Delay-Aware Scale-Free Display System under Ubiquitous Grid Networking (uGrid) Environment

Yusukei Okazaki*, Yuki Susa*, Ryota Usui*, Yutaka Arakawa*, Satoru Okamoto*, and Naoaki Yamanaka*
*Department of Information and Computer Science, Faculty of Science and Technology, Keio University,
3–14–1 Hiyoshi, Kohoku-ku, Yokohama, 223–8522, Japan
Email: okazaki@yamanaka.ics.keio.ac.jp

Abstract—New scalable display system in a ubiquitous Grid networking (uGrid) called scale-free display system is proposed. Tiled display system which can visualize large high-resolution images has been becoming famous. However, the more display size grow large, the more hard to establish the system. Also, a study of widely distributed computing or uGrid has been growing. In this paper, we propose scale-free display system under distributed computing network and optical broad band network. In proposed system, computing resources are widely distributed in the network, so distances from each computing resource to the tiled display are different. Thus, to synchronize all frames of image, computing resources which have almost same delay to the tiled display have to be selected in case that the system starts. For this reason, we consider the method to select the computing resources. Also we examine the characteristic of delay in power-law network under the assumption that the proposed system will be applied to power-law network.

I. INTRODUCTION

Fundamental TV system has not been changed for a long time. TV station broadcast contents to TV users. The users choose the program which broadcasted by TV station. Thus, due to limitation of TV program, the users might not be able to watch the program which the users really want to watch. Moreover, even if a user watches the sports program that he wants to see, the user cannot watch by the camera angle that he really wants to see.

With the growth of computer system and measurement technology, the date size became large and complex. Also, necessity of the technology to visualize a data such as satellite image or electron microscope image on a large screen has risen.

A study of grid computing [1] or widely distributed computing has been growing. Grid Computing can realize a high performance virtual machine by combining high performance computers. Likewise, with the advance of ubiquitous society, it is expected that everything will be connected to the network. From such a background, a ubiquitous grid networking environment (uGrid) [2], [3], [4] has been proposed. In this environment, everything is defined as service-parts and some Service-parts will be combined to provide new service for users.

In this paper, new scale-free display system under uGrid environment and optical broad band network is proposed. In proposed system, computing resources are widely distributed in the network, so distances from each computing resource to the tiled display are different. Thus, to synchronize all frames of image, computing resources which have almost same delay to the tiled display have to be selected in case that the system starts. For this reason, we consider the method to select the computing resources. Also we examine the characteristic of delay in power-law network under the assumption that the proposed system will be applied to power-law network [5].

II. RELATED WORKS

A. Tiled Displays

Tiled display is a method to visualize a high resolution image on large scale screen composed by multiple LCD panels. Technologies to realize tiled display system, for example, SAGE (Scalable Adaptive Graphical Environment) [6], Chromium [7] and Tenmado [8] were established. In this paper, to realize the proposed system, we use and improve SAGE to apply the proposed system.

B. SAGE

SAGE is one of the projects developed by Electronic Visualization Laboratory (EVL). SAGE realizes the seamless display which can visualize simultaneously various applications such as 3D rendering, remote desktop, video streams and so on. Figure 1 shows Architecture of SAGE. SAGE composed by tiled display, a control PC, application servers, display nodes, and user interface.

1) tiled display: Tiled display composed by multiple LCPs. Each LCD connects to the display node, and LCD displays video signal from display node.

2) Control PC: Control PC manages whole of the system. Each components of SAGE is operated as control PC indicates.

3) Application server: Application server is a component to execute applications such as movie player, 3D rendering. Application is applied to SAGE, and output of application is captured as pixel information. Then, pixel information sends to display by streaming.

4) Display node: Each display node receives pixel information from Application server. Pixel information is converted as video signal, and is send to corresponding LCD.

5) User interface: SAGE has GUI user interface. User can execute applications, resize application windows, change the position of application windows.
III. PROPOSED SYSTEM

We propose a new image distribution system which differs from TV system. In uGrid environment, it is possible to assume that camera will be connected to the network. Therefore, there will be many cameras connected to the network in the world. Figure 2 shows overview of our proposal system. In this system, using uGrid technique, user can select a camera which widely distributed in the network, and users can watch images of the camera through the network. Basic operation of this system is as follow.

1) Select a camera in the network user wants to watch.
2) Select computing resources in the network to convert the data to video signals.
3) Display to the tiled display.

In order to archive this system, we improve SAGE system as N-SAGE system and apply N-SAGE system to our proposal. Figure 3 shows the placement of SAGE components. SAGE system is set up in LAN. However, N-SAGE system is set up as shown in Figure 4. In N-SAGE system, computer resources not in use in the network are used as display nodes. Thus, proposed system needs to get computing resources when the system start. Users do not need to prepare computing resources at their side. That is why this system is scalable.

In SAGE system, LCD and display node are connected by DVI signal. However, in N-SAGE system, there is the network between LCD and display node. Hence, DVI over IP is needed to communicate over the network. It is possible to set DVI over IP into proposed system, because DVI over IP has already been put to practical use [9].

IV. COMPUTING RESOURCE SELECTION METHOD

In proposed system, computing resource widely distributed in the network is used as display nodes, so it is likely that distances from each display nodes to the tiled display are different like I, II, III in Figure 4. As a result, there is a possibility that delays from each display node to the tiled display are different. Therefore, synchronization method is needed to synchronize all frames of image. There are three methods as follow.

1) Select display nodes which have almost same delay to the tiled display when the system starts.
2) Synchronize frames using buffer at display side. However, this method have to adapt buffer to display.
3) Select display nodes at random, and adjust all output to a display node which has maximum delay to the tiled display.

Because of its simplicity, method 1) is better. In addition, to get more high-accurate, we combine the methods 1) and, 2) or 3).

A. simulation of delay characteristic in power-law network

As a result of recent measurement studies on Internet topology, it became clear that Internet topology goes along power-law attribute. So we assume that the proposed system is applied to power-law network, we examine the characteristic of delay in power-law network by computer simulation. In power-law network, the number of out-going links at a node distributions follows the power-law. Hence, let $p(k)$ be the
probability that a node is connected $k$ other nodes, $p(k)$ is represented as $k^{-\gamma}(r$ is constant).

In order to create BA model [10] which follows power-low, we use BRITE [11] as a topology generator. The number of nodes set to 500 nodes that is the number of nodes in ISP of Sprint Corp [12].

Figure 5 shows average of shortest path delays from each node to the other nodes. Maximum network delay was set to 30msec. As a result of simulation, it is clear that peak value is existing, since there are “Hub” nodes which have a lot of out-going link in power-law network.

Therefore, to minimize delay jitter between display nodes and tiled display, display nodes which has delay around peak value should be selected. For example, consider a situation that we need 40 computing resources as display nodes. If we get nodes from minimum delay, jitter of delays $\Delta t_A$ is 6msec. If we get nodes from around peak value, jitter of delays $\Delta t_B$ is 3msec. If we get nodes from maximum delay, jitter of delays $\Delta t_C$ is 8msec. Comparison of jitters is as follows.

$$\Delta t_B \ll \Delta t_A < \Delta t_C$$

It is possible to minimize jitter of delay by selecting display nodes around peak value.

B. selection method

To get display nodes which has almost same delay to the tiled display, we should figure out which computing resource is available. Several studies have been made on management method about service parts in uGrid [4]. I will not take up such method in detail. In this paper, we assume that all of service parts participate proposed system is known, and IP address of service parts is also known.

The data table is made ahead the system startup as Figure 6. First, send flooding packet to observe delay to all nodes. Second, detect peak value according to result of first step. Then, compare to the condition "peak value $\pm \Delta t'$", where $\Delta t$ is set by administrator.

When the request to startup the system is occurred, operation follows the step as Figure 7. First, send request message according to the data table.

V. IMPLEMENTATION

We built up a prototype of the proposed system. Figure 8 shows the tiled display composed by 24 LCDs. This tiled display has $7680 \times 4096$ resolution which corresponds to 8K resolution. Table I shows specification of display nodes. There are 12 display nodes, and each display node supports 2 LCDs.
VI. CONCLUSION

We have proposed a new image distribution system under uGrid environment called scale-free display system. In this system, computing resources are widely distributed in the network. Therefore, to synchronize all frames of image, computing resource selection method is needed. We simulate the characteristic of delay in power-law network under assumption that the proposed system will be applied to power-law network. As a result from simulation, we consider computing resource selection method. In addition, we built up a prototype of the proposed system.

TABLE I

<table>
<thead>
<tr>
<th>Machine Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display node</td>
</tr>
<tr>
<td>OS</td>
</tr>
<tr>
<td>CPU</td>
</tr>
<tr>
<td>Clock frequency</td>
</tr>
<tr>
<td>Memory</td>
</tr>
<tr>
<td>VGA</td>
</tr>
<tr>
<td>LCD</td>
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<tr>
<td>Resolution</td>
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