A Distributed Multimedia Presentation System with Floor Control Mode Based on Extended Timed Petri Nets

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Abstract-- ***Communication over Internet is growing increasingly and will have profound implications for our economy, culture, society and education. Currently, multimedia presentation technologies among the network are most often use in many communication services. Examples of those applications include video-on demand, interactive TV and the communication tools on a distance learning system and so on .In this paper, we describe how to present different multimedia objects on a web presentation system with floor control mechanism as a result of the distance learning environment indispensably. The distributed approach is based on an extended timed Petri net model. Using characterization of extended time Petri net, we express the temporal behavior of multimedia objects; on the other hand, we introduce the concepts of user interaction. The main goal of our system is to provide a feasible method to represent a schedule and navigation of different multimedia objects with user interaction. In addition, users can dynamically modify and verify different kinds of conditions during the presentation. To verify the structural mechanism, we implement an algorithm using the Petri net diagram, analyzing the model by time schedule of multimedia objects, and produce a synchronous set of multimedia objects with respect to time duration. Specially, we consider the interactive facilities to support the distance learning requirement. We propose a floor control mechanism, which provides four types of control (free access, equal control, group discussion, and direct contact). These control mechanisms are sufficient to the use of distance learning environment.***

Keywords-- Petri Net, Distributed Multimedia Presentation, Distance Learning, Floor Control, Virtual University

I. INTRODUCTION

To control and demonstrate different types of multimedia objects is one of important functions in distributed multimedia presentation system. Unfortunately, we saw many "Black magic" compromised multimedia presentation systems; there is little theory to describe the methodologies of such compromised system.

The concept of our model is based on the Petri net [1-3]. Petri net is a graphical and mathematical modeling tool applicable to many systems. Its features can be used with both practice and theory. Thus, it provides a powerful medium of communication between them. Additional extensions have been proposed, and this has led to the following types of Petri nets: the timed Petri net, the stochastic Petri net, colored Petri net, and object-related Petri net.[6-12] The "Object Composition Petri Net"(OCPN) and the "extended Object Composition Petri Net"(XOPCN) were two graphic-based models that proposed synchronous theoretical for multimedia. The OCPN is a comprehensive model for specifying timing relations among multimedia data. The XOPCN can specify temporal relationships for the presentation of pre-orchestrated multimedia data, and to set up channels according to the required Qos of the data [4, 5]. These two models lack methods to describe the details of synchronization across distributed platforms and do not deal with the schedule change caused by user interactions in interactive multimedia systems [13]. However, when considering the network transport issue of multimedia and the floor control with multiple users, OCPN/XOPCN model are not sufficient to deal with those problem.

In this paper, we use the extended timed Petri net to construct the web operations on a distance learning system. When multimedia objects are represented on the system, we have to consider different situations of multimedia objects such as asynchronous operation, time scheduling, and flow control. In addition to system operations, dynamical operations of users are important issues. Thus, we can apply characteristic of Petri net to implement our mechanism and study the theory.

This paper is organized as follows. Section II defines multimedia objects based on Petri net. Section III constructs an algorithm for our web system based on the

Petri net and uses an example to verify the algorithm and the group communication mechanism with floor control mode. Section IV discusses multimedia objects presentation that includes software metrics, testing, and maintenance phases based on software engineering. Section V gives the conclusions.

II . BASIC DEFINITIONS OF DISTRIBUTED TIME PETRI NETS AND MULTIMEDIA SPECIFICATION

We define multimedia objects representation based on the characteristics of the Petri net. As a graphical tool of Petri net, the followings are basic properties of a Petri net [1,2,8] and the description of multimedia objects:

Definition 2.1. A PETRI NET IS A 5-TUPLE, PN = (P, T, F, W, M_o) WHERE:

? P = {P_1, P_2, ………, P_m} is a finite set of places,
? T = {T_1, T_2, ……….., T_n} is a finite set of transitions,
? $F \subseteq (P \times T) \cup (T \times P)$ is a set of arcs (flow relation),
? W: $F \rightarrow \{1, 2, 3, \ldots\}$ is a *weight function*,
? Mo: $P \rightarrow \{0, 1, 2, \ldots\}$ is the *initial marking*,
? $P \cap T = \emptyset$ and $P \cup T \neq \emptyset$.

The structure of Petri net N = (P, T, F, W) without any specific initial marking is denoted by N. The generic components of Petri net include a finite set of places and a finite set of transitions. Petri net is a finite bipartite graph. Its places are linked with transitions in turn are connected to the output places. For a given place, there are input and output transitions defined.

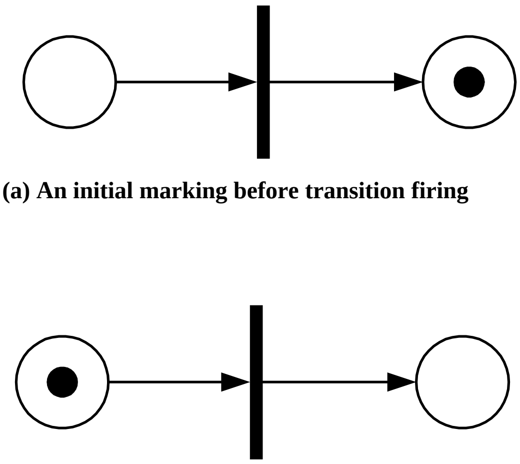
Definition 2.2. A transition that has no input places is called a *source transition* and a transition that has no output places is called a *sink transition*. Note that a source transition is unconditionally enabled or fired and that the firing or enabling of a sink transition consumes tokens, but cannot produce any.

Definition 2.3. The distribution of tokens over places is called a marking of the net. A transition may enable or fire when each of its input places contains at least one token. The firing of a transition results in removing tokens form its input places and adding tokens to the output places.

Definition 2.4. If a place is both an input and output of a transition, a pair of a place and a transition is called a *self-loop*.

Definition 2.5. If a Petri net has no self-loops, it is said to be *pure*. If all of arc weights of a Petri net are 1's, it is said to be *ordinary*.

A marking represents the state of a system, which changes when a transition fired to produce a new marking. An example of Petri net is given in figure 1.



(a) An initial marking before transition firing

(b) A new marking after transition firing

Figure 1. State transfers by transition firing on a Petri net

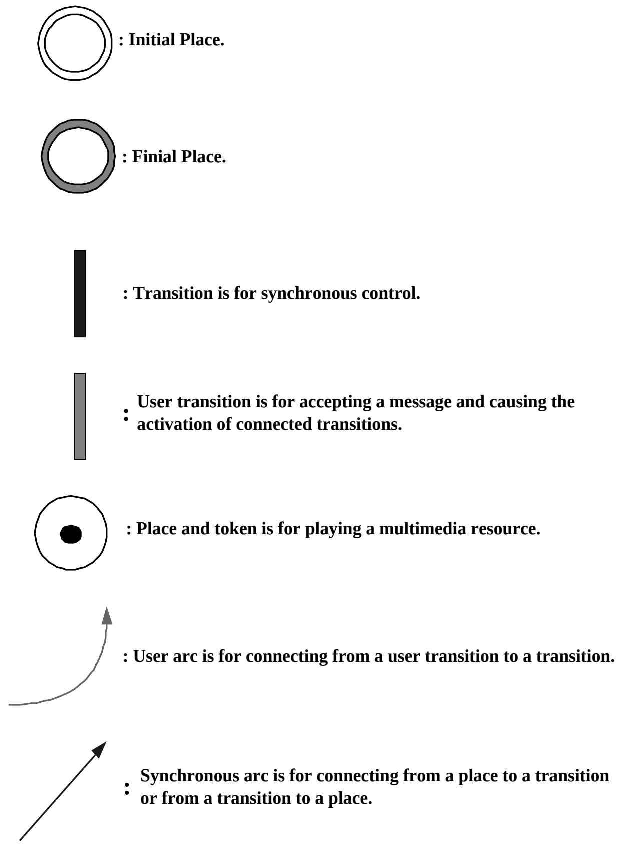
Definition 2.6. Multimedia objects representation specification

? A multimedia object is as a place node including a unique token and a transition node displays an event enabling or conditional sufficiency in the multimedia Petri net.

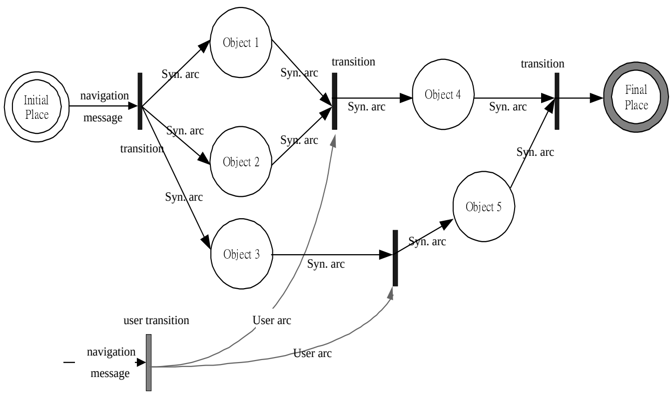
? A place node holds a token and time duration. It controls a multimedia resource to be played for the time duration. A transition node controls synchronization and it is fired only after each place node adjacent to the transition releases the token. The nodes of place and transition connect via synchronous arcs in a Petri net.

? We add *user transitions* and *user arcs* to our multimedia Petri net. A user transition receives a navigation message form the user before it is fired. A user transition is directly connected to some transitions. The activation of user transition can interrupt the demonstration of an arbitrary presentation window and cause the activation of the connected transitions simultaneously.

As illustrated in figure 2, the followings are components of multimedia objects in a Petri net and an example for multimedia objects based on our multimedia Petri net:



(a) The definitions of multimedia objects by a Petri net



(b) The overview of a multimedia web based on a Petri net

Figure 2. The representation of a multimedia Petri net

III. An Management Algorithm Based on Timed Petri Net

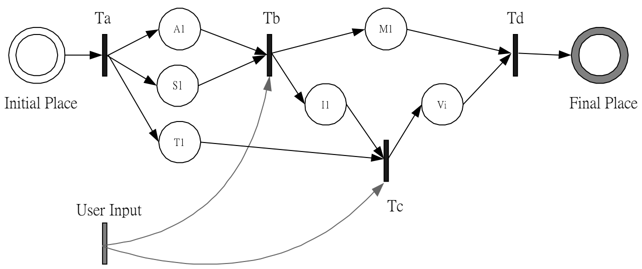
To design the algorithm based on the Petri net [7, 9, 10], we consider two points. The first is the algorithm independent to any operating system. The second is the realization and feasible of our web system.

Algorithm: multimedia objects synchronous set on the Petri net at the run_time
Input: A diagram of a Petri net
Output: multimedia objects synchronous set
Procedure multimedia_objects_synchronous_set
Max: integer;
Index: integer;
Begin
Sort the transition_node to a transition_list by topological sort algorithm;
Setup the first transition_node to Index;
Computing the number of transition_list;
Setup the number of transition_list to Max;
Initial the node pointed by the first navigation_message to node_time = 0;
For index ≦max do **Begin**
For each incoming edge do **Begin**
estimated_time = node_time + eage_duration;
Setup node_time of some node to the maximum of all estimated_time of incoming edges;
End;
Setup node_time to transition_node;
Index = Index + 1;
End;
For transition_list ≠ list_end do **Begin**
Cobegin
Process 1:
Play the resource concurrently at some transition_node during node_time;
Process 2:
If user interaction **Then** interrupt;
Wait for instructions;
Coend;
End;
End;

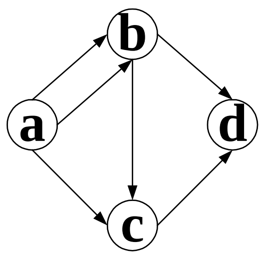
A. *Implementation by Above Algorithm*

We give an example to implement the above algorithm in figure4. The example is a diagram including multimedia objects such as animation, sound, image, music, text, and video multimedia resources. Transitions “a”, ”b”, ”c”, and “d” control synchronous operations for the diagram. In addition, we will consider a situation including user transition in the diagram.

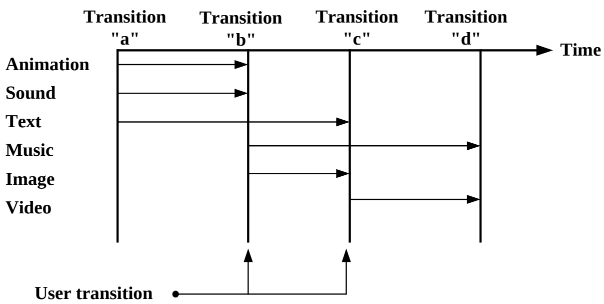
There are two cases discussed in the example. Case 1: In figure3, under the condition that the user transition is not fired, the transition order is “a”, ”b”, ”c”, and “d” by topological sort of the algorithm. When transition “a” is fired, the synchronous set is {animation, sound, text}. When transition “b” is fired, multimedia objects animation and sound completed. The place named “text” is continuing to play and the places named “music” and “image” begins to play. So the synchronous set is {music, image, text}. When transition “c” is fired, the multimedia resources “text” and “image” complete, and the multimedia object “video” begins to play. So the synchronous set is {music, video}. When transition “d” is fired, all operations completed. The synchronous sets are given in figure (3c) with respect to some transition duration. Case 2: In figure (3d) , If user transition is fired, transition “b” and “c” are fired, but transition “a” is not fired. So the synchronous set is {music, image, video}. The multimedia objects including “animation” and “sound” do not play because the transition “a” is not fired. The operation of the synchronous set is given in figure (3c) and figure (3d).



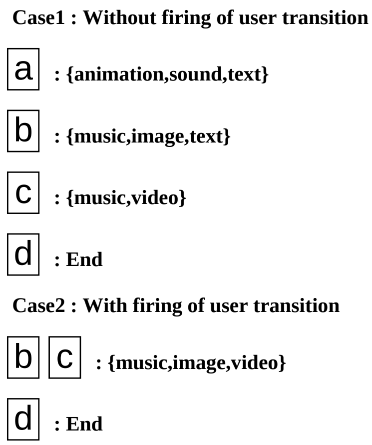
(3a) An example by the above algorithm



(3b) Topological sort of the transition node



(3c) Time schedule of the example by above algorithm



(3d) The synchronous set order of firing of transitions

Figure 3. The description of an example by above algorithm

B. Distributed Multimedia Presentation Environment

The multimedia presentation system in distributed environment can be taken it into a communication tool for virtual conferencing or distance learning. The communication tools need to considerate the group communication and floor control mechanism. In order to achieve these objectives, the distributed multimedia presentation system (DMPS) needed to build a global clock first (as shown in figure 4).

The global clock is a standard time in the present period of the client sides. A communication tool which be held “Synchronous” one is because of the bonded delay time. The global clock not only provides the global time frame facility but also control the higher priority of user interaction floor control. For instance, in a group communication case, user need to initial the group first, then every user can set their communication medias of what they needed via our DMPS tools (as shown in figure 5 DMPS communication window).

The DMPS server build a communication group and initial a global clock when the client side had initialed the communication configuration. The global clock admission control is centralized mode. It has the highest priority to handle the transition enforced to fire immediately or not. If the clock in client side is faster than global clock, the current transition will not fire until global clock arrives. On the other hand, if the local clock in client side is slower than global clock, the transition will be fire without delay. In the presenting period, user can request the floor control and change the presenting media. The floor control include four modes:

1. Free Access
2. Equal Control

3. Group Discussion
4. Direct Contact

Free access means everyone (ex: including session chair and participant) can send the message to the message-window or whiteboard. This mode is like general discussion with no privacy and priority. We have a limitation of speak in equal control mode. In this mode, there is only one (session chair or participant) can deliver at the same time until the floor control token passed by the holder.

Participants are encouraged to propose their ideas in some time. So, another small group discussion mode is provided. The manner is that a user can create a new group to invite others. For example, user A wants user B receiving his invitation, he can send an inviting message. User B can makes a decision to accept or not. If yes, user B will be chosen as listen group of user A, and the user A will be the session chair in his small group. Everyone can choose whom to receive the message actively. Therefore, all participants in the same group can send message together, we regard it as private communication group. The fourth floor control mode is direct contact. Actually, it is similar to the third mode. It means two people can communicate directly in a private window and communicate with others via free access, equal control, and direct contact at the same time.

The floor control model is managed by group administration of the DMPS server. All the users floor control request inputs are sent to the server, the server will take the messages with their rationality to handle the floor control in group communicating period. If the users floor control requests are permitted, the request will combine with the global clock control and with the same highest priority.

IV. SOFTWARE TESTING TO MULTIMEDIA PRESENTATION

After the user design the schedule and layout of the presentation via our Petri net tool and graphical user interface, our multimedia system generates the presentation automatically. Unlike the typical software development, no programs should be written. This generation strategy is also used by most multimedia presentation systems available on the market [11, 12]. The advantage is that if the specification and design of a presentation is correct, our system guarantees the correct implementation.

It is possible to obtain the software metrics of a presentation. Our system is able to calculate software complexity of a presentation based on the following criteria:

- Number of presentation windows
- Number and sizes of multimedia resources
- Number of transitions
- Number of user transitions
- Number of dynamic mutations
- Number of synchronous arc messages
- Number of user arc messages
- Number of navigation messages

Software metrics of a presentation indicates the complexity and the amount of efforts to test the presentation. Complexity of the presentation also indicates the effort to collect presentation resources and the size of potential disk storage used. Presentation testing is essentially important to ensure a smooth demonstration without missing resources and error navigation sequences. It is hard to perform a complete testing due to the amount of navigation sequences. Fortunately, our system facilitates testing by means of an automatic tool. The tool traverses the presentation based on the following testing criteria:

- Every presentation window should be tested
- Every multimedia resource should be tested
- Every navigation message should be tested
- Every transition should be tested
- Every user transition should be tested
- Every synchronous arc should be tested
- Every user arc should be tested

The testing of a presentation window includes the Petri net itself, which may accept navigation messages sent to transitions or user transitions. Synchronization of multimedia resources used by places tested as well. Moreover, selections, assignments, and conditions are tested. Since there is no particular sequence that the user navigates the presentation, the path topology of testing is arbitrary. Our testing tool traverses a graph consists of nodes (i.e., selections, assignments, conditions, and starting transitions/user transitions) and links (i.e., navigation messages) based on a modified breadth first search (BFS) algorithm. Upon the activation of a presentation window, each selection, assignments, or conditions are kept in a queue for further traverse. When the internal state of the presentation is changed due to the change of state variables (which may cause navigation change, layout change, or resource change), some modified nodes are added to the queue used in the BFS algorithm for re-testing. The testing tool keeps a testing log file indicating a testing sequence.

Another feature of our system is the evaluation tool of the presentation design status. It is very likely that a user design an incomplete or inconsistent presentation. The following is a list of potential mistakes that a user create in the presentation:

- Non-used state variables
- Non-used multimedia resources
- Non-used assignments
- Non-used conditions
- Incomplete navigation messages
- Incomplete selections
- Incomplete assignments
- Incomplete conditions

- Incomplete presentation windows (i.e., if any component of the window is incomplete)
- Inconsistent presentation windows (i.e., unbalanced links)
- Undocumented presentation windows

Non-used items, such as state variables not used in any condition, multimedia resources not linked to places, or the tool marks assignments and conditions not triggered by navigation messages. Incomplete items, with one of their properties missing, are also marked. A presentation window is inconsistent if the window and its refinement have different links (i.e., the unbalanced link problem). An inconsistent or undocumented presentation window is also marked. The user is able to check the list of problematic items before releasing the presentation.

It is possible that the user will release different version of a presentation. Therefore, presentation maintenance is an important issue. A presentation specification in our system contains a number of presentation windows. Each presentation window has a documentation box. It is important to document the presentation script in the box for further reference. Moreover, how to keep track of different versions of a presentation window is important. In a multimedia presentation database we developed, presentation windows as well as presentation resources are reusable objects. Each of these objects has several versions. A presentation is a composed object from these reusable objects. The database system serves as an underlying supporting tool for several multimedia presentation systems that we have developed, including the one we propose in this paper.

V. CONCLUSIONS

The main goal of our multimedia presentation system provides an interactive Petri net model. We suggest a method constructing a web structure on a distance learning system. We hope that the algorithm is independent to any operating system applied different platforms. In addition, we provide a friendly user interface to access multimedia resources on the system. The prototype system was developed on MS Windows 98 or MS Windows NT to justify our approach. We will focus the performance of the system and improve the web multimedia presentation in the future research. We have some contributions in the paper. We provide a model for web multimedia presentation on distance learning by the extension of basic Petri net. With the system, we hope to bring a feasible method including structural design and analysis for the design of the distributed multimedia presentation. Collocating with floor control mechanism, the distributed multimedia presentation system is very suit for tele-teaching. The model can be used for computer-supporting cooperating work (CSCW), in education, business, and others.

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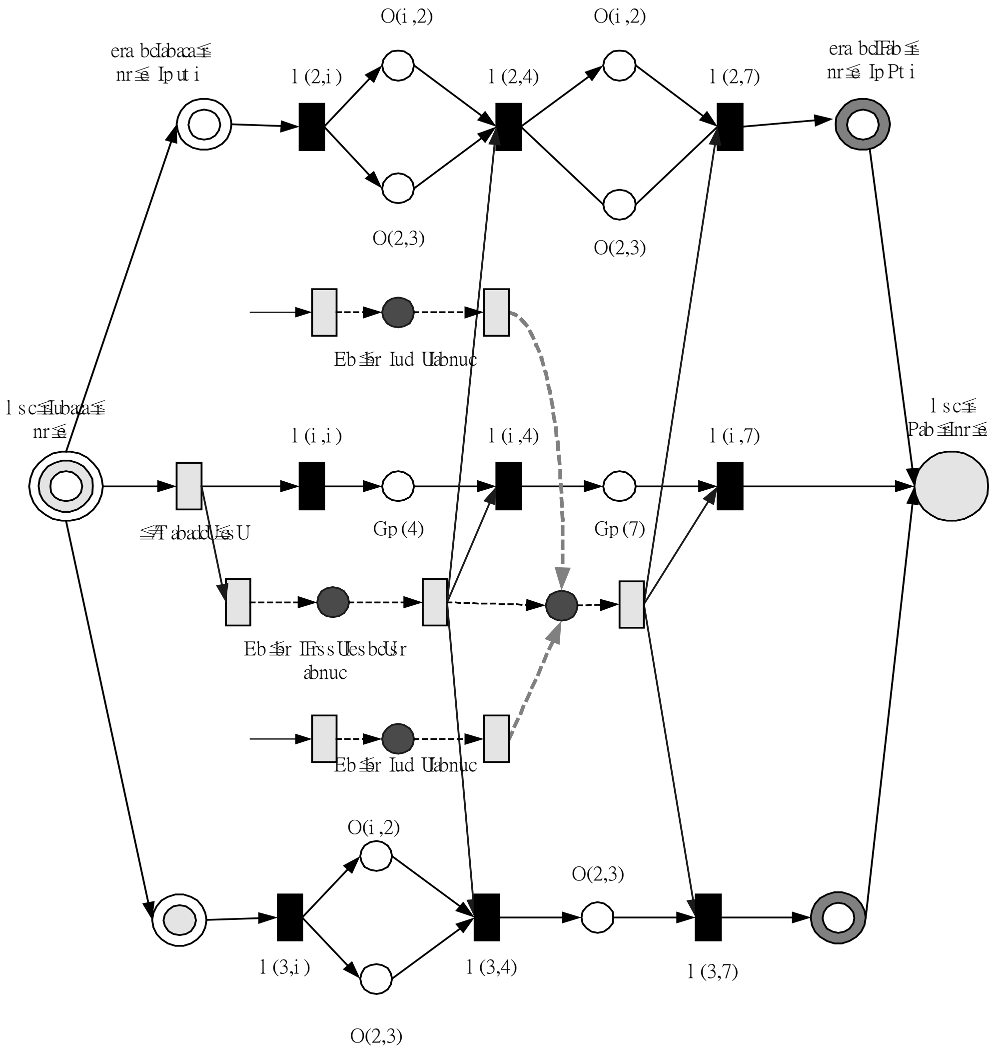
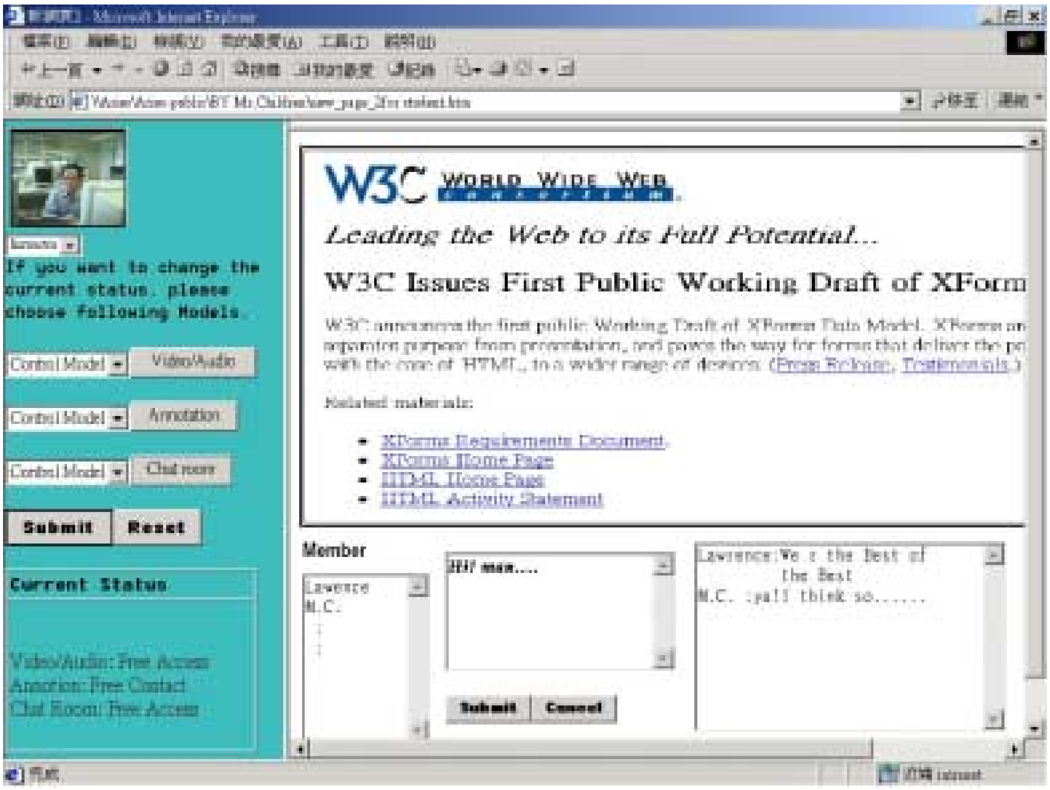
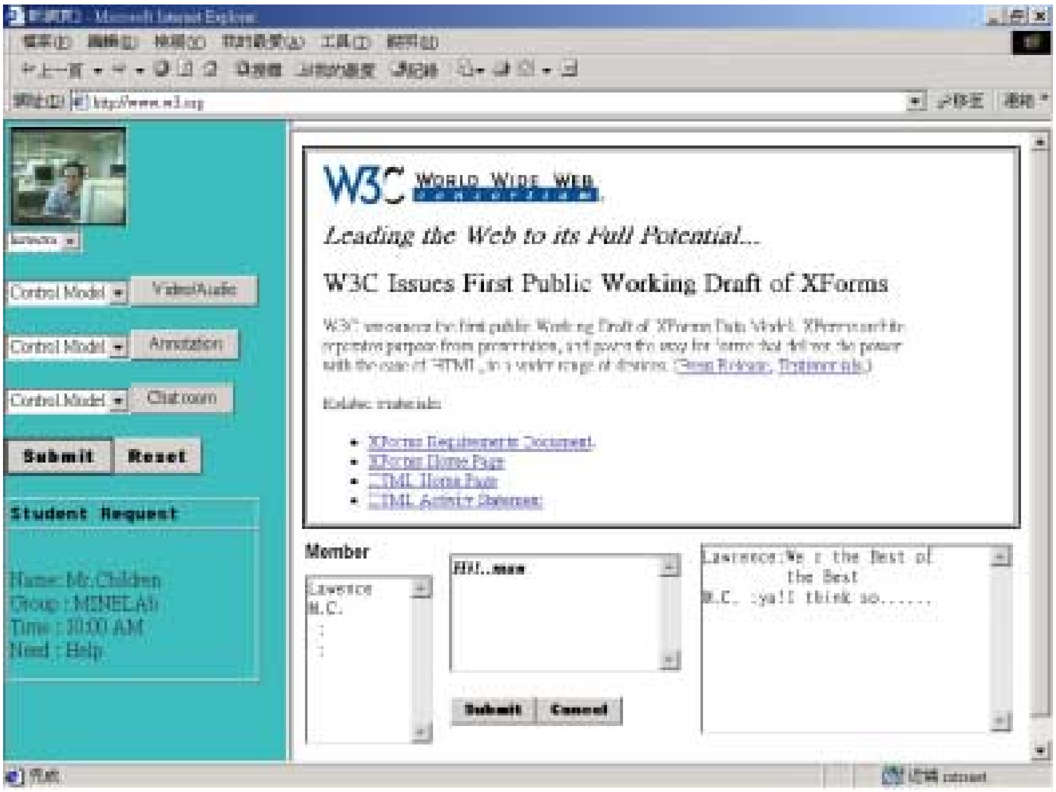


Figure 4 An overview of distributed multimedia presentation Petri net



5(a) DMPS communication window for student



5(b) DMPS communication window for teacher

Figure 5 The example of the DMPS communication windows