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A Flexible and Extensible Framework for Delivering Designer Images for K-12 Pedagogy

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Motivation K-12 schools are "under the gun" because they are increasingly expected to do more with less funding. The strains on already-strapped school districts make it extremely challenging for these schools to adopt any meaningful curricular changes to improve the quality of education. For economically disadvantaged schools, which are common in rural Virginia, such changes have effectively become an impossibility.

The decline of traditional cash crops, such as tobacco and cotton, have left many rural communities without a strong economic base. Without sufficient tax income, communities cannot afford to provide the educational opportunities that their children need to be competitive in the global marketplace. Access to the computing resources and training needed to function in contemporary society is one casualty. For example, while the average student-to-computer ratio is 3.8-to-1 for the nation and 3.1-to-1 for the Commonwealth of Virginia [Education Week 2008], a school near Virginia Tech has an average student-to-computer ratio of 10.5-to-1.

Virtualization has the potential to help overcome the technology disparities faced by rural schools. As shown by the successful Virtual Computing Laboratory (VCL) [Averitt et al. 2007], it can improve the educational opportunities of students in rural school districts and help bridge the digital divide. Virtualization allows everything that is needed to run specific educational software to be packaged up into a convenient whole that can be deployed without burdening teachers with computer minutia. Because custom virtual machines satisfy a focused need, we call them *designer images*. Figure 1 shows the Dr. Geo interactive geometry application running in a virtual machine as a designer image.

Building Community There are many websites that make pre-built virtual machine images available. However, very few virtual machine images are geared for education. To support the creation and sharing of designer images for education, we announce the Free Repository of Educational Software and Curriculum Archive (FRESCA), an Internet community for educational professionals and technologists.

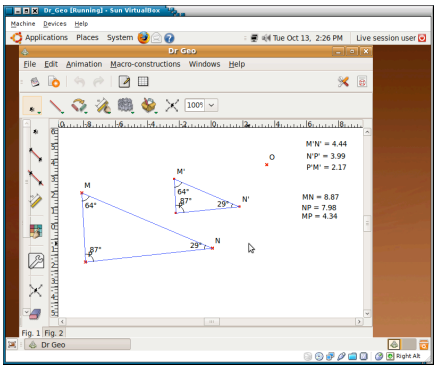

Fig. 1. Screenshot of Dr. Geo running as a VirtualBox image.

Heterogeneity Because it is unreasonable to expect that community-built images will all use the same virtualization technology, our Secure, Extensible, and Reliable Virtual Computing Environment (SERViCE) [Gardner and Feng 2008] has been refactored and extended to support multiple virtualization options.

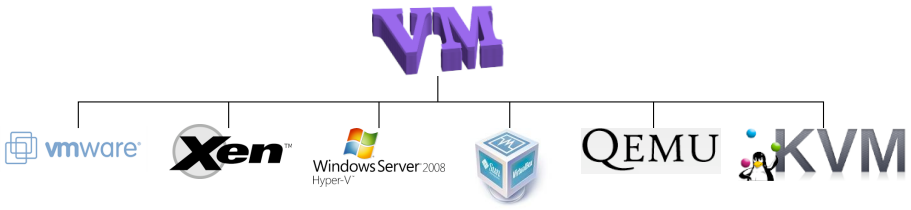

Fig. 2. Class Hierarchy Supporting Multiple Virtual Machine Technologies.

The SERViCE framework, implemented in Python, is a shallow class hierarchy with the logic needed to instantiate and run virtual machines in the SERViCE environment encapsulated in a base class (`VM`), as shown in Figure 2. Support for concrete virtualization technologies are added by subclassing (e.g., `VMware` or `VBox`). More details are available in the paper.

Startup Latency One measure we have found important in engaging and holding the attention of students is how fast the software environment encapsulated in a virtual machine becomes available. The time between user initiation until the software is ready to use depends on four broad factors: network communication time, virtual machine preparation time, time to start the virtual machine (or more precisely, time to start the operating system contained in the virtual machine), and time to start the application. Limited space precludes a full discussion of the various latencies which will be covered in the paper. As a preview, by paying attention to latency, the startup time of one education application in the SERViCE framework went from 175 seconds to 29 seconds, a 5.0x improvement.

Conclusions and Ongoing Work Virtualization is a very useful tool for bridging the digital divide, particularly for schools in rural areas. Custom virtual machines or *designer images* containing ready-to-run software are of great benefit to educators. We have created FRESCA to facilitate the building of a community around designer images for education.

Delivering software is only one part of making effective use of technology in the classroom. Another critical element is an interesting and engaging curriculum that teachers embrace and students enjoy. We are developing a curriculum for the Storytelling Alice application used to teach programming to elementary and middle school students. We are also preparing to teach classes to 3rd through 5th grader students in as many as ten elementary schools this spring.

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