

THE CHALLENGES OF USING MULTICOMPUTING IN REAL TIME VISUALAPPLICATIONS

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ABSTRACT

Displaying visual data in a graphical distributed application is one of the main challenges and constraints that should be studied in real time applications. Many problems could be reported in using multi-computing for real time visual applications. These problems are identified throughout this survey, and are classified into two main categories. The first is computation and transfer time while the second is display speed. The real bottleneck in using grid or cloud computing in such applications is whether the communication time between nodes (inside the cloud) increases to the point of degrading overall application performance. This survey paper describes the impact of time and communication speed on applying visual systems on a grid or in cloud computing.

KEYWORDS

Multi Computing, Cloud Computing, Grid Computing, Visualization and Virtualization

1.INTRODUCTION

Managing (controlling) parallel applications is difficult, and is based on communication and synchronization between different subtasks. It involves extracting information about the interaction and collection among process units, preparing it in useful formats, and then displaying information on interactions among concurrently executing processes. Displaying visual data in a graphical distributed application is one of the main challenges and constraints that should be studied. The interactive computer graphics architecture was developed through four generations over the past two decades. Not only has the performance improvement of computer graphics hardware exceeded Moore's Law, modern computer graphics hardware also possesses more transistors than modern central processing units (CPUs) do. However, many applications, such as scientific visualization of large data sets, high-resolution display, and photo-realistic rendering, still cannot run in real-time on high-end modern graphics hardware [1]. In this paper, several grid topologies used in different visual applications will be analyzed to describe the impact of time and communication speed on applying visual systems on a grid or in cloud computing.

2.MULTI-COMPUTING

A distributed application consists of multiple autonomous computers that communicate through a computer network. These computers interact with each other to perform a common goal [2]. Parallel computing could be defined as a form of computation in which many calculations are executed simultaneously [3]. It is easy to derive an integrative definition as well as a minimum common denominator. Grid computing refers to servers collecting and working together to

perform a single task. Cloud computing is the convergence and evolution of several concepts such as virtualization, distributed application design, grid, and enterprise IT management, to enable a more flexible approach for deploying and scaling applications [4]. Most available definitions of multi-computing (grids and cloud computing) are in Tables 1 and 2, respectively. One of the main challenges in cloud computing is interconnecting remote sites at the lowest possible cost of ownership. The success of the cloud computing business is strongly dependent on cost-effective service offerings, which compete heavily with traditional local implementations [19].

Table 1. Grid Computing Definitions

Reference/Author/Year	Definition
[5] Foster et al. 2001	“Grid” computing has emerged as an important new field, distinguished from conventional distributed computing by its focus on large-scale resource sharing, innovative applications, and, in some cases, high-performance orientation.
[6] Adabala et al. 2005	Information “grids” promise to revolutionize scientific computing and information processing by enabling access to unprecedented computing power and functionality of diverse interconnected computers, geographically distributed software applications and other network-accessible resources
[7] Jacob et al. 2005	It is any variety of levels of virtualization along a continuum. Exactly where along that continuum one might say that a particular solution is an implementation of grid computing versus a relatively simple implementation using virtual resources is a matter of opinion. But even at the simplest levels of virtualization, one could say that grid-enabling technologies are being utilized.
[8] Lakshmi and Ravichandran 2006	It is a form of distributed computing that involves coordinating and sharing computing, application, data, storage, or network resources across dynamic and geographically dispersed organizations.
[9] Linesch] 2007	It is a platform for all types of network distributed applications or services
[10] Wang 2009	It is the approach that offers practical solutions for parallel and distributed computing. It can provide reliable, collaborative and secure access to remote computational resources as well as distributed data and scientific instruments.

Table 2. Cloud Computing Definitions

Reference/Author/Year	Definition
[11] Bechtolsheim 2008	The fifth generation of Computing (after Mainframe, Personal Computer, Client-Server Computing, and the web)
[12] Armbrust et al. 2009	It refers to both the applications delivered as services over the Internet and the hardware and applications software in the datacenters that provide those services
[13] Gillis 2009	It is the provision of dynamically scalable and often virtualized resources as a service
[14] F5 Networks 2009	It is a style of computing in which dynamically scalable and often virtualized resources are provided as a service over the Internet. Users need not have knowledge of, expertise in, or control over the technology infrastructure in the "cloud."
[15] Vaquero et al. 2009	Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically re-configured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the Infrastructure Provider by means of customized SLAs.
[16] Mell and Grance 2009	It is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models.
[17] Buyya et al. 2009	It is a type of parallel and distributed system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resource(s) based on service-level agreements established through negotiation between the service provider and consumers.'
[18] MacVittie et al.2010	The cloud is simply an architectural model that employs many of the same components used in datacenters around the world today in a more flexible, responsive, and efficient way.

3.CLOUD COMPUTING APPLICATIONS

Many people are confused on the definition of cloud computing, especially as the term can be applied to many things. However, it means making computations through the Internet, from which all resources can be accessed without worrying about resource maintenance or management. [16] discussed the concept of cloud computing to achieve a complete definition of the cloud, and described the relationships and distinctions between grid and cloud approaches.

The University of California (UC) Berkeley Reliable Adaptive Distributed Systems Laboratory [13] stated that cloud computing refers to applications delivered as services over the Internet, and the hardware and systems software in the datacenters that provide these services. They tried to identify the top technical and non-technical obstacles and opportunities in cloud computing. Their view is shaped in part by working since 2005 in the UC Berkeley RAD Lab and in part as

users of Amazon Web Services since January 2005 They spent six months brainstorming about cloud computing, leading to their main 10 obstacles and opportunities for cloud computing in Table 3. The review of Table 3 does not mention the obstacles on applying visual application in cloud computing.

Table 3. Quick Preview of Top 10 Obstacles to and Opportunities for Growth of Cloud Computing [13]

	Obstacle	Opportunity
1	Availability of Service	Use Multiple Cloud Providers; Use Elasticity to Prevent DDOS
2	Data Lock-In	Standardize APIs; Compatible SW to enable Surge Computing
3	Data Confidentiality and Auditability	Deploy Encryption, VLANs, Firewalls; Geographical Data Storage
4	Data Transfer Bottlenecks	FedExing Disks; Data Backup/Archival; Higher BW Switches
5	Performance Unpredictability	Improved VM Support; Flash Memory; Gang Schedule VMs
6	Scalable Storage	Invent Scalable Store
7	Bugs in Large Distributed Systems	Invent Debugger that relies on Distributed VMs
8	Scaling Quickly	Invent Auto-Scaler that relies on ML; Snapshots for Conservation
9	Reputation Fate Sharing	Offer reputation-guarding services like those for email
10	Software Licensing	Pay-for-use licenses; Bulk use sales

Buyya et al. [20] introduced CloudSim, which is an extensible simulation toolkit that enables modeling and simulation of cloud computing environments. The CloudSim toolkit supports modeling and creating one or more virtual machines (VMs) on a simulated node of a datacenter, jobs, and their mapping to suitable VMs. The authors did not specify the application type used in testing the toolkit and did not evaluate using it with visual applications. ElasTraS was proposed by [21], which addresses the issue of scalability and elasticity of data stored in a cloud computing environment to leverage the elastic nature of the underlying infrastructure, while providing scalable transactional data access. The review of [21] does not mention visual data, which could be stored in the cloud.

Many Web applications need strong data consistency for correct execution. However, although the high scalability and availability of the cloud makes it a good platform to host Web content, scalable cloud database services provide relatively weak consistency properties. Wei at al. [22] showed how one can support Atomicity, Consistency, Isolation, Durability(ACID) transactions without compromising the scalability of the cloud for Web applications, even in the presence of server failures and network partitions.

A review of cloud computing applications shows that no paper until this study has focused on the obstacles of applying visual applications using cloud computing.

4.GRID COMPUTING APPLICATIONS

Grids today appear mostly in high-performance computing environments, where many inexpensive compute nodes link to solve parallel processing problems that previously could only have been addressed by using supercomputers. Seventeen up-to-date papers (Table 4) were collected as a sample of using grid computing in different applications. The applications,

topologies, and problems of these samples will be discussed in the next section. Many parallel problems could be solved using grid computing. It plays an important role in applications that need visual (graphics and images) rendering. Table 5 summarizes the applications in the papers listed in Table 4. Each application uses a different grid computing topology (Table 6) that determines the number of process units and display specifications in addition to the software used in grid application construction.

Table 5. The Applications List

Reference	Application
[23]	Medical image processing
[24]	Medical image retrieval
[25]	Remote sensing images
[26]	SWAP (Soil Water Atmosphere and Plant) crop model and the Remote Sensing (RS)
[27]	Parallel data mining that utilizes new-generation graphics processing units (GPUs).
[28]	Parallel interactive applications MPI fluid simulation real-time 3D modeling
[29]	Studding the strong scaling of the graphics application at high resolution (17.6 Megapixels) with advanced lighting , scientific data set
[30]	Video stream MPEG
[31]	The parallel scientific applications are 3D parallel volume rendering application and 2 D high resolution imagery application
[32]	Grid Online Game Jake2
[33]	Graphical Geographic information applications
[34]	Multiscreen display applications
[35]	Large scale volume data (Image)
[36]	General graphics 3d and 2d Ant Colony Optimization is used in rendering (solving scheduling problems).
[37]	Magnetohydrodynamics
[38]	Medical image
[39]	It describes how the computational steering and online visualization with the covs framework implementation can be used within todays Grid and e-science infrastructures.

The main problems facing parallel applications are computation and transfer time. Creating applications to run on a grid is more difficult than creating a large monolithic custom application for a dedicated supercomputer. Most people currently working on grid computing focus on the challenges of its physical operations, such as determining available computer and database resources, and organizing them into a functioning application. However, the most important thing to focus on is time. Grid application coordination requires a list of available computer nodes, performance characteristics, communication time, display specifications, computation time, and complexity of problem parts. Grid application coordinators utilize this information to configure the grid by calculating the optimal number of computer nodes or processors, partitioning the problem, and distributing these parts to obtain the best possible performance regardless of grid used. These measurements enable the application's autonomic program manager, which serves as the application coordinator, to reassign problem parts among grid

nodes and make other needed adjustments. Table 6 shows the hardware specifications and the necessary time for each application listed in Table 5.

Table 6 . Specification and Execution Time

Reference	Number of processors	Time
[36]	For testing purpose 7 homogeneous grid nodes 2 nodes (Inter Xeon 3040 1.86G,1024memory, Windows XP) 2 nodes (Inter Celeron 2.00GHZ,1024 memory ,Windows Vista) 3 nodes (Inter Core 2 double Extreme E7200,1536 memory ,Windows 2000)	19 minutes for 50 slice rendering
[25]	4 computers a processing node	2868 ms for 4 M data segmentation by OTSU
[26]	1 computation node 2 15 Single site only	17,382 sec 9,276 sec 1,218 sec Pixel based data
[34]	6 nodes 16 nodes	18.3 read write and transmit 31.0 ms
[27]	30 SIMD /8 processors The CPU has4 cores running at 2.4 GHZ	23.8255 sec./ data size 400 k
[35]	12 agents with 3 types of computing powers (low, medium and high) only 54.2 % agents utilization	10000 second /100 sub volume of data
[31]	32 node / 1 process per node 32 node / 2 process per node The data size is 2 to power 27	1475.37 sec 1892.42 sec
[28]	Flat data flow graph of the acquisition component for 6 cameras (50 nodes and 68 edges) Flat data flow graph of the acquisition component for 6 cameras and a supervision interface (105 nodes and 176 edges)	30 images per second
[29]	6144 processor	11.5268 second Scene, Parsing Preprocess Ray, Tracing, Image I/O
[39]	65536 processors	No mentioned to time $O(n \log n)$.
[37]	128X1X1 128X128X1 128X128X128	235 ms 1535 ms 21774 ms

5. VIRTUALIZATION AND VISUALIZATION

Virtualization was invented more than 30 years ago to allow large, expensive mainframes to be easily shared among different application environments [40]. It could be understood as a technique to partition resources of a machine in multiple environments, creating a new level of indirection between physical resources and applications [41]. However, virtualization creates an abstraction environment between two computer resources; it also refers to running a virtual application that appears from the inside to be a real computer, but is actually being emulated on a real machine. It became popular in grid and cloud computing. The cloud could be with or without virtualization. Figure 1 shows the virtualization concept graphically.

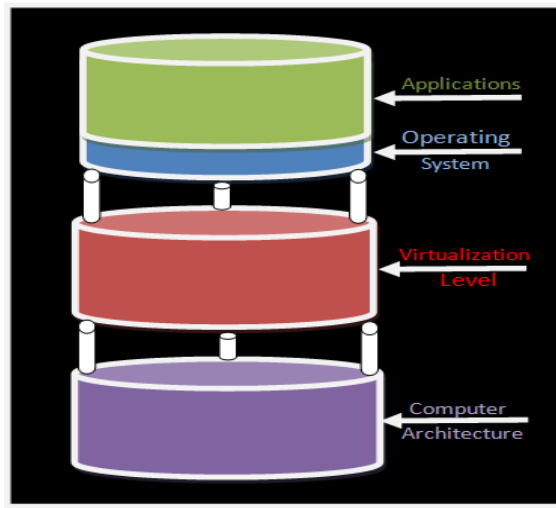


Figure1. Virtualization

Today, the term virtualization is widely applied to a number of concepts such as:

Server virtualization

- Client/Desktop/Application virtualization
- Network virtualization
- Storage virtualization
- Service/Application infrastructure virtualization

Visualization application is one of the most important communication applications. Visualization could be defined as converting data into graphics or images using computer software. It is also used to render screen images into three-dimensional (3D) models that can be viewed from all angles, and could be animated. Grid-based architectures might be suitable platforms for satellite and medical images, and graphical digital processing and analysis because they offer the required computational power to process in real time.

6. TIME PROBLEM ANALYSIS

Many problems could be noted and reported in using grid computing for visual applications. Throughout our survey which is used to identify potential problems with these applications and

the grid itself. The problems could be classified into two main categories: the first one regards with the computation and transfer time while the second category regards with the display speed. Fang et al. [27] for example (see table 4 and 5), showed that the execution time for data size equals 400 k is 23.83 seconds. This time is divided into 0.1093 seconds for data transfer, 23.5763 seconds for GPU and 0.1399 seconds CPU time. While the performance measurements of Wong et al. [37] (table 4 and 5) showed that GPU-based implementation achieves speedups of 2 (1D problem with 2048 grids), 106 (2D problem with 10242 grids), and 43 (3D problem with 1283 grids), respectively, compared to the corresponding serial CPU MHD implementation. The performance test showed that when the number of grids of the test problems is small, such as those in 1D case (128X1X1...2048X1X1), GPU MHD code could not give a significant performance improvement. This is because some processing time was spent when the initialized data and the necessary parameters were copied to the GRAM in the initialization status. When the number of grids increases, an obvious disparity of performance becomes clear, especially for multidimensional cases. On the other hand, rendering 50 slices of an image took 19 minutes using 7 homogeneous grid nodes [37]. This time is high for rendering one image in real time. Besides that, the total run time of data set consists of 214 parameters is 220 min using grid computing Krefting et al [38] (table 4 and 5) and it is also very high to be used with real time rendering. The elapsed time is still high for real time data as pointed by [35] where, the approximate elapsed time is 270 seconds, for data resolution equals 4096^3 and volume equals 128 GB.

Terzza and Djemame [42] used a dedicated test-bed for all rendering, comprising 2 Quad Core Xeon machines at 2.83 GHz with 4 GB RAM each. For the cloud, the same test-bed set up was used with Open Nefula (an open source cloud computing implementation). Four VMs were run on each machine (one VM per core), each with 768 MB RAM.

POVRay (an open source ray tracing application) was chosen for tests along with a version patched for Message Passing Interface (MPI). Once each testing environment was set up, the rendering was run from a script that rendered images from 0.5 to 5 MP. Rendering was benchmarked with both POVRay and MPI POVRay run in several environments: from the command line on the test-bed, as a Globus Service using the Globus Toolkit, with and without grid security infrastructure file transfer protocol (GSIFTP) file staging, as a Web service using the Globus Toolkit, and finally as a Web service using Apache Tomcat and Axis. Terzza [42] showed that POVRay scales well with multiple cores (due to the embarrassingly parallel nature of the problem). Rendering tests on the grid and cloud showed that although not as fast as a "bare-bones" machine, their overhead is fair and they both perform with similar efficiency. Figure 2 illustrates the results graphically.

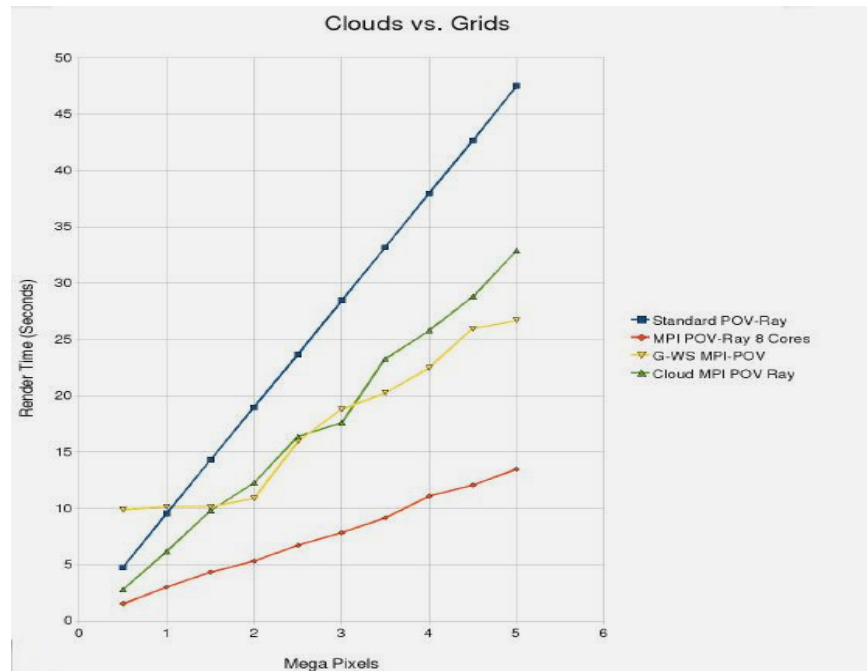


Figure2. Different render time clouds vs. grids [42]

Alexandre et al. [32] demonstrated some experiments to assess and compare the scalability of Jake2 and grid-based Jake2 (named Jake2Grid). In this context, it is important to determine the number of players a single game server could handle in real time (see Figure 4). MAC OS X Quad-Core Intel Xeon with 2.86 Ghz, 2 CPUs, 8 cores, 12 MB of L2 cache, 6 GB of memory, and 16 Ghz of bus speed were used to run the server. One hundred other computers were used to run game clients. The scalability measurements of Jack2 versus Jack2Grid are shown in Figure 3.

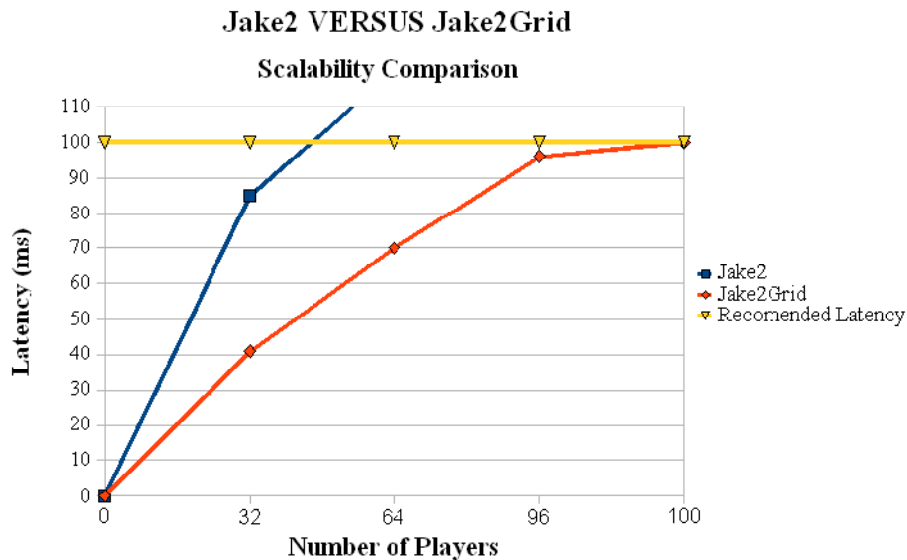


Figure3. Scalability measurements [32]

However, although the elapsed time in the previous two examples improved using grid computing compared with traditional approaches, it is still high for real-time applications. Despite recent advances in accelerator technology, many real-time graphics applications still cannot run at acceptable rates.

7. ADVANTAGES AND DISADVANTAGES

Since time is measured in variant environments and conditions, and different data and processing are used, it is difficult to have a clear picture of the impact of time and communication speed factors on the performance of grid computing. However, it is important to address the potential advantages and disadvantages of using grid or cloud computing in different environments. Some **advantages** and **disadvantages** are obvious.

The main advantage of grid computing is more efficient use of idle resources because many resources sit idle especially during off business hours. Jobs are allowed only to communicate with servers that are lightly loaded or have the appropriate amount of memory/CPU characteristics. If one of the servers/personal computers (PCs) within the grid fails, other resources will pick the load. However, jobs can automatically restart if failure occurs. In addition, jobs can be executed in parallel speed performance where grid environments are extremely well-suited to run jobs that can be split into smaller chunks and can run concurrently on many nodes.

Transmitting large files over optical burst switching (OBS) grid networks results in poor performance primarily due to the many burst losses that will occur, as well as transmission control protocol (TCP) behavior due to these losses. Thus, a new adaptive assembly algorithm suitable for OBS grid networks involving large file transfers was presented by Korkakakis [43].

On the other hand, the use of grid and cloud computing especially with visual applications is limited by the following reasons.

- 1- It may need to have fast interconnection among resources' nodes, but various processors (e.g., PCs) on the Internet do not have high-speed connections. All results of all processes have to be sent from place to place and collaboratively assessed for any outcome to be deduced. This can be a strain in terms of timing issues as well as the fact that grid and cloud computing are heavily reliant on the ever-unpredictable notion of connectivity. The speed of the processors is different; thus, much is consumed waiting results.
- 2- It requires a stable Internet connection. Cloud computing is impossible if there is no connection to the Internet. A dead Internet connection means no work; in areas where Internet connections are few or inherently unreliable, this could be a deal-breaker. It does not work well with low-speed connections. Similarly, a low-speed Internet connection such as dial-up services makes cloud computing painful at best and often impossible. Web-based apps require much bandwidth to download; cloud computing is not for the broadband-impaired. Even on a fast connection, Web-based applications can sometimes be slower than accessing a similar software program on desktop PCs. Everything about the program, from the interface to the current document, has to be sent back and forth from the computer to computers in the cloud. If the cloud servers happen to be backed up at that moment, or if the Internet is slow, instantaneous access will not be the same as with desktop apps. Stored data might not be secure and can be lost.

8. CONCLUSIONS AND FUTURE WORK

Grid or cloud computing is used effectively to advance image processing and analysis. For example, medical image applications and game playing need high-speed rendering especially when used in a real time. Grid or cloud computing is suitable technology to solve problems that require intensive processing, and was believed capable of flexibly coping with visual real-time applications like game playing. The real bottleneck in using grid or cloud computing in such applications is whether the communication time between nodes (inside the cloud) increases to the point of degrading overall application performance. The main technological challenges that can be identified and that are commonly associated with visual cloud systems are virtualization and data Management which are described throughout this paper. We analyze the impact of time and communication speed problem on applying visual systems on grid and cloud computing. Future work should focus on this problem with a new selection approach of parallel methods of applications and their distribution over the grid nodes or the cloud.

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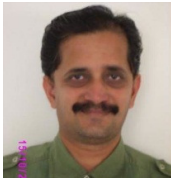
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