The Design of Remote Control in Multiple Display for a Synchronous Collaborative System

Lun-Chi Chen, Jyh-Horng Wu, An-Pang Wang, and Shyi-Ching Lin

Abstract—At the aim of delivering education to students who are physically departed from their teachers to access more education resources via Internet, distance learning becomes a trend in the teaching field. Currently, synchronous learning model are mostly supported for those users located in geographically dispersed classrooms at this early stage of distance learning environment construction in Taiwan. To consider economically, the solution to reach a low-cost goal of providing learning resources for students is quite demanded. Therefore, the paper will indicate that the design and implementation experiences of constructing a configurable display network for distance learning. A root display node sharing the learning resources builds a dynamic display network for a distance learning while other display nodes joint to it in succession. In this paper, we proposed an idea of a multiple display embedded system to assist in the distance learning for lowering the cost and complexity of sharing the learning resources. In a multiple display system, a display node is a software component bundled with an embedded wireless module connecting to a display projector or panel in a classroom. Moreover, soft component of display node is implemented an interface for mobile device to make a remote control. We also presented a node soliciting algorithm to articulate the construction of the learning display network, including of the design of display nodes.

Keywords—Collaborative environment, Remote control, mobile control, Dynamic resource allocation, Distance learning.

I. INTRODUCTION

Collaborative communication becomes much more crucial than ever due to these high developing synchronized methods. In the meanwhile, enterprises can decrease their cost by using these applications to achieve the goal of energy conservation and carbon reduction. ICT (Internet Communication Technology) tools have been widely implemented in various ways, such as videophone calls, virtual conferences and distance education courses. At schools, teachers can not only allocate their teaching resources with each other but provide lessons for students virtually and simultaneously. Thus, distance education grows popular with this emerging collaborative platform [1].

Practical and efficient collaborative platform can lead to excellent bilateral communication. Nowadays, there are two dimensions in this interactive high technology: synchronization and asynchronization. A synchronous communication can allow people to interact with an instructor in real time, and has two methods for using, such as:

Centralization is based on a power node, which is an easier way to build and can provide the service for all users. Moreover, the server must be powerful enough to run the service for them. Once a single failure happens, it will stop the entire system from working. National Center for High-Performance Computing (NCHC, Taiwan) focus on video conferencing for distance learning to develop Collaborative Life (Co-Life) [2],[3], which is a collaborative learning platform for multi-synchronous sharing and designed by centralized sever to set to provide exciting real-time, multi-users with an on-line collaborative platform.

Distribution is based on power nodes. To design group-oriented network environment, it is based on predefined many powerful servers to enable large data on collaborative learning to transmit between groups of users in different locations [4]. Asynchronous communication stands out with a just-in-time, on-demand user learning experience while synchronous communication needs users to schedule their time with the instructor under the predetermined plan. It has a complete flexibility in two ways, facilitated and self-paced [5]. Usually, the asynchronous communication for learning is applied as a learning framework for asynchronous Web-based training [6], which is operated by relying on a Web server, a group of modules with instructional and administrative purposes, and repositories for the relevant data sets. On the other hand, the synchronous teaching environment can keep those teaching activities recorded and then post-produced as asynchronous eLearning content stored on web site. Users can find the materials they are interested in through the website. However, the disadvantage of this model is a single point of failure.

Typically, it is useful and great efficient to supports bi-directional data transmission for collaboration platform. The design intent of collaborative application is to transform the way rich media are shared in order to enable more effective team collaboration. For the collaboration application in education,
two or more coequal individuals voluntarily bring their knowledge and experiences together by interacting toward a common goal in the best interest of students' needs for the betterment of their educational success. Hence, to interact and to change the provider is need for collaborative platform in learning, and especially it is easy to do in centralized server because the system designed to control management is not difficult.

The interface of smart phone is friendlier due to becoming more and more accepted by the market. Besides, user is allowed to programming on the devices, hence facilitating the development of software applications and improving user interface and performance. To control and share a single source and be capable of replacing sources synchronously, we use a remote display network for synchronized collaborative systems which enables dynamic and bidirectional data transmission. In control interface, we choose the android phone as controller to remote control how multiple display system operates. Therefore, a multiple display system (MDS) altered from our proposed algorithm is developed for teachers to present training materials for remote students residing at different geographic locations as shown in Fig. 1. Moreover, we also implement our methodology in the projector, in which self-configuration is with the capability to share the data, making every projector a data provider.

![Fig. 1 The implement of multiple display and remote control for synchronized collaborative learning systems in projector](image)

In section 2, this paper will introduce related collaborative learning platform application and in section 3, with more descriptions of our design concepts and algorithms and in section 4, show the experience of our methodology implement.

II. RELATED WORK

There are a lot of implementations of synchronous display system in Taiwan[3], which transmits images and sounds to achieve real-time sharing of knowledge by Co-Life platform shown in Fig. 2.

Virtual network computing (VNC) [7], developed by the AT&T laboratory, is one kind of tool of sharing the remote computer desktop. As an open source, it’s popular among all mechanisms of remote desktop sharing to help many applications developed in long-distance e-learning and cooperative work by transmitting the computer desktop through the network to others. There are many research groups still making great effort in its upgrade, such as compressing RFB data, recording and so on. VNC was used as a framework for information sharing in multiple collaborative operating systems with RFB as their communication agreements. To update the screen display, it uses these following modules: the updated region, mouse position, and event-triggered function and to reduce the traffic flow at the client side, VNC Server and VNC Client operate it as their primary mechanism [8].

![Fig. 2 An application of collaborative platform by Co-Life service for sharing of knowledge](image)

A lot of synchronized collaborative systems use web-based as their communication protocol and interface for development [9]. For users, it is more friendly. In distance training, synchronous display and the information sharing are mainly emphasized. A real-time synchronous display, like desktop sharing, is needed in the experimental operation, real-time courses and so on. In 2001, Tomohiro Haraikawa [10] put forth an idea of a mechanism for the remote collaboration with video display architecture and implemented it in embedded systems. He presented that the embedded device like video recorder can be integrated into a learning system while all the data used to be stored in the terminal for synchronous collaboration on the computer. The purpose of this paper is to solve the problem about how to simplify present training materials for remote students located in different geographic places.

III. MULTIPLE DISPLAY SYSTEM AND MOBILE REMOTE CONTROL

The proposed self-configurable network construction algorithm reduces the design complexity of synchronized distance learning and collaboration applications. We should design the algorithm to achieve the high performance of data transmission and dynamic adjustment when the source is changed.
A. Dynamic allocation strategy

The graph of the process of sharing data by synchronous communication is shown as Fig. 3. There are six nodes joined this communication, consist of one root node. Let session graph (SG) denotes the structure of the relation of nodes. In fact, we can regard SG as the structure of a bi-direction tree, and the root can be changed dynamically. A dynamic allocation strategy obtains three parts, which are dynamic allocation, root replacement and performance of adjustment. We wish to find the appropriate node with enough bandwidth and short round trip time within TCP for existing nodes by this algorithm.

Fig. 3 The learning resource was propagated in the session graphic

1. Dynamic Allocation Algorithm

To search a fit node is the main subject in dynamic allocation algorithm. This algorithm plays a major role in searching a fit node when the new node would be joined in session graph. A fit node should be capable of transmitting the data from root to the new node stably and immediately.

We define the source node as root and the round trip time between two nodes as \( RT\), before describing the algorithm. Let \( W_i\) denote the \( RT^{-1}\) between two nodes. Suppose there is a node \( N_i\) and its total weight \( SUM_i\), as in.

\[
SUM_i = SUM_j + W_j
\]

\( SUM_i\) denotes the summary of round trip time from root to \( N_i\), and thus we can obtain total weight of node \( N_i\). Normally, bandwidth quality, response time and loss rate are the important factors affecting transfers between two nodes on the network because speed of data transmission is limited by the bandwidth traffic congestion. Thus the system determines the fit node using bandwidth and round trip time as selection factors.

Suppose the new node \( N_v\) would like looking for a fit node on SG. The steps of our algorithm are shown as follows. At First step, \( N_v\) should ask root node to receive addresses of all nodes and the sum of weights of all nodes on SG, and then the system measures every weight between the node \( N_v\) and all nodes (Fig. 4).

In the application, whole information about weights between all nodes and relationships are stored at TreeTable in root node. At second step, the system determines one fit node by dynamic allocation algorithm. The algorithm complexity of dynamic allocate algorithm is roughly \( O(3n)\). The algorithm is as TABLE I.

In general case, traveling whole nodes of SG to find out the maximum weight is not quite efficient. In real world the system just searches the node which is available to fulfill enough bandwidth and shorter round trip time, that is, the selected node should just suffice for receiving the data synchronously and providing enough bandwidth for transmitting data. For this reason, we can use first fit strategy, which simply travels the SG until a large enough weight threshold is found, to define a min-weight threshold \( T_{threshold}\) and then the node is selected if the \( SUM + W > T_{threshold}\) This algorithm is shown in table algorithm 1. By using this method the first fit node could be searched without checking whole existing nodes. Additionally, the variables \( W\) and \( SUM\) at TreeTable are adjusted per unit time. That is because the weight at TreeTable would be changed when the new node inserted. In real case, there is usually variation on a network environment with time.

Fig. 4 The weight between the node x and all nodes before the node x jointing the session graph

TABLE I

<table>
<thead>
<tr>
<th>DYNAMIC ALLOCATION ALGORITHM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>[Initialization]</strong></td>
</tr>
<tr>
<td>Set the lower bound of bandwidth ( \beta )</td>
</tr>
<tr>
<td>Set min-weight threshold ( T_{threshold}) are adjusted per unit time</td>
</tr>
<tr>
<td><strong>[Allocate an appropriate node to requesting node]</strong></td>
</tr>
<tr>
<td>( W_i = \text{get weight between root and requesting node} )</td>
</tr>
<tr>
<td>( W_i = \text{Search the appropriate node} )</td>
</tr>
<tr>
<td>for each node ( v ) in ( SG ) and its bandwidth is ( B_i ), then</td>
</tr>
<tr>
<td>( (SUM_i = TreeTable(v)) + W_i ) if ( B_i &gt; \beta ) and ( T_{threshold} )</td>
</tr>
<tr>
<td>then return ( v )</td>
</tr>
<tr>
<td>else if ( W_i &lt; \beta ) then</td>
</tr>
<tr>
<td>return ( H )</td>
</tr>
</tbody>
</table>

Besides, the system defines the step of searching node begins from lowest level of SG. Because the node at lower level is nearer to Root, the performance of data transmission is likely to be better. Usually, there is shorter round trip time happened in low-level nodes. By this way, we can reconstruct the searching method of this algorithm in \( O(m) \) such that \( 1 \leq m \leq n \), assuming there are \( n \) existing nodes, and therefore the running
time of dynamic allocation algorithm is $O(2n+m)$.

2. Root Replacement Algorithm

Our methodology can support bi-directional data transmission sufficient for collaborative platform. The source data is usually provided from different user and then the system would change the root node to adjust the architecture of SG. For avoidance of arbitrary requesting from the node on SG, the algorithm is adopted the general election strategy of distribution system to determine if the replacement request is agreed. Hence, we provide the light replacement algorithm to handle the change taken place when the root node is changed. At first, Let $N_r$ denote the node will be the root node so that we can obtain the pseudo code of swap method is as follows:

\[
\begin{align*}
\text{\textbf{root} & $\leftarrow$ Root} \\
\text{root & $\leftarrow$ $N_r$} \\
\text{root & inserted by dynamic allocation algorithm}
\end{align*}
\]

In fact, it is simply to know this light algorithm is not best performance but the result is acceptable for our request. We wish to execute less node shift to decrease the cost of adjustment and reconstruct.

3. Performance of Adjustment Algorithm

In Root Replacement Algorithm, we just discuss special case that the node $N_r$ is a leaf node. In general, the determined $N_r$ usually belongs to an internal node or a leaf node, and hence we should discuss the solutions in two cases.

If the node $N_r$ is an internal node, which means the node $N_r$ has child nodes, child nodes of the node $N_r$ will be reconstructed by dynamic allocation algorithm after the node $N_r$ has replaced the root node. Fig. 5 illustrates an example of how to adjust when an internal node $N_r$ replaces the root node.

\[
\begin{align*}
\text{Node C is } N_r, \\
\text{replace} \\
\text{root} \\
\end{align*}
\]

Fig. 5 The node replacement by dynamic allocation algorithm

B. Module of multiple display system

The module of multiple display system includes web service, MDS API set via SOAP and core library of MDS. As shown in Fig. 6, multiple display system is also based on web-based and user can use this service quickly. By the network setting via web user can run multiple display service with Java Web Start to share screen with synchronous. Moreover, the implement of android application is as control interface to provide another kind of control operation [11]. The purpose of MDS API set is to call library which is display module of the embedded system to provide the service for user. The screen sharing is based on RFB protocol.

![Fig. 6 The model of multiple display system and mobile control](image)

IV. EXPERIMENT

We have presented my method of the multiple display system, but there are more factors to affect the delay time of a remote display. This paper will discuss these factors are relative to the performance of a remote display are as follows. Afterward we will implement the proposed methodology.

In the experiment, we analyze the performance of the remote display using the round-trip time, which is the time it takes for a transmitter to send a request and the receiver to send a response over the network, not including the time required for data transfer. We denote the weight $W$ is the inverse round-trip time, and the time is based on 10 milliseconds.

A. Effect of the Threshold

The method of this paper decreases the time of allocated a node with setting threshold. We choose four thresholds as 0.05, 0.1, 0.15, 0.2 and use these thresholds to compare with none threshold. The results show that there is significant when the threshold is less than 0.1, and it is because there is the node is chosen by threshold (TABLE II).

<table>
<thead>
<tr>
<th>Threshold</th>
<th>0.05</th>
<th>0.1</th>
<th>0.15</th>
<th>0.2</th>
<th>none</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 nodes</td>
<td>2.16</td>
<td>3.37</td>
<td>4.64</td>
<td>4.15</td>
<td>4.02</td>
</tr>
<tr>
<td>8 nodes</td>
<td>3.39</td>
<td>3.88</td>
<td>4.83</td>
<td>4.61</td>
<td>4.38</td>
</tr>
<tr>
<td>12 nodes</td>
<td>2.31</td>
<td>3.64</td>
<td>4.96</td>
<td>5.42</td>
<td>5.57</td>
</tr>
</tbody>
</table>

The allocation time of different thresholds

Unit: Allocation time (sec)

B. Comparison of the Architecture of Remote Display

This experiment is order to know whether or not the amount of nodes influences the performance of dynamic allocation algorithm. Finally, we will attempt to compare some of current common architecture of remote display. In this experiment, there are three servers are installed in distribution item.
The result of centralization is good when there are several nodes. With increasing number of nodes the performance was becoming progressively worse, even over the acceptable delay time.

Distribution is based on predefined many powerful servers, and the goal is to design group-oriented network environment to share and propagate. In the experiment, the distribution is a good choice, but it is possible that many nodes receive from a certain server if the number of nodes is more. In this situation, the performance is like centralization model. Besides, it is need to spend more cost to build many servers in distribution model (TABLE III).

<table>
<thead>
<tr>
<th>Amount of nodes</th>
<th>3</th>
<th>6</th>
<th>9</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralization</td>
<td>2.77</td>
<td>3.94</td>
<td>6.23</td>
<td>8.38</td>
</tr>
<tr>
<td>Distribution</td>
<td>1.38</td>
<td>2.13</td>
<td>3.98</td>
<td>4.35</td>
</tr>
<tr>
<td>MDS</td>
<td>1.95</td>
<td>2.17</td>
<td>4.06</td>
<td>5.82</td>
</tr>
</tbody>
</table>

The delay time with increasing in amount of nodes
Unit: Delay time (sec)

Our methodology MDS is to propose a self-configurable network construction algorithm. This algorithm could be implemented in embedded system to reduce the cost. In the results, the performance is close to distribution model and is better than centralized model if the number of nodes is increasing. The proposed method could be integrated in learning system easily and the cost of building the system is low.

V. CONCLUSION AND FUTURE WORK

The methodology of multiple display system reduces the design complexity of synchronized distance learning and collaboration applications. The root node election algorithm and root replacement procedure are used to enforce the orderly transition between difference data sources without re-constructing the network topology. Based on that, distance learning or collaboration system developers can concentrate on the application logic but not the complicated bi-directional data transmission protocols between all parties. Besides, the node-joint procedure introduces the efficient and feasible solution to welcome new nodes to join the session graph without any downgrade of system performance. It guarantees the best system round trip time for a new node to join an existing session graph. To demonstrate the feasibility of the proposed algorithms, a multiple display system is developed for teachers to present training materials for remote students resident in different geographic locations. In additional, we design the control interface on the smart phone that makes operation of multiple display system easy and quick.

Although the implementation issues of MDS are out of the scope of this research. There are still several issues leaned while developing or deploying the MDS system to remote districts in Taiwan. For example, there are types of exceptions need to be discussed and solved for data lost or network failures. We will continue this research on the exception handling and try to promote the results of this study by developing more application scenarios in the near future.

REFERENCES