

ISIS WORKSHOPS USING VIRTUALIZATION. Kris J. Becker and Tammy L. Becker, U. S. Geological Survey, Astrogeology Science Center, 2255 N. Gemini Dr., Flagstaff, AZ, 86001 (kbecker@usgs.gov).

Introduction: The Integrated Software for Imagers and Spectrometers (ISIS) [1] version 3 system provides image processing and cartographic mapping capabilities for many NASA missions, instrument team's ground data processing (GDP) systems [2], and the scientific user community [3] at-large. The USGS Astrogeology Science Center (ASC) has provided web-based and hands-on ISIS workshops for instrument mission teams and science users. The diversity of the workshop topics, number of participants and computing resources have presented challenges in providing efficient and effective workshops. Recently, we have developed workshops using machine virtualization technology, or virtual machines (VM), with Virtual-Box [4]. This has resolved many technical issues encountered in past hands-on workshops as well as supplied participants an ISIS platform which can be further customized for their specific needs beyond the scope of the workshop materials presented.

Discussion: ISIS is comprised of over 300 applications and provides support for more than 55 NASA and European imaging devices [2]. It is a complex system with a steep learning curve. However, once mastered, ISIS provides a comprehensive image processing system that can produce high quality cartographic products created from datasets acquired by different instruments.

History: Hands-on workshops have been conducted for spacecraft mission instrument teams since ISIS2 was used for Clementine and Galileo missions followed by ISIS3 for the Mars Reconnaissance Orbiter (MRO) High Resolution Imaging Science Experiment (HiRISE) team (one of the first adopters of ISIS3) and more recently teams such as Mercury Surface, Space ENvironment, GEochemistry and Ranging (MESSENGER) Dual Imaging System (MDIS) and Lunar Reconnaissance Orbiter Camera (LROC). There have been a number of workshops for the general community provided as well.

Requirements and Logistics: A successful hands-on workshop requires a stable, reliable and efficient computing environment. Focus is on interactive learning of ISIS and the cartographic concepts and techniques through prepared lessons. It is imperative that participants are not interrupted with network bottlenecks or inadequate computing resources. This can only be achieved by overcoming the challenges created by the number of participants, requirements for disk space, computing power, network connectivity, graphics support and limited support for OS configurations.

Disk Space: ISIS system installation size requirements can be reduced by selecting and installing supporting data (i.e., SPICE kernels, calibration files and

other ancillary data) for only those missions needed by users (or a workshop lesson).

Copies of all workshop materials and image datasets made available to each participant may require large amounts of disk space. Running ISIS image processing application steps provided in each lesson increases storage requirements as intermediate output products are created.

OS Platform: ISIS is currently supported on several popular Linux distributions including Scientific Linux and Fedora, both Redhat based systems, Debian and Ubuntu. Also supported are MacOSX (10.6 and above) platforms. The Scientific Linux operating system (OS) is used to host ISIS workshops for no particular reason other than it is Linux-based and arguably the more popular and widely used distribution. Some of the ISIS lessons are graphics intensive in nature and require an X client for each participant.

CPU: ISIS applications executed in the lessons have moderate CPU requirements. Computer systems used by more than one participant may easily be overwhelmed when lesson scripts are run simultaneously on the same machine. Modern laptops provide a suitable platform for most workshops provided adequate disk resources are available.

Results: We have continuously modified our hands-on computing environment to meet workshop objectives while keeping pace with technology and ISIS system evolution. Additional problems have been discovered as we increasingly scale the workshops, both in number of participants and requested advanced topics covered in the hands-on lessons.

Lessons Learned: Early workshops required users to provide the hardware and an ISIS system installation to use for the hands on lessons. ASC instructors provided workshop materials and the data needed for the hands-on lessons that were presented. It quickly became apparent this did not provide a consistent, stable environment and a lot of time was spent getting ISIS installed properly and/or working through problems encountered while executing lessons in the student's environment.

Workshops have been conducted on Linux computers configured with full ISIS installations. This configuration would accommodate several participants per machine, require many computers to be configured with ISIS and workshop materials, and but resulted in competition for compute resources.

Some successful workshops were conducted using three Mac minis with Fedora Linux installations, full ISIS configurations and wireless routers to provide access to users. Users were assigned unique student logins and used wireless access points to connect to an assigned Mac mini. Problems arose with this approach

as the minis could not handle more than several users per system and the wireless channels quickly became overloaded when graphical processing dominated network traffic. Some problems were alleviated with direct hardware connections to the minis, but CPU contention still remained.

ISIS Virtualization: Problems of scaling ISIS within an educational setting exist not only because of student numbers, but also because of hardware and OS limitations and connectivity to resources. To address these issues, we have designed a virtualization solution using a VirtualBox VM.

A main objective of any solution is to address known problems while at the same time keep from introducing new problems or limitations. VMs have shown to provide one solution with minimal impact on the user experience.

VM Specifications: The ISIS workshop VM was initially created using Vagrant [7]. Vagrant is designed to use VirtualBox as its virtualization provisioning system (mainly because VirtualBox is free). This approach provides the initial VM configuration with a very minimal Linux installation footprint. We chose to install Scientific Linux 6.5 using a preconfigured Vagrant box, an existing Vagrantfile developed using a specific OS installation procedure. For our objectives, we chose a small box that did not install unnecessary software. Another goal is to keep the VM size as small as possible to ease installation and minimize workshop startup time.

Once the initial VM is created, it is copied into the VirtualBox default VM directory and Vagrant is abandoned. The reason for this is to minimize user requirements by limiting software dependencies for use of the VM.

Three basic users are provided in the VM, each with a specific purpose in mind:

- **student** – This is the primary user account that will be used for most all normal operations. The home directory of this user has a directory named *IsisWorkshop* that contains all the files used in the workshop
- **isis3mgr** – The ISIS3 manager account. Management of ISIS is separated from the student account so that it is not accidentally corrupted or modified by any users.
- **vagrant** – The account under which all Linux administration and activities that require root permissions should be used.

To simplify use, passwords for all accounts are the same as the account name (i.e., password for the **student** account is “student”).

ISIS Configuration: The goal for the ISIS installation is to provide a complete processing environment while keeping the install size to a minimum. Image data used by the hands-on lesson scripts identify only the required ancillary ISIS files. They are placed into a data directory structure that emulates a normal ISIS

data installation. This is the most challenging part and customized aspect of creating the VM environment. Attempts are made to keep ISIS installations current to support coordinated ISIS release cycles. A simple startup script, used by developers and users at the ASC, is installed in the VM to maintain consistency.

All VM configurations include installation of FWTools, including GDAL, to support ease of importing and exporting data to and from ISIS.

User VM Installation: The components of a complete VM workshop package is 1) the ISIS VM including all lessons, 2) documentation and presentations of the workshop materials including a VM installation guide and 3) tar files containing ISIS applications and custom ancillary data configurations. The tar files are provided for users who have a compliant ISIS installation from which the lessons can be ran.

All these files are configured to fit on a USB 3.0 drive formatted with an NTFS file system. NTFS was chosen because of its (read-only) compatibility with most VM host OSes. The ISIS workshop VMs are typically around 11 gigabytes in size. The installs (transfers) complete in a few minutes to the students computer system. Students are required to have VirtualBox installed on their computers to expedite the VM installation process and to confirm support for their OS. Some laptops require virtualization to be “turned on” in the BIOS as it may not be enabled by default.

Instructions are provided to guide the user through installation of the VM in VirtualBox and optimizing its performance through host tools provided by VirtualBox for supported systems. The whole installation process takes about 15 minutes.

Conclusions: ISIS workshop scaling problems have been reduced by use of virtualization techniques using a VirtualBox VM running the Scientific Linux guest operating systems and a custom ISIS installation. Users provide the hardware and sufficient disk space to run the hands-on lessons. Once the workshop is complete, users now have an ISIS system which is capable of installing all of ISIS for additional use – something previous workshops did not provide. All of the scaling issues identified in previous workshop computing environment configurations are reduced or eliminated entirely. This ISIS configuration is available on all systems that support VirtualBox including Windows and MacOSX systems. We are also investigating ISIS development options using virtualization technology.

References: [1] Anderson J. A. et al. (2004), *LPSC abstract #2039*. [2] Becker K. J. et al. (2013), *LPSC abstract #2829*. [3] Kestay L. et al. (2014), *LPSC abstract #1686*. [4] <https://www.virtualbox.org/>. [5] Torson J. M. and Becker K. J. (1997), *LPSC abstract #1219*. [6] Becker K. J. et al (2007) *LPSC abstract #1779*. [7] <https://www.vagrantup.com/>.