A Self-Configurable Remote Display Network for Synchronized Collaborative Learning Systems

Lun-Chi Chen, Jyh-Horng Wu, Shyi-Ching Lin, and Ruey-Kai Sheu

***Abstract*—Distance learning aims to deliver education to students who are not physically on site with teachers, and try to enhance the accessibility for education resources through Internet. Here in Taiwan, it is still at the early stage of distance learning environment construction, and most distance learning classes support synchronous learning model that teachers and students are located in geographically dispersed classrooms at the same time. For economical considerations, there are demands of low cost solutions to multicast the learning resources to students. It is the purpose of this paper to share the design and implementation experiences of constructing a configurable display network for distance learning. A dynamic display network for a learning class is constructed by a root display node sharing the learning resources, and other display nodes joint to the display network in succession. To reduce the cost and complexity of sharing the learning resources, this paper proposed a multiple display system based on the embedded system to assist in the distance learning. A display node of multiple display system is a software component bundled with an embedded wireless module connecting to a display projector or panel in a classroom. Besides the design of display nodes, a node soliciting algorithm is also presented to articulate the construction of the learning display network.**

***Index Terms*—Collaborative environment, dynamic resource allocation, distance learning.**

I. Introduction

With the development of the Internet, synchronous method plays an import role in collaborative communication, such as video conference, distance learning environment and cooperative work [1]. Along with the popularity of internet and the high wide bandwidth, long distance communication is shown by various ways, such as video, voice, document and applications based on collaborative communication.

There have been many ICT (internet communication technology) tools for long-distance communications, such as the internet phone service, video conferencing systems and collaborative e-learning. With these online communication mechanisms, information exchange becomes easy and convenient.

Distance communication has become increasingly prominent, especially when awareness of environmental protection is rising nowadays. Thus, the internet communication technology can bring enterprises cost down with the policy of energy saving and carbon reduction.

Besides, the collaborative distance learning can resolve the problem of the resource allocation in education and be easy and convenient to encourage teachers to share education resources with each other. Now, the improvement of these tools for long-distance learning is never stopped although there are many collaborative platforms for learning in education [2].

Collaborative platform supports bi-directional communication. Currently, collaborative platforms can be classified into two basically dimensions, which are synchronous and asynchronous communication. From the viewpoint of synchronous communication, involves interacting with an instructor in real time, there are two methods can be used, such as:

Centralization is based on a power node. This method is easy to be built and a service for all users, hence, the server must be powerful enough to run the service for them. There is an important problem, that is, a single point of failure is a part of a system which, if it fails, 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) [3], which is a collaborative learning platform for multi-synchronous sharing. Co-Life is designed by centralized sever set to provide exciting real-time, multi-user for on-line collaborative platform. The service of Co-Life consists of message, application sharing, remote control, media stream to achieve long-distance collaborative application for multiple users [4]. Other applications are such as web-based, application software, integrated system and so on [5].

Distribution is based on power nodes. Based on predefined many powerful servers, the goal is to design group-oriented network environment. It enables large data based collaboration between groups of users in different locations [6]. Access Grid [7], which was developed by Argonne National Laboratory, is a popular platform with Grid architecture for video conferencing communication, provides communication from multiple points. Many applications are used by communication from multi-point model of Access Grid to achieve distributed cooperation environment. These research groups invest a lot time in developing application with Access Grid, such as long-distance medical care, e-learning, disaster prevention, emergency response [7].

As for the dimension of asynchronous communication, it is more common because it creates a just-in-time, on-demand user learning experience. Unlike synchronous communication, user does not need to schedule their time around the predetermined plan of the instructor. There is complete flexibility with asynchronous communication, which comes in two forms, facilitated and self-paced [8]. Usually, the asynchronous communication for learning is

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applied such as a learning framework for asynchronous Web-based training (WBT) [9]. The operations of WBT rely on a Web server, a group of modules with instructional and administrative purposes, and repositories for relevant data sets. The synchronous teaching environment also provides recording function, that is, synchronous teaching activities can be recorded and then post-produced as asynchronous eLearning content stored on web site. Every student needs to link to the web site and search the materials in which you are interested. The disadvantage of this model has a problem about single point of failure.

Besides, the other collaborative platform based on the asynchronous communication is Peer-to-Peer network, which that is popular in emerging network technique because it provides a good substrate for creating large-scale data sharing [10]. Every provider can deliver various sharing materials as video, audio, and reports via P2P model. 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 [11].

To share single source with synchronous and be capable of the replacement source, we propose a self-configurable remote display network for synchronized collaborative learning systems which is capability of dynamic and bi-direction data transmission, and further, we wish distance learning or collaboration system developers can concentrate on the application logic but not the complicated bi-directional data transmission protocols between all parties. Hence, a multiple display system (MDS) designed from our proposed algorithm is developed for teachers to present training materials for remote students resident in different geographic locations. Moreover, we also implement our methodology in the projector which could be self-configuration capability to share the data, and hence every projector can be as a data provider.

In Section II, this paper will introduce related collaborative platform applied in learning. Section III, describes our design concepts and algorithms. Section IV shows experience of our methodology implement.

II. Procedure for Paper Submission

Virtual network computing (VNC) [12], which was developed by the AT&T laboratory, is one kind of tool of sharing the distance computer desktop. With VNC is an open source, it's popular among all mechanism of distance desktop sharing to help many applications development in long-distance e-learning and cooperative work by transmitting the computer desktop through the network to others. Many research groups still spend on upgrading until now, such as compressing RFB data, recording and so on. In large number of collaborative operating system, VNC was used as a framework for information sharing, with RFB as their communication agreements, including the update region, mouse position, event-triggered and so on, by using these modules to update the screen display. The primary mechanism is to reduce the traffic flow at client side, and the framework operates by VNC Server and VNC Client [13].

A lot of synchronized collaborative systems use web-based as their communication protocol and interface for development [14]. The service of web-based interface is friendly for user. The most important part in distance training is synchronous display and sharing. In the experimental operation, real-time course and so on, they both need real-time synchronous display, such as desktop sharing. Besides, it also set up a remote collaborative learning environment using the tools of VNC and Access Grid [4].

In 2001, a mechanism for remote collaboration with video display architecture was proposed by Tomohiro Haraikawa [15], and implemented by embedded systems. For synchronous collaboration on the computer, all the data are usually stored in the terminal, but he presents to integrate the embedded device like video recorder into learning system.

The purpose of this paper is to solve how to simplify present training materials for remote students resident in different geographic locations.

III. Multiple Display System

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. 1. 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.

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.

$$SUM_i = SUM_j + W_j \qquad (1)$$

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_x would like looking for a fit node on *SG*. The steps of our algorithm are shown as follows. At First step, N_x 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_x and all nodes (Fig. 2). 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 Algorithm 1.

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 $T_{threashold}$ and then the node is selected if the $SUM + W > T_{threashold}$. 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.

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 (Fig. 3). By this way, we can reconstruct the searching method of this algorithm in $O(m)$ such that $1 \le m \le n$, assuming there are n existing nodes, and therefore the running time of dynamic allocation algorithm is $O(2n+m)$.

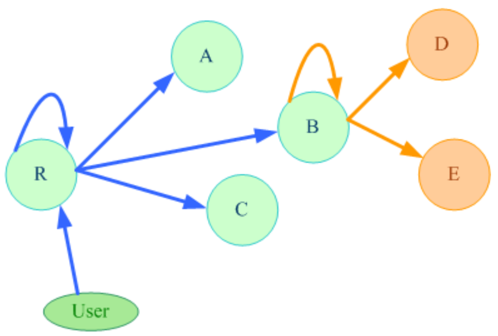

Fig. 1. The learning resource was propagated in the session graphic.

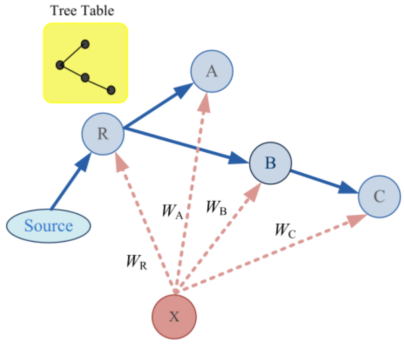

Fig. 2. To estimate the weight between the node x and all nodes before the node x joints the session graph and the TreeTable is stored in root node.

Algorithm I: Dynamic Allocation Algorithm

[Initialization]
  Set the lower bound of bandwidth β
  Set min-weight threshold $T_{threshold}$
[Timer-driven event]
Update variable SUM' when a certain node N' returns new weight between self and its parent per unit time
[Allocate an appropriate node to requesting node]
μ ← Root
W_r ← get weight between root and requesting node
// Search the appropriate node
for each node ν ∈ V [SG], and its bandwidth is Bi
  do SUM_ν ← TreeTable[ν]
  W_ν ← get weight between ν and requesting node
    $\pi \leftarrow SUM_\nu + W_\nu$
    if $B_i > \beta$ and $\pi > T_{threshold}$
      then return ν
    else if $W_r < \pi$
      then μ ← ν
return μ

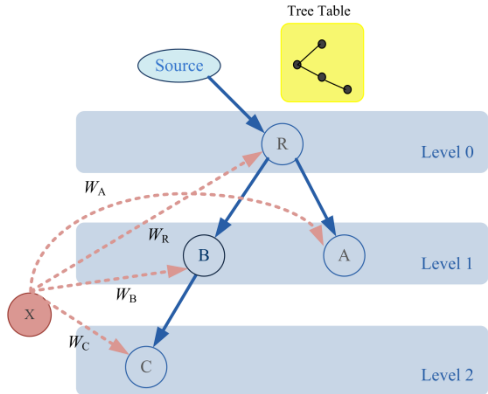

Fig. 3. The node x searches from low level of session graph when it would like finding the fit node to joint.

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:

ω ← *Root*
Root ← N_r
ω inserted by dynamic allocation algorithm

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 (see Algorithm II).

If the node Nr is an internal node, which means the node Nr has child nodes, child nodes of the node Nr will be reconstructed by dynamic allocation algorithm after the node Nr has replaced the root node. Fig. 4 illustrates an example of how to adjust when an internal node Nr replaces the root node.

Algorithm II: Adjustment Algorithm

```
INPUT Nr // Nr is a node which will be the root node by election algorithm
if  Nr hasChild
    then ν  ← Root
        Child_r ← SubTree[Nr]
        Root ← Nr
        ν inserted by dynamic allocation algorithm
        μ ∈ Child_r inserted by dynamic allocation algorithm
    else ν ←Root
        Root ← Nr
        ν inserted by dynamic allocation algorithm
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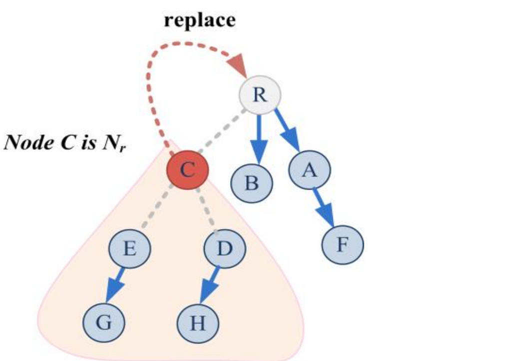

Fig. 4. The node C replaces the root node R, and then nodes E, G, D, H will insert to SG again by proposed dynamic allocation algorithm.

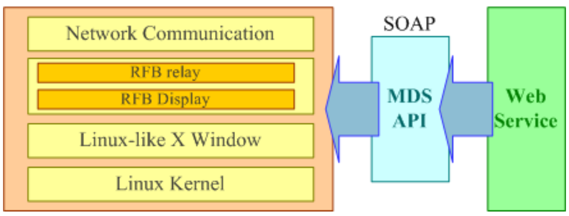

Fig. 5. The model of multiple display system.

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. 5, 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. 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.

IV. Experiment

We have presented my method of the self-configuration remote display network, 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 (Fig. 6).

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.

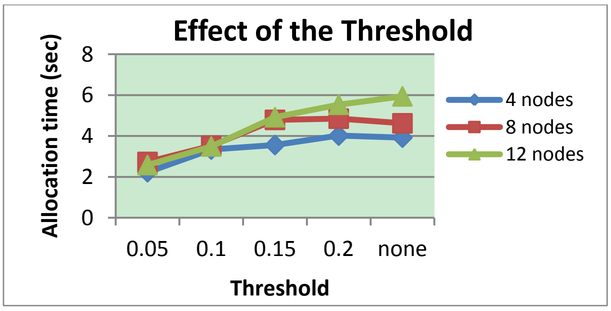

Fig. 6. The allocation time of different thresholds.

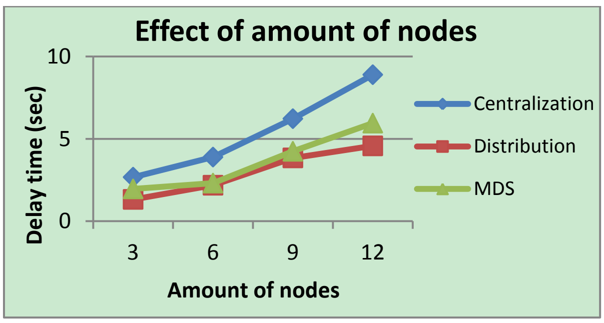

Fig. 7. The delay time with increasing in amount of nodes.

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 (Fig. 7).

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 proposed self-configurable network construction algorithm 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 (MDS) is developed for teachers to present training materials for remote students resident in different geographic locations.

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.

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