Construction of visualization system
for scientific experiments

A. V. Bogdanov[a], A. I. Ivashchenko[b], E. A. Milova[c], K. V. Smirnov[d]

Saint Petersburg State University, 7/9 University Emb., Saint Petersburg, 199034, Russia

E-mail: [a] bogdanov@csa.ru, [b] aiivashchenko@cc.spbu.ru, [c] milova.evg@gmail.com, [d] constcoh@gmail.com

Scientific visualization is a visual representation of results of scientific research by computer graphics. Thus, the numerical results of research can be presented in a more appropriate graphic visual form. This makes it possible to see something that is hidden in the numerical data, since the main goal of the research is not only a numerical measurement of any performance, but also an opportunity to make visible some processes. Often scientific visualization is tool that can be used only to explain the essence of the modeled process and to consider a process in dynamics.

This proposal considers about possible approaches for the creation of visualization system designed for scientific experiments. Possible hardware solutions are represented with various combinations of numerous components, such as computing nodes which are based on graphics cards, visualization and virtualization servers. Peripheral devices are studied in details. Description of software solutions that can be used are also provided.

The discribed system can be divided into three subsystems. First of them is subsystem of virtualiza-tion, based on Nvidia GRID m60 cards. The main task of NVIDIA GRID graphics accelerators is to provide a high-performance graphics-intensive applications working with demanding graphics compu-tation in a virtual environment directly. This approach also avoids additional costs of purchase licenses for individual computers.

Next subsystem is a computing cluster with Nvidia k80 cards, which provide high rendering performance. This platform com-bines the fastest GPU-accelerators widely used model CUDA parallel programming and extensive ecosystem of application developers, application providers.

The third subsystem is the subsystem of the image output. The company Nvidia has a special NVS technology. It is the standard for business graphics with support for multiple displays.

Keywords: computing infrastructure, computer graphics, visualization

1. Introduction

Scientific visualization is a visual representation of results of scientific research by computer graphics. Thus, the numerical results of research can be presented in a more appropriate graphic visual form. This makes it possible to see something that is hidden in the numerical data, since the main goal of the research is not only a numerical measurement of any performance, but also an opportunity to make visible some processes. Often scientific visualization is tool that can be used only to explain the essence of the modeled process and to consider a process in dynamics.

Thus, scientific visualization is a powerful tool for scientific research, but the amount of data needed for scientific visualization is enormous, the required computing power is predicted by Moore's law predicts. It is necessary to use methods of parallel computing to be able to use scientific visualisation in practice.

This report will be considered a parallel visualization system,rendering equipment and the necessary software for visualization will be described.

This system can be used in particular to increase performance of CAD-programs, to perform the tasks of rendering videos, animations, images, both with the same CAD-programs and with using scientific packages such as ParaView. The sysem can be used for providing computing resources for simulation programs (like simulation of physical processes, and simulation of any activity), for exploration and visualization of large data sets obtained during computations in tasks are of gas dynamics and hydrodynamics, for example.

2. Architecture

The whole system can be divided into three subsystems. First of them is subsystem of virtualization, based on Nvidia GRID m60 cards. The main task of NVIDIA GRID graphics accelerators is to provide a high-performance graphics-intensive applications working with demanding graphics computation in a virtual environment directly. This approach also avoids additional costs of purchase licenses for individual computers [Makhinya, 2012, electronic resource].

Next subsystem is a computing cluster with Nvidia k80 cards, which provide high rendering performance. Tesla K80 accelerator is one of the most powerful accelerator in the worldintended for a wide range of applications, including machine learning, data mining, scientific and high-performance (HPC) calculations. Dual Processors accelerator Tesla K80 is the new accelerated computing platform flagship Tesla, the best platform for information analysis and accelerate research. This platform combines the fastest GPU-accelerators widely used model CUDA parallel programming and extensive ecosystem of application developers, application providers.

The third subsystem is the subsystem of the image output. The company Nvidia has a special NVS technology. It is the standard for business graphics with support for multiple displays.

There are also Nvidia Quadro products, which are a more powerful for output devices. it provides for the most demanding visualization tasks high performance through a large amount of built-in memory. Such cards have advanced playback on displays with 4k definition. The choice of cards depends on the specific devices of display images [Nvidia cards..., electronic resource].

The whole system you can see at picture 1.

Networks speed increases slowly in comparison with power and speed of accelerators, therefare data transfer method is important for the system. Let's consider image with 4k resolution with different refresh rate. Information contained in table 1. We need channel with speed 7,9 Gb per sec for 30 Hz refresh rate, such speed can be provided by 10 Gb Ethernet. We need channel with speed 15,82 Gb per sec for 60 Hz refresh rate, such speed can be provided by 40 Gb Ethernet or InfiniBand(EDR) which provides 25 Gb per sec speed. InfiniBand is a high-speed switching computer-network communication standard which is used in high-performance computing, it promised a very high bandwidth and low latency. InfinyBand is more suitable because it has big iops.
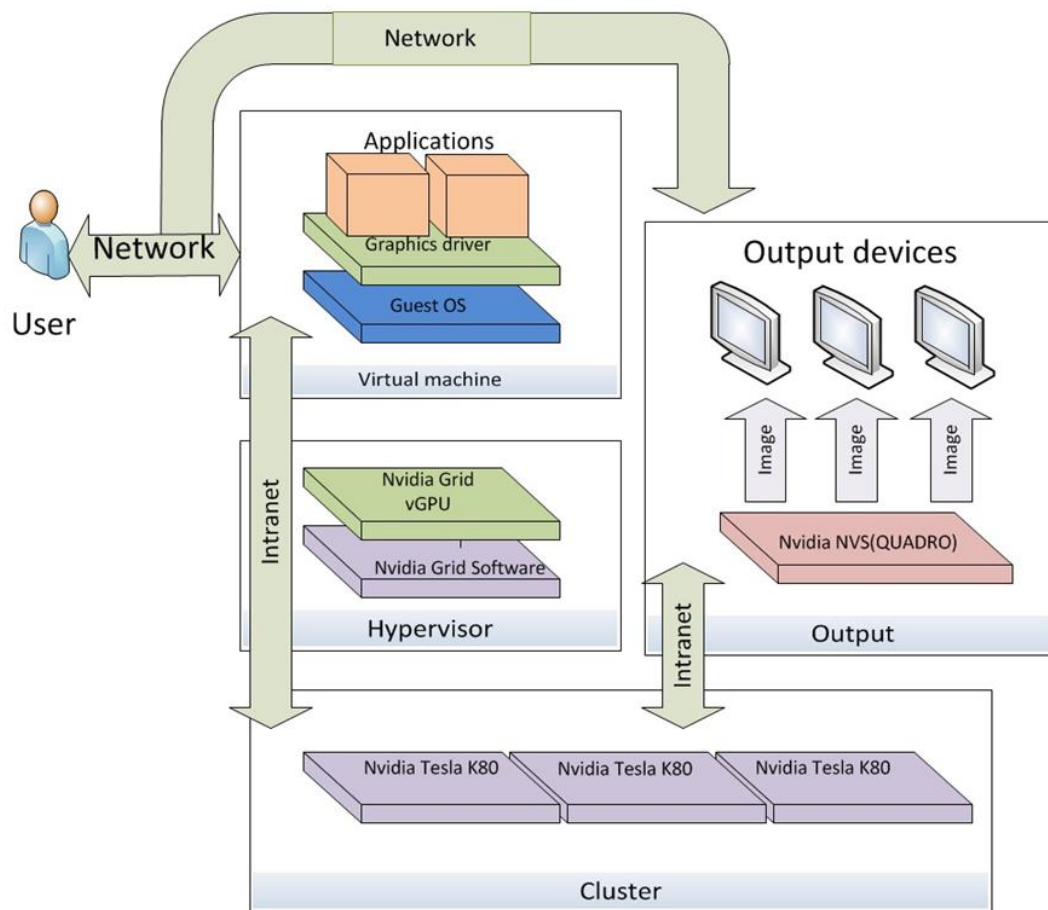
Fig. 1. Architecture of the system for scientific experiments

Table 1. Data transfer rate

Resolution	Amount of pixels	Color depth (bit)	Refresh rate (Hz)	Speed (Gbit/sec)
4096x2160	8847360	32	30	7.91
4096x2160	8847360	16	30	3.96
4096x2160	8847360	8	30	1.98
4096x2160	8847360	32	60	15.82
4096x2160	8847360	16	60	7.91
4096x2160	8847360	8	60	3.96
4096x2160	8847360	32	120	31.64
4096x2160	8847360	16	120	15.82
4096x2160	8847360	8	120	7.91

3. Output devices

The most simple and accessible system are Single/Multi display and Active Wall systems. Single/Multi display are display information from a single or multiple displays.

In this case Active Wall is a combination of multiple grid displays for large screen or for a panoramic view. In this case Nvidia NVS cards are more suitable [ve-group company, electronic resource].

Holographic Display is a device for displaying information, and it gives illusion of presence in the real volume of displayed objects to a viewer and the illusion of partial or total immersion in the scene due to the stereoscopic effect. These devices are very demanding on the performance of the hardware and the data channel. Some of these displays are very expensive [Virtual reality projects, electronic resource].

Immersive Display. In this case, the effect of augmented reality is achieved by an optical illusion based on the composition of the projections from different angles. The system can contain the following elements: a cylindrical screen with a wide viewing angle, a few stereoscopic projectors, stereo glasses that create effect of the hologram [ImmersiveDisplay, electronic resource].

EYE is a Stereoscopic Virtual Reality Display. In the moment the most promising virtual reality glasses are HTC Vive and Oculus Rift. HTC Vive is equipped with a dual-screen with a refresh rate of 90 Hz and 1080x1200 pixels resolutions. Oculus Rift has 2 screen with resolution of 1080x1200 with 75 Hz, 72 Hz and 60 Hz refresh rate. The viewing angle is about 110 degrees. Also, these glasses contain a set of additional sensors such as a gyroscope, accelerometer, laser sensors [Htc Vive, electronic resource],[Oculus Rift, electronic resource].

CAVE system is similar to Immersive Display, but it passes in a closed space. Today the projection virtual reality system CAVE (Computer-Aided Virtual Environment) or a room of virtual reality is the most powerful and realistic. Virtual reality room is a projection system of virtual reality, in which 3D imaging is performed on special screens (from 2 to 6 screens in form of room).

In last three cases increase of efficiency is needed, so the most suitable products for image output are Nvidia Quadro [Cave, Electronic resource].

4. Additional equipment

It should be considered that traditional controllers are difficult to use in the complex output systems such as the CAVE or VR. That is why these devices can be used in addition:
• movement tracking system
• suit, tracking your body movements (motion capture);
• Haptika. The devices simulate different tactile sensation of person and allow the use tactile communication channel in human-computer interface. It is very effective for creating simulators and trainers,
• Gloves for interaction [ve-group company. electronic resource],
• Depth sensors can describe shape of objects in the world such as Google tango project [Google tango, electronic resource].

5. Software

Equalizer is an open source project providing a minimally invasive programming interface and resource management system for parallel, scalable OpenGL applications. It allows an application to run unmodified on any visualization system, from a simple workstation to large scale graphics clusters and multi-GPU workstations [Equalizer, electronic resource].

IceT (Image Composition Engine for Tiles) is a library for parallel rendering. It is oriented to work with systems to display images that use multiple displays. The displays are arranged mosaic, to form one large display [IceT, electronic resource].

ParaView is an open graphical cross-platform package for parallel data processing in VTK-compatible formats for interactive visualization of researches. The package supports client-server architecture for organization of remote visualization of data and level of detail using the method (level of detail, LOD) to support the visualization of large amounts of data in an interactive mode. ParaView package is implemented on the basis of the library Visualization Toolkit (VTK) and designed for data parallelism on computers with shared, distributed memory and clusters [VTK, electronic resource].

6. Examples

1) Aircraft simulator and simulator for refueling in the air

The system can contain the following elements: a cylindrical screen with a wide viewing angle, a few stereoscopic projectors, stereo glasses, creating the effect of the hologram and tracking system. And also special equipment look like pilot cabine.

It is can be used for virtual tests creation and for dynamics of flight. This approach also avoids the additional costs for real flights.[ve-group company, electronic resource]

2) Shipbuilding and ship repair

The system can be used for:
• Modeling of necessary technologies for installation of equipment
• Modeling of behavior of ship in different conditions
• Optimal placement of equipment
• Calculation of reliability ets [ve-group company, electronic resource].

3) GIS and oil production.

It hlps in analysis of the data on oil production, sensing of land, and other gis systems [ve-group company, electronic resource].

7. Conclusion

Now we are comparing output systems. Single/Multi display and Active Wall systems are the simplest and accessible. Holographic display has real 3D view, but some of it is expensive. Glasses of VR has problem with movement and tracking system, in this systems people can not see their body. CAVE is the most powerful system, but is is need for hardware and it is expensive. The main advantage of glasses and CAVE is wide choice of additional equipment from simple device like joystick, to complex systems like pilots cabin.

Some devices have been chosen for particular involvement into the system's implementation.

Active wall and CAVE system is more perspective for realization, because CAVE provide movement in 3D space, Active Wall is useful for presentation of results to audience.

References

Performance challenges in distributed rendering systems [Electronic resource]: http://www.zora.uzh.ch/62015/1/Makhinya.pdf

Nvidia cards [Electronic resource]: http://www.nvidia.ru/object/nvs-graphics-ru.html

ve-group company [Electronic resource]: http://ve-group.ru/

Htc Vive [Electronic resource]: https://www.htcvive.com/us/

Oculus Rift [Electronic resource]: https://www.oculus.com/en-us/

Virtual reality projects [Electronic resource]: https://www.barco.com/ru/Продукты-и-решения/Проекторы/Проекторы-для-виртуальной-реальности

Cave [Electronic resource]: https://www.evl.uic.edu/entry.php?id=2016

ImmersiveDisplay [Electronic resource]: http://www.mcs.csueastbay.edu/~tebo/TheCompCoreImmersiveDisplay.pdf

Intel Realsense [Electronic resource]: https://software.intel.com/en-us/realsense/home

Google tango [Electronic resource]: https://www.google.com/atap/project-tango/

VTK [Electronic resource]: http://www.vtk.org/

Equalizer [Electronic resource]: http://equalizergraphics.com/

IceT [Electronic resource]: http://icet.sandia.gov/_assets/documents/IceTUsersGuide-2-1.pdf