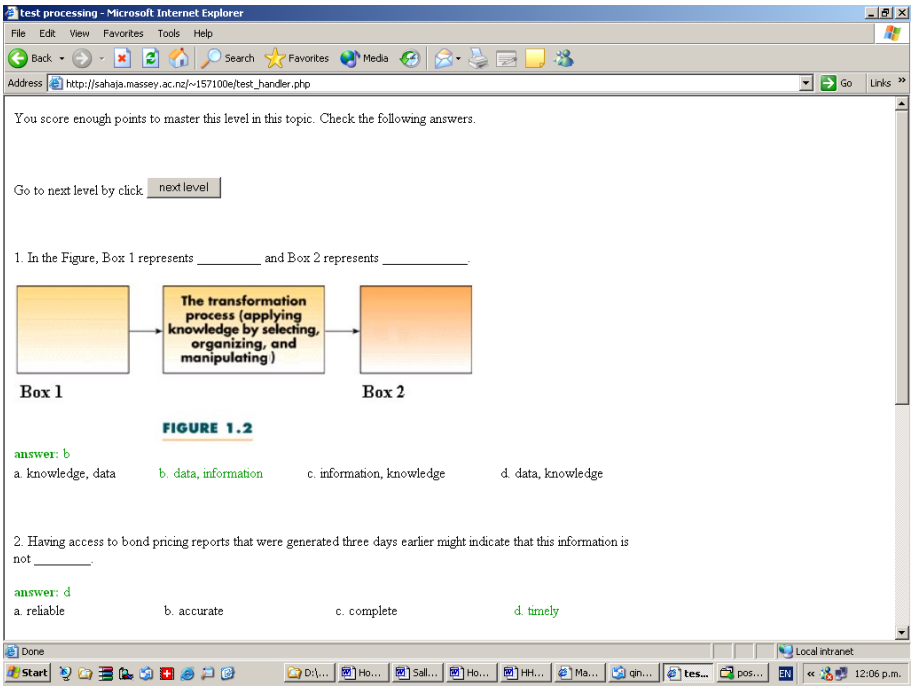

Figure 8: one example of feedback

If the student selects to do some exercise, the system brings the student to the exercise area and randomly provides the selected level of questions to the student. When the student submits the answers, the system analyses the results and gives proper feedback to the student. And the system only records what the student has done, but not the assessment result.

Student adaptivity in this quiz system

The student adaptivity in this quiz system is able to address the potential of adaptivity in the Web-based assessment environments

- Monitoring Student's Performance: When a student uses this system, she/he is presented with a set of questions. The student works on the set of questions, answers each question, and then submits the answers to the system. The inference engine within the system refers to the questions base in the backend database. The question base consists of a set of different levels of questions for

assessing, the answer for each question, assessment criteria for assessing student's test. The content of question base is provided and defined by the teachers. The inferring steps includes:

- Matching the student's answers with standard answers provided by the teachers;

- Calculating the final result for the student and deciding the student's level and next suitable step.

In fact, the quality of question base is the core of this system, which largely depends on teachers' experience.

- Presenting Proper Guidance: initially the system provides the suitable level of questions to the student, based on his or her profile. Based on student performance, the system adapts itself to provide proper feedback to students. The feedback includes the correct answers and next recommended step, e.g. system recommends the student to go to the next level if the student gets the satisfying results. Otherwise, the system recommends the user to either try the exercises again or go to revise the relevant learning material. For example, in this system:

  - If the student got less than 80 points in a set of questions out of 100, then the system infers that the student needs further study in the relevant material. The system in this case provides very concrete guidance to the student, such as presenting the correct answers as feedback to the student, the related information and links, and then recommends the student to review the relevant content and try the assessment again. From this feedback and recommendation, the student is able to decide his/her next step and carries on by opening the links provided by the system or refers to relevant books.

  - If the student got 80 points in an assessment, then the system infers that the student has mastered the relevant knowledge. In this case, the system infers that the student has adequate knowledge related to the assessment. In that case, the system just sends the student to the next level of assessment.

CONCLUSION

In this paper, we presented a framework to introduce the student adaptivity into web based assessment system. The framework provides the mechanism to adapt selection of questions with pre-defined contextual boundaries and tolerances and revises granularity in the presentation of questions at varying degree of complexity.

Based on the framework, an adaptive Web-based quiz system is designed and implemented for a first year course at the Massey University. The system provides the flexible student adaptivity to the students. By using this quiz system, students are able to take the individualized assessment, and know their own level of competence and the learning progress. Furthermore, the system is able to provide focused and timely feedback to students. Feedback can be used to direct future learning, motivate students to investigate other resources.

Currently, the system is being used by about 150 extramural students and 150 internal students. An evaluation is underway to ascertain the effectiveness of the system. Anecdotal comments from the students at this early stage suggest that the students are finding the system as very useful and helpful.

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