Virtualization Technology for Multi-display Systems

Igor Petukhov, Lyudmila Steshina, Ilya Tanryverdiev
Mari State Technical University, Deptartment of Radio Technical
Yoshkar-Ola, Russian Federation
Emails: {PetuhovIV@marstu.net, SteshinaLA@marstu.net, ili.tanryverdiev@gmail.com}

Abstract – **The method for creation of multi-user multi-monitor systems designed for educational purposes is suggested. The method utilizes virtual machine technology which makes possible to create completely isolated user working environment, remote access to equipment and remote workstation administration. Standard interfaces like DVI, VGA or USB are used as data transmission channels along with network technologies. Such architecture facilitates the operator's work, making it more comfortable, and improves the quality and capabilities of the distant access to remote resources.**

Keywords-multi-user multi-monitor systems; virtual machine technology; interface.

I. INTRODUCTION

Intense progress in remote educational techniques and reformation of the existing intramural ones stimulates the information systems developers to seek for newer technologies to be convenient and beneficial for the educational process. First, it concerns the reformation of computerized student workstations organization, namely, their graphics architecture, ways of workstations interaction with each other and with the teacher's workstation. Nowadays, tablet PCs, graphics systems having two or more displays, multi-user designs on the base of a single computer, etc. are being implemented together with non-removable computerized student workstations.

Graphical systems having two or more displays are well known and successfully used by specialists in different spheres, especially where the human-operator has to deal with great amount of changing data. Such systems are used at stock exchanges, in monitoring different natural processes, in the systems of technological process automated control at industrial enterprises and in many other fields.

Most of these systems are designed for the work with a single operator, i.e. they create common information space including a single operator. There are works on creating graphical systems with intelligent terminals and direct allocation of data processing function to several computing machines [1], systems with intelligent satellites [2], client/server models 'host computer plus user terminals' using different types of PCs [3, 4].

Software programs like Citrix providing terminal access for Windows and UNIX and terminal services incorporated in server versions of Windows [5] are among the primitive mechanisms of terminal access known today.

Heterogeneous distributed computer systems for decentralized machinery control using Web-server and remote web-client servers [6], multi-user system Multiseat implementation technologies [7], corporate solutions of distributed user systems in virtual environment on the base of Microsoft RemoteFX [8] are also of interest.

Most of these systems are designed for the work with a single operator, i.e. they create common information space including a single operator. However utilizing multi-display systems in education may be still more efficient, if their own working environments are created for them.

Moreover, implementation of distributed terminal systems gives an advantage of providing substantial financial saving on purchase of equipment, diminishing operational costs for system maintenance and, in a way, realizing 'green' energy saving concept [9, 10].

Thus, the fact of practicability of multi-user terminal systems implementation is becoming evident.

Meanwhile there still exist a number of problems requiring special attention. They are the problems of providing the system processing speed and its productivity, the security of information communication when transmitting it through the open access networks, implementation of the 'severe real time' mode.

The aim of the given work is to elaborate the way of creating a multi-user multi-monitor system with remote access capability designed to be used as information environment in education process.

II. THEORETICAL ANALYSIS

Multi-user multi-monitor systems are those built on the base of a single computer and having many monitors each meant to be used by one operator.

In information systems, the so-called terminal principle is usually used to provide multi-user work, interaction of technical provision of operators' workstations through local processing networks or other network technologies underlying the principle.

This causes substantial delays in information communication and limits the communication bandwidth between operators. Technical provision of operators' workstations is common user PCs having input/output devices for interaction with an operator and network adapter for adding a client to the network. Organization of user workstations without using the client PCs has limited implementation so far because of its low dynamic features. For example, ArtistaNET controller making possible to integrate LCD displays into a local area computer network without a client PC has for the time being the productivity [11] shown in the table below.

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TABLE I. COMPARATIVE FEATURES OF ARTISTANET CONTROLLER PRODUCTIVITY

Resolution	Interface	Image Transfer Rate
VGA	100 Mbps	16 images per second
SVGA	100 Mbps	12 images per second
XGA	100 Mbps	5 images per second
WXGA	100 Mbps	4 images per second
SXGA	100 Mbps	3images per second

Such communication bandwidth of data channels between the operators' workstations is evidently insufficient for monitoring the quickly changing processes and creating the 'real time' for a user.

There is another principle, suggested by the authors earlier and based on utilizing analog channels for data transfer. The essence of the technique is in setting a lot of video cards into the computer and connecting each of them with two monitors by a standard cable through DVI or VGA interface (Fig. 1) [12].

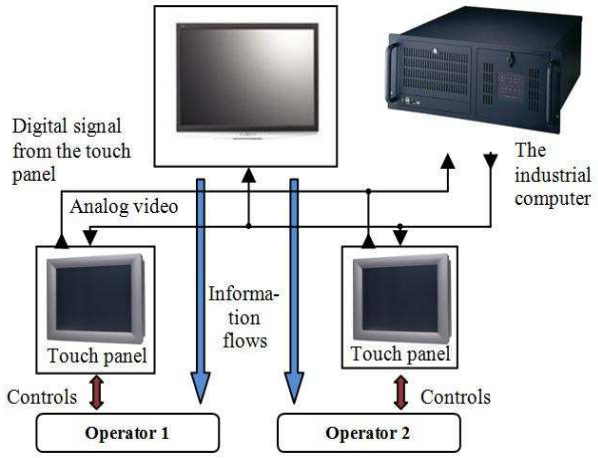

Figure 1. Scheme of separation of information and control functions

Video data are transferred through the cable without any transformation and come directly to the monitor, which completely excludes delays in the channel of data transfer. From the view point of hardware, the method can be used to create small area multi-user information systems, since usage of even special shielded cable to connect the monitors on the operators' workstations cannot provide total noise absence and, as a result, makes enhancing the coverage area infeasible.

An important issue in using the method discussed is software support of isolated users work environment. Every operator usually performs his/her function that is loosely coupled with the function of some other operator. In this case, each operator requires specialized software or hardware at his/her workstation, e.g. access to the CAD-system being studied. Moreover, such a technology does not make it possible to bring tablet PCs into the information environment to create mobile computer workstations.

Another burning problem appearing in creation of information environment for educational purposes is the problem of multiple access to hardware located in the university premises. It is common that demonstration of this or that effect or phenomenon in educational process involves complex technical means connected to a computer, be it an electronic microscope or some other specialized equipment. As a rule, the existing information systems used in distance learning are not able to supply a remote student with access to the equipment set in the university premises, limiting this by the access only to electronic resources. This results in the fact that remote students are unable to fulfill practical, laboratory and research work at distance and sometimes causes deterioration of distance education quality.

III. VIRTUAL MACHINE TECHNOLOGY

The analyses of the problems mentioned gives evidence that most of them depend on the implementation of network technologies, namely, local computer networks (LCN). Thus, the solution of the larger part of these can be provided via rejection of LCN usage and implementation of a terminal system through a new technology. According to this, the authors developed an alternative technology the essence of which is in creation of multi-user computational system based on a single computer. To identify such a system it is suggested to use the term 'pseudo terminal system' because of the absence of exteriorized terminals [13].

It is suggested that solving the problem of creating individual isolated environments in multi-user multi-monitor systems should be realized applying virtual machine technology.

A unique virtual machine (virtual terminal) corresponds to each of a number of operators. The terminal has guest operating system and its unique input (keyboard, mouse, touch panel, etc.) and output (monitor, VR-headset, etc.) devices, as well as video adapter and information input interface controllers, as shown in Fig.2.

Virtual machine monitor provides access of guest operating system of each operator to the hardware appointed to it (video adapter, input controller), while guest operating system works with the hardware offered via standard drivers.

In this case, guest operating system of each operator forms a desktop and processes graphical elements in video processor of the appointed to it adaptor, puts the graphical information out by means of the interface of the same physical adaptor without applying virtualization of the device by the monitor of virtual machines.

The information designed to be displayed for the user comes from the interface to the user monitor connected with the video adapter corresponding to this user.

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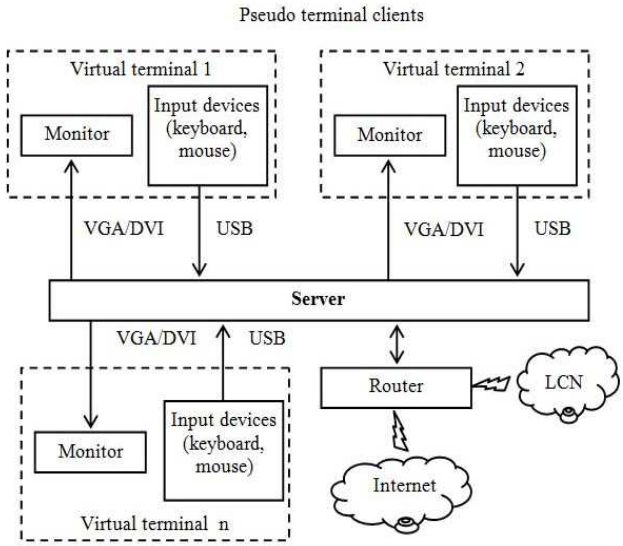

Figure 2. Pseudo terminal concept

When some user puts data in by means of a keyboard or other input devices connected with the input physical controller corresponding to this very user, virtual machines monitor does not capture data from the controller of data input, giving them to the processor of the user guest operating system.

Every operator works with the virtual machine via IO devices appointed to him/her and ideates that s/he is working on a separate dedicated computer.

Using the technology of virtualization it is possible to introduce mobile automated workstations based on tablet PCs, iPhon, etc. into the information system as well.

Software-hardware links are presented schematically in Fig. 3.

As such, the system provides “Desktop as a Service”, i.e. processing power of a computer with physically switched on hardware and working virtual machines monitor are “leased” to the remote user. The problem of multiple access with virtual machines is solved by appointing hardware to a virtual machine on demand of a user in real time mode as well.

IV. TECHNICAL MAINTENANCE

The main merit of the developed method for multi-user system organization is in the fact that it does not require modernizing of the existing computer arrangement architecture. The desired number of video adaptors and data input controllers are connected to the PCI-Express bus, while data IO devices necessary to each operator (monitors, touch panels, VR-headsets, keyboards, etc.) are set on the computer workstations and connected with the computer through transmission links of DVI interface for data output device and of USB interface for data input device (Fig. 4).

The number of terminals is limited by the number of video adaptors of the computational server; the number of terminals equals the total number of server video outputs. In case modern computational systems with 6 video adapters are exploited, the number of terminals amounts 12.

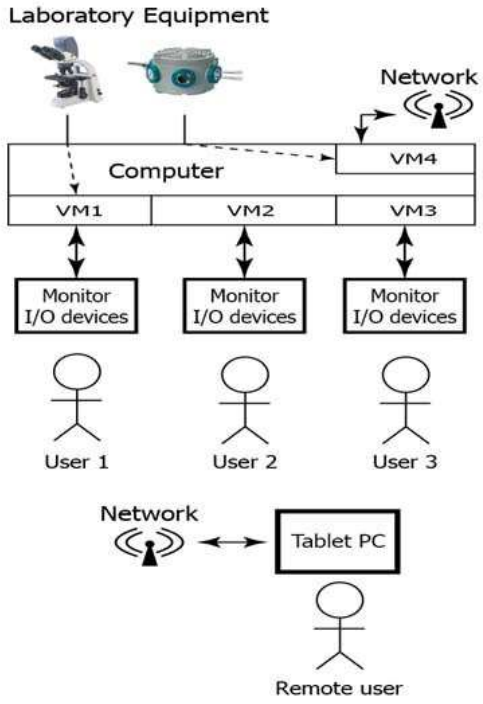

Figure 3. Software-hardware links

Each of the users works on an individual virtual machine served by a hypervisor. It should be noted that in case hypervisor Xen is used practically no limitations are imposed on the operational systems exploited by users. Moreover, they may be completely different depending on the requirements of the user.

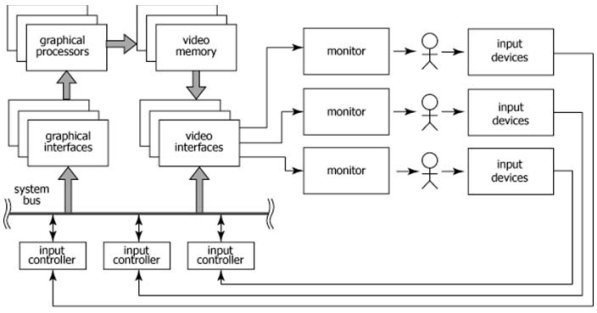

Figure 4. Virtualization technology for multi display systems

Linux remains the main software platform of the complex, however, it is only the host-system for the virtual machines monitor, i.e. it provides the work of the most part of the computer and hypervisor hardware.

V. CONCLUSION

Thus, the method of building multi-user multi-monitor systems can be used for creation of information educational systems for educational establishments of different levels.

Familiar alternative systems exploiting Userful MultiSeat Linux and Multiterminals technologies differ from the suggested one by fewer number of terminals (up to 10) and lower functional capabilities, which significantly limits the freedom of users in choosing software. In other words, alternative technologies, in contrast with the suggested one, make it possible that many users worked with one operating system simultaneously, which imposes limitations both on the software used and on the provision of the information security for the users.

The method elaborated provides convenient and efficient user work in the close to real time mode thanks to the lack of delays in the channels of data transfer between the automated workstations. It also allows to significantly lower the cost of the information system at the expense of more efficient resources usage.

Remote access broadens functional capabilities of the information system largely and improves the quality of distance education.

Besides, the suggested structure of building terminal systems with improved dynamic features can be used for technological processes control by means of a small number of users, for creating "islands of automatization", complex geographically-distributed automated control systems, as well as for creating computer workstations in computer-aided design systems.

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