

# *Nemeaux – A Supercomputer for the Arts*

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## Abstract

*Nemeaux*, a cluster of 32 Apple Xserve G5 computers, is one of the first supercomputing clusters in the nation dedicated to computational problems in the arts. Purchased with a \$114,000 grant from the Louisiana Board of Regents, the cluster will fundamentally transform digital media courses that can take advantage of the increased computational capacity by returning rendered media files significantly faster by an order of magnitude. This paper will discuss the underlying technologies at work, as well as provide examples of how *Nemeaux* will transform the educational process in digital media.

## Introduction

Artists have always used the technologies of their time. History has shown us that often, those technologies have been advanced by the needs and demands of artists, sometimes by the artists themselves. Pythagorus' work in ratios and geometry was founded in the exploration of musical pitch, which in turn became the foundation of modern mathematics<sup>i</sup>. Da Vinci's engineering plans for helicopters, water wheels, and the human form remain the ultimate definition of renaissance knowledge: the combination of art and science, advancing both at the same time<sup>ii</sup>.

It is no surprise that in the Information Age, artists are drawn to computer technology as both a vehicle for expression as well as a tool for creation. At the same time, their demands for visual and aural products have pushed the computer industry to develop advanced tools for animation, film, video and music. Clearly, consumers of the video game industry and special effects industry are driving the recent scientific advances in computer graphics. The computational needs of artists can be found in computer animation, digital audio, video compositing and high-performance networking.

For example, the digital media network that is being constructed by the Laboratory for Creative Arts & Technologies (LCAT) includes a 7 Terabyte file store, workstations, and a computer cluster all interconnected with both Gigabit Ethernet and FibreChannel networks. This network connects workstations in Johnston Hall, the School of Music, School of Art, and Frey Computing Services Center such that large media and data files can be shared equally between the various locations. Our facilities in Frey include FibreChannel connections for the processing of high-definition video and animation rendered from data on our computer clusters.

## Nemeaux

In response to the growing demand for computational arts resources and research interests, the Laboratory for Creative Arts & Technologies designed and built *Nemeaux*. Designed from the ground up as a supercomputer for the arts, *Nemeaux* has applications in computer music, digital video, computer animation and film compositing. Additionally, the cluster can also function as an alternative platform for science-domain applications as well as core computer science research.

Funded by a grant from the Louisiana Board of Regents Enhancement Fund<sup>iii</sup> with matching funds from LCAT, the *Nemeaux* cluster was originally assembled with 24 Apple Xserve computers running the Apple OS X operating system (9 additional computers were added to the cluster in June 2005 with funds from LCAT's parent center, the Center for Computation & Technology, CCT). Although Apple computers have not been extensively used in the construction of computing clusters, we chose them because they provided access to best of breed tools for image processing, video editing, animation rendering and digital audio.

Two other criteria led us to this particular hardware/software platform: ease of use, and compatibility with existing resources. Because of its roots in the UNIX operating system, Apple OS X easily integrated with computer services already used by LCAT and CCT. Directory services' (LDAP) integration with CCT resources provided a seamless connection to CCT's user authentication system, and the underlying UNIX core enabled a smooth transition for custom software originally written for CCT's other supercomputer, *SuperMike*. More importantly, LSU's Music & Art Digital Studio (the MADstudio) has utilized Apple resources for many years, and integration with their infrastructure was an important component of the project.

*Nemeaux* is part of CCT's "garden of architectures" strategy for high-performance computing. Rather than invest huge sums of money for a single huge supercomputer that is consistently losing ground on the Top500, CCT is developing a garden of smaller computing clusters that are targeted at specific disciplines while having the flexibility to address any general computational problem. *SuperMike*, a 1024-processor 32-bit Intel cluster, is a general-purpose supercomputer, and *Helix*, a 256-processor 32-bit Intel cluster, is primarily used for biological computing. While *Nemeaux* complements these other clusters, it also can be used as a host cluster for large grid computing solutions. The flexibility of the "garden of architectures" strategy enables LCAT and CCT to get the most out of each cluster, whether they are used separately or linked together through grid computing applications.

## Architecture, Installation and Configuration

*Nemeaux* consists of 32 compute machines (nodes) and 1 head node. Each of the original 24 machines have dual 2.0 GHz G5 processors, 2 GBytes of RAM, and 80 GBytes of internal storage. The second phase of machines have similar configurations with the upgrade of dual 2.3 GHz G5 processors. The entire cluster is interconnected with Gigabit Ethernet, and the head node has a FibreChannel connection to a 3.5 Terabyte hard disk RAID array.

Peak performance for the compute nodes is 9 GFlops per machine (2.0 GHz Dual G5s)<sup>iv</sup>, and 10 GFlops per machine (2.3 GHz Dual G5s)<sup>v</sup>, bringing the computational performance of the whole cluster to 297 GFlops. The cluster is used to run both commercial applications (Maya, Shake, Logic Audio) and open-source software (POVray, Triana). Custom software can also be compiled directly for the cluster using development tools such as MPICH 1.2.6, IBM C/Fortran compilers, Cactus and the Grid Application Toolkit.

Perhaps the most remarkable aspect of the installation and configuration of *Nemeaux* was the timeline by which this was done. Discussions with representatives from Apple Computer regarding the cluster began in early September of 2004. By September 20, a procurement plan had been finalized, and a purchase order was drafted and sent. All of the component parts of the cluster were delivered by September 28. Installation of power and network connections for the cluster took longer than expected and delayed the process by three weeks.

Once installed, assembly of the cluster began a few days later, and was completed in two days. By November 3, the cluster was operational. Cactus was running across all the compute nodes, the Grid Application Toolkit was installed, and GridSphere was operational, all by November 9. That day, CCT researchers were demonstrating and running applications on *Nemeaux* from the show floor at SuperComputing 2004 in Pittsburgh.

In 6 weeks, we were able to order, accept delivery, install and configure the cluster, and be fully operational. After SuperComputing, we continued to test *Nemeaux* and develop processes and scripts to help us manage and maintain it. In January, 2005, we officially launched the cluster.

## Benchmarks and Performance

Performance testing was done in November and December, 2004, using Maya, an animation modeler and renderer that has quickly become the industry standard for animation and special effect. The testing simulated reasonable use-cases in a computer animation course. Simple models with integrated physics simulation were first used to test compile times on single machines and using the whole cluster. Standard format renderings (640x480 pixels) that took 3 ¼ minutes on a single machine were processed in 22 seconds by the cluster (an 8-fold improvement). A 720p high-definition format (1280x720 pixels) rendering of the same file took ten minutes on a single machine, and just under 1 minute on the cluster.

However, a complex model with procedural rendering and shading at 720p resolution which took almost 2 hours to generate on a single machine was rendered in just over 5 minutes on the cluster, a 22-fold improvement. It is clear to us that *Nemeaux* performs best when it handles highly complex and extended calculations. While users do save time on smaller jobs with shorter time frames, the real benefit comes from giving users hours of time to iterate ideas and develop more robust and complex animations.

## Conclusion

The *Nemeaux* cluster will have a profound impact on both research and educational activities at LSU. The research component is fairly obvious, with a robust and well-integrated platform for experimentation in digital media applications, as well as grid computing and generalized parallel computing.

The impact on educational activities is far more profound. By decreasing the “turnaround” time for computing complex animation scenes or increasing the capacity for real-time sound generation, we are enabling students to fully explore their ideas, giving them an interactive environment that helps realize their work faster and more efficiently. Ultimately, *Nemeaux* will allow students to learn more thoroughly as they are able to get better feedback on their work and to do more during their classes. It is our expectation that students will enjoy the benefits of *Nemeaux* for years to come.

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<sup>i</sup> Levenson, Thomas *Measure for Measure: A Musical History of Science*. Simon & Schuster, New York 1994

<sup>ii</sup> Rossi, Paolo *Nascita della scienza moderna in Europa (The birth of modern science)*, trans. By Cynthia De Nardi Ipsen. Blackwell Publishers, Oxford, UK 2001

<sup>iii</sup> *Music & Art as Digital Media (MADmedia): Enhancements in Digital Media for the Music & Art Digital Studio (MADstudio)*, contract # LEQSF(2004-05)-ENH-TR-14.

<sup>iv</sup> *Xserve G5 Technology Overview*, Apple Computer, January 2004

<sup>v</sup> *Xserve G5 Technology Overview*, Apple Computer, May 2005