A Framework of Design Pattern for Distance Education System

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Abstract: The main topic addressed in this paper is to propose a design methodology called "Design Pattern" for sustainable distance education system. The design pattern for distance education system is based on a communication model by integrating educational requirements and system components. This paper describes an overview of the design pattern and discusses a couple of case studies for analyzing distance live lecture system using our design pattern approach.

Keywords: Distance Education System, Design Pattern, Use Case, System Component, Distance Live Lecture, Design Support

1. Introduction

Information and Communication Technology (ICT) has a strong impact on the practical implementation of distance education, which removes geographic or time constraints. There have been a lot of case studies of online universities and international university consortium programs by taking advantage of ICT's interactive properties [1][2]. In implementing such distance education, we have to tackle designing high-quality programs suited to the diverse requirements, such as various types of students or different educational environments.

In order to overcome such difficulties, it is important to improve the programs based on previous practical findings as Plan-Do-Check-Act (PDCA) cycle. However, actual distance education systems are usually designed under multiple restrictions as follows:

A) Restrictions on Educational Technology (Use Cases): Purposes of the program, forms of education, characteristics of student, lecture style, etc.
B) Restrictions on ICT (System Components): Network technology, video image technology, sound technology, etc.

In other words, it is difficult to apply the previous findings to other programs which differ in kinds or priorities of the restrictions. Our approach is to aggregate
smaller parts of the use cases and the system components for distance education systems as a design methodology called “Design Pattern”.

The concept of design pattern was first proposed to utilize previous patterns and samples for designing a city or a street [3][4]. In recent years, it is positioned as part of the software design methodology by aggregating reusable parts of program [5]. We propose the design pattern for distance education system from both of the above viewpoints. The main feature of our design pattern approach is to aggregate the reusable patterns by integrating practical ideas from educational technology field and hardware/software system from ICT field.

2. Design Pattern for Distance Education

2.1 Framework of Design Pattern

In designing effective distance education program, it is necessary to implement adequate system components to communicate between each lecture room by considering diverse factors, such as educational effects, forms of education, characteristics of lecture and student, lecture style. However, we often face some difficulties in system implementation because:
- Requirements and restrictions for the program are not always clear in advance,
- Unexpected use cases are sometimes requested after implementing the system,
- Operational cost is often forgotten about.
- It is difficult to apply the previous findings to other programs which have different kinds or priorities of restrictions.

In this paper, we propose a design pattern approach which integrates educational requirements and system components organically so that we could share and reuse the practical findings of the previous experiences of distance education program. This approach would enable us to design suitable system components which satisfy the requirements on the specific use case.

2.2 Communication Model and Design Pattern

A distance education program is realized by utilizing the system components which communicate with other rooms over the network. From the standpoint of design pattern, such components should be designed by communication patterns between the lecturer and the students, or between the students such as the purpose of the lecture, the number of the rooms, and the number of the students shown in Figure 1. We propose a following communication model for distance live lecture. The key idea of this model is to integrate educational use cases and system components from the standpoints of the following five communication factors.
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Figure 1 Diagrams of Communication Model for Distance Live Lecture.

i. Purpose: Knowledge Transmission, Material Distribution, etc.
ii. Target: Lecturer, Students, Room Atmosphere, System Status, etc.
iii. Direction: From Lecturer to Students, From Students to Lecturer, etc.
iv. Frequency: Communication Frequency in the Lecture.
v. Quality: Video Image Quality, Angle of View, Sound Quality, etc.

The factor ‘Purpose’ usually depends on characteristics of lecture and lecture style. In addition, this factor is basic restriction for the other factors. The factors ‘Target’ and ‘Frequency’ also depend on the number of distance room and the number of students. On the other hand, the factor ‘Quality’ is not determined only by the physical aspects of actual system components but also by network bandwidth, system performance, system operation, etc. Our approach is to analyze and define the quality requirement of each communication pattern from the design pattern standpoints. In other words, we can regard the communication pattern (the arrows described in Figure 2) as a basic element of the design pattern. Each communication pattern consists of the use case factors (‘Purpose’, ‘Target’, ‘Direction’, ‘Frequency’) and the system component factor (‘Quality’). The design pattern is accordingly represented by the correspondence relationship between the use cases and the system components.

As an important feature of the design pattern, we deal with the communication pattern between the system administrators and the system components because this is a very important issue for designing sustainable distance education program.
3. Case Studies

3.1 Design Pattern Extraction from Practical Lecture

The following steps show the procedure of extracting the design pattern from practical use cases.

First, we illustrate the communication model based on the use cases of the practical distance live lecture and then divide it into the communication patterns. We next make a correspondence relationship between the use cases and the system components implemented to the actual lecture. The functions of the system components are divided into data communication function, image/sound input function, and image/sound output function.

Our design patterns are aggregative descriptions extracted from over 30 practices represented by practical distance live lecture course. Table 1 shows typical examples of the design pattern which collects 4 kinds of the system components to implement a use case. In addition, we linked and registered related documents (specification, report, etc.) of the distance education program in the database.

Table 1. Examples of Design Pattern

<table>
<thead>
<tr>
<th>Use Cases</th>
<th>Purpose</th>
<th>Lecture/Speech (Knowledge Transmission)</th>
<th>Direction</th>
<th>Media</th>
<th>System Components</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lecture/Speech (Knowledge Transmission)</td>
<td>[Lecturer] -&gt; (Contents) -&gt; [Students]</td>
<td></td>
<td>Whiteboard/Blackboard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Etc.</td>
<td>Room 1:1</td>
<td>Students: n</td>
<td>TA: 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quality</td>
<td>Image of SD Video Camera</td>
<td>Available Existing system, Low-impact</td>
<td>Low Resolution, Operation needed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quality</td>
<td>Image of HD Video Camera</td>
<td>High Resolution, Low-impact</td>
<td>System upgrade needed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quality</td>
<td>Electrical White Board</td>
<td>Directly/bi-directionally Writing Materials</td>
<td>Accurate, unfamiliar surrounding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quality</td>
<td>PC Conference System</td>
<td>Directly/bi-directionally Writing Materials</td>
<td>Tablet PC needed</td>
<td></td>
</tr>
</tbody>
</table>

3.2 Example for Planning Distance Live Lecture System

This section describes another example applying the design pattern approach to planning a distance live lecture system between JAIST and National Institute of Informatics (NII) scheduled for 2009. It is generally difficult for all concerned in the distance education program to share the image of distance live lecture system
in advance because educational and informatics restrictions are unshared by
different position of the concerned, such as instructors, administrators, office
staffs, etc. In this case, we had a meeting with a chief of this program to share
some viewpoints to be concerned in advance using design pattern approach and
confirmed the following use cases.

Purpose: The main lecture style is of knowledge transition type and programming
practice. In the knowledge transition lecture time, the lecturer would use
whiteboard and PC screen at the same time. In the programming practice
time, it is desirable for the lecturer to check student's PC screen in the
distance room.

Target & Direction: Both organizations would prepare dedicated lecture rooms for
the program. Lecturers and students could participate in the lecture at
both rooms.

Frequency: Sometimes the lecturers would have Q&A or practice session.
Remarks: Both rooms would have no regularly assigned administrator. Therefore,
it is important to realize remote administration.

As a matter of fact, there are other restrictions such as budget, existing systems,
time difference, etc. The design pattern helps us to design the suitable system
components by the use cases. This would enable us to provide multiple candidates
of the system components based on the use cases.

4. Conclusions

In this paper, we have proposed a framework for integrating educational
requirements and system components based on the communication model in order
to construct the design pattern of distance education program. We also describe
the case studies for extraction of design pattern and system planning. This
approach makes it possible to aggregate the reusable patterns by integrating
practical ideas from educational technology and hardware/software system from
ICT. In the future, we would like to conduct practical evaluations of the approach
and develop design support system using design pattern database.

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