TECHNOLOGY ENHANCED LEARNING WITH OPEN SOURCE SOFTWARE FOR SCIENTISTS AND ENGINEERS

Maurice Dawson¹, Imad Al Saeed², Jorja Wright³, Marwan Omar²

¹ Alabama A&M University (UNITED STATES)
² Colorado Technical University (UNITED STATES)
³ Florida Institute of Technology (UNITED STATES)

Dr.mauricedawson@yahoo.com

Abstract

This paper represents the evaluation and integration of Open Source Software (OSS) technologies to enhance the learning of engineers and scientists within the university. The utilization of OSS is essential as costs around the world continue to rise for education, institutions must become innovative in the ways they teach and grow Science, Technology, Engineering, & Mathematics (STEM) majors. To do this effectively professors and administrative staff should push toward the utilization of OSS and other available tools to enhance or supplement currently available tools with minimal integration costs. The OSS applications would allow students the ability to learn critical technological skills for success at small fraction of the cost. OSS also provides faculty members the ability to have students dissect source code, analyze network traffic, create virtual instances of real Operating Systems (OSs), and prepare students for low level software development. It is critical that all institutions look at alternatives in providing training and delivering educational material regardless of limitations going forward as the world continues to be more global due to the increased use of technologies everywhere. Through reviewing the available technology, possible implementations of these technologies, and the application of these items in industry could provide a starting point in integrating these tools into academia. When administrators or faculty debate the possibilities of OSS, gaming, and simulation tools this applied research provides a guide for changing the ability to develop future scientists and engineers that will be competitive on a global level in STEM fields.

Keywords: Open Source Software, Linux, innovation, technology, information systems, education technology.

1 OVERVIEW

This paper will cover the utilization of virtualization, Open Source Software (OSS), and simulation tools that are also OSS. OSS can be defined as software that is made available in source code form. This is important as this source code may fall under the General Public License (GPL) which is a widely used free software license that is managed under the GNU Not Linux (GNU) Project [1]. Virtualization is important as this is an effective method to reproduce system learning environments on the same systems the learner is using reducing the overall hardware footprint and need to for a massive lab. This paper will also cover various software applications that can be integrated into the university system.

1.1 Virtualization

In terms of virtualization there are available tools to create a virtual version of a system. In terms of educational resources this provides a method for institutions to train on Virtual Machines (VMs). This allows a university to teach students complex techniques to computer science, engineering, or Information Technology (IT) students such as networking, programming, system administration, and Information Assurance (IA). There are multiple types of virtualization such as hardware, desktop, memory, storage, data, and network. In Fig. 1 displayed is a screenshot of Ubuntu 12.04 running in a VM on the Ubuntu 12.10 desktop.
For institutions that would like the opportunity to provide a cloud like environment tools such as Oracle Virtual Box and VMware Player provide that ability. However it should be noted that new Linux distributions running that require GNOME 3 will have issues running on older hardware. With older hardware as a constraint there are bare minimal Linux distributions such as Puppy Linux and Damn Small Linux (DSL). VMs provide the ability for a student to experiment with hundreds of Operating Systems (OSs) without installing uninstalling the base OS.

Additionally, this allows for the creation of baseline OS images for classes. For example, a marketing course would have an OS created with all the software, case studies, and etc. preloaded. This baseline OS for marketing would have statistics software, graphic design software, social marketing tools, case studies, eBooks, links to online course management tool, and etc. This would allow an institution to have image ready for every class to ensure consistency, and that the students have all required tools needed. In the case for a more technical course such as software engineering the students would have a baseline OS image with all the programming software, the Integrated Development Environment (IDE), quality testing tools, and etc. preloaded.

For professors, this virtualized environment would allow for the monitoring, distribution, and quicker deployment of available tools. This environment would be a cloud computing solution. Cloud computing is based on concepts of virtualization, distributed computing, networking and is underpinned in the latest web and software technologies [2]. A useful definition of cloud computing is that it is a way of delivering applications as services over the Internet as well as a way of providing for the hardware and system software that act as platforms for these applications and services [3]. Cloud is also used to refer to a network of computers that are linked together and distribute processing capacity and applications to different systems [4]. Cloud computing lets organizations add on to their IT and computing capacity without having to invest in new architecture, software or hardware or in training and developing personnel [5]. A cloud environment could prove to be a cost effective implementation of which would allow for scalability if these right tools are utilized.

1.1.1 Adding and Expanding Capabilities with Linux

In terms of virtualization the most cost effective method is with the use of Linux as the OS. As institutions around the world look to provide their students and faculty with the ability to work in highly technical or large demand fields it is imperative that all institutions have the ability to provide a simulated environment to teach the necessary concepts such as program management, design, and engineering. However to do this at a fraction of the cost Linux and other OSS are vital for implementation.
1.1.2 Why We Need to Consider Linux Essential in Higher Education

Linux is a Unix like OS that is built on the Linux kernel developed by Linus Torvalds with thousands of software engineers. As of 2012 there are over two hundred active Linux distributions. The majority of the kernel and associated packages are free and OSS. This type of software provides a license which allows users the right to use, copy, study, change, and improve the software as the source code is made available. Providing source code allows developers or engineers to understand the inner workings of development. Imagine being able to study Mac or Windows by viewing all the source code to replicate similar developments. This exercise would be great for a developer to learn low level coding techniques, design, integration, and implementation.

In terms of associated cost the majority of Linux distributions are free. However some distributions require a cost for updates or assistance that related to specific needs such as OS modifications for server hosting. In software, there is a packet management system that automates the process of installing, configuring, upgrading, and removing software packages from an OS. In the Linux OS builds the most common packet management systems are Debian, Red Hat Package Manager (RPM), Knoppix, and netpkg. Below, there are a list of some Linux distribution and potential uses in education.

<table>
<thead>
<tr>
<th>Linux Distributions</th>
<th>Description and Potential Use</th>
<th>Packet Management System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ubuntu</strong></td>
<td>One of the most popular Linux OS developed to be a complete OS that can be an easily replacement for other comparable OSs.</td>
<td>Debian-based</td>
</tr>
<tr>
<td><strong>Edubuntu</strong></td>
<td>OS targeted for grades k-12. Contained in OS are tons of software applications that is useful to those who are education majors.</td>
<td>Debian-based</td>
</tr>
<tr>
<td><strong>Damn Small Linux</strong></td>
<td>This OS is designed to as a small OS to be utilized on older hardware. This OS is great for institutions that have old computers and want to revitalize them for use. OS is also great for VMs as DSL requires a low amount of memory</td>
<td>Knoppix-based</td>
</tr>
<tr>
<td><strong>BackTrack</strong></td>
<td>OS based on Ubuntu for digital forensics and penetration testing. Great tool for students majoring in technology fields. As cyber security is becoming a hot topic around the world this tool provides students the ability to learn from over thirty software applications that aid in penetration testing and more.</td>
<td>Debian-based</td>
</tr>
<tr>
<td><strong>Fedora</strong></td>
<td>This OS is supported by the Fedora Project and sponsored by Red Hat. This OS provides a great resource for learning Red Hat Enterprise Language (RHEL). As there are thousands of jobs requiring expertise specifically with Red Hat this OS is a great tool to prepare students for employment in IT. Fedora has over six Fedora Spins such as Design-suite, Scientific-KDE, Robotics, Electronic-lab, Games, and more.</td>
<td>RPM-based</td>
</tr>
<tr>
<td><strong>CentOS</strong></td>
<td>This OS derived entirely from RHEL. The source code is developed from Red Hat which allows a student to learn RHEL with a small number of differences. CentOS can be used for teaching IT students on how to setup, administer, and secure a server.</td>
<td>RPM-based</td>
</tr>
<tr>
<td><strong>Ubuntu Studio</strong></td>
<td>This OS is derived from Ubuntu. This OS is developed specifically for multimedia production such as audio, video, and graphics. Departments for multimedia could use this OS for multimedia instruction and the development of projects. As many of the tools for multimedia production are expensive this alleviates large license costs for institutions.</td>
<td>Debian-based</td>
</tr>
</tbody>
</table>
Other countries are supporting the OSS movement as well. In China, Red Flag Linux commands over thirty percent of the market [6]. China is actively looking for an OS to combat Windows OS thus the momentum for OSS continues to grow. In Russia, Linux may become a national OS by 2015 as they are as well looking for lower cost solutions in all levels of education. The Edubuntu OS, which has roots in South Africa, is being utilized by The Republic of Macedonia in all K-12 schools. With software packages such as LibreOffice students and faculty have the ability to perform similar functions as those found in the Microsoft Office suite without having to spend any money to obtain the software.

Since the early 2000, there has been significant encouragement for the use of Linux in the Spanish public school system [7]. This use has been at the K12 level however the university level has yet to fully integrate this technology into the classroom. However in a survey conducted by Accenture over 300 large blue chip organizations utilize OSS [8]. This indicates that roles such as project manager and systems manager will need to be familiar with OSS tools for development to include those for management.

The need and presence of project management knowledge has developed to become a necessity in many organizational industries, while project management methods, processes and certifications have become accepted standards in many industries [9]. In 2008 Global Knowledge and Fortune Magazine listed project management in their top 10 career of choice, while in a recent salary survey conducted by ZDNET’s Tech Republic organization, the PMP (Project Management Professional certification) was listed as the highest paying certification to have in the technology industry, while other project management certifications governed by the International Project Management Association (CPD, CPM) and Office of Government Commerce (PRINCE2) are highly sought after in European industries.

Communication and information technology has also developed rapidly within this decade. With the enhanced role of information technology, project managers must also prepare themselves to face the challenges of the future, both in the industry of project management as a whole and in the IT sector in particular. The increasingly important role of information technology is undoubtedly the effect of rapid globalization that requires companies to have a larger capacity, timelier and more accurate information management within their decision making system.

In project management part of a project manager’s toolkit is the Microsoft Office Project software suite. One of the many available OSS is Project Planner which allows the creation of Gant Charts, ability to manage resources, and ability to track tasks created. Using Linux based software allows institutions and organizations to teach this critical skillset at a fraction of the cost. Additional OSS tools that are present can be found on websites such as Open Source as Alternative (OSALT) which provides open source alternatives for items such as Microsoft Windows Suite, Araxis Merge, Bea Weblogic Server, and more [10].
1.1.3 Design Collaboration with Linux

In many graduate and undergraduate programs institutions teach techniques for collaboration and system processes such as the Capability Maturity Model Index (CMMI). In teaching these techniques OSS is the perfect platform as one of the key pillars for development is essentially coloration. With websites such as SourceForge there are over 3.4 million developers participating in the development of over 324,000 projects. With these projects there is a group of developers that develop, deploy, and maintain these projects. For institutions this provides a method for students to understand the Software Development Life Cycle (SDLC) first hand.

The success of open source software demonstrates the alternative form of software and systems development processes. Software development is undergoing a major change from being a fully closed software development process towards a more community driven open source software development process [11]. As a significant number of the Information System (IS), computer science, or systems engineering students worldwide need to understand the SDLC the OSS environment provides a great opportunity to learn all facets of the lifecycle [12]. The SDLC known as the Waterfall Method is comprised of six key phases that entail completing one phase and moving to the next without going back to the previous phase in the development cycle. The first phase is the requirements phase. During this phase of developments requirements are gathered for development. This allows developers and customers to capture requirements such as software functionality to user authentication requirements. The second phase of the SDLC is the design phase. In this phase the requirements become design specifications and developers develop the system. In the third phase, which is implementation, systems and subsystem are integrated to function as an entire system. For example, a software application may be comprised of multiple subsystems developed independently. At this phase they are integrated to together for a final implementation of the system. In the four phase verification, a final test of the software or system is conducted before the final release. In the fifth state deployment the software application is installed after it has passed a rigorous check in the fourth stage. The last state is maintenance which consists of maintaining the software or system. It is important to also note in this stage the decision to retire a software application or system is also made.

2 OUYA GAMING SYSTEM

Ouya is the Android-powered solution to the lucrative gaming arena. Ouya is a black and silver gaming console designed by Yves Behar, industrial designer and philanthropist [13]. Ouya is an inexpensive alternative for gaming aficionados, in that Ouya is based on open source development. Currently, Ouya retails for $99 – that is the most inexpensive TV gaming console available. Unlike, the major gaming company, such as Playstation and Nintendo, Ouya does not require “any licensing fees, retail fees or publishing fees” [13]. Ultimately, Ouya’s creators want to create a developer-friendly environment in which hackers and hobbyists are all welcome to create games for Ouya. The only condition developers must meet is that the games they create must offer some free elements, such as free demos [13]. Ouya is scheduled for a March 2013 retail release.

As for academia, Ouya has the potential to transform the educational system in the 21st century. Technology has advanced at an exponential rate in the past 20 years, and continues to improve in the near future. The skill sets that are required for successful 21st century students include proficient computer literacy. In fact, the next generation of jobs will be characterized by increased use of technology, in depth problem solving and complex communication [14]. What students learn is no longer the focal point of their education, how and when they learn is just as important. Today’s students have grown up with laptops, cell phones, tablets, and mobile internet; naturally this technology should be applied to their learning environment as well. Advocates of game-based learning in education assert that digital games can teach students important skills, like thinking, planning, learning and technical skills that are vital for today’s workforce [14].

Lastly, Fedora’s Electronic Lab (FEL) is a possible platform to utilize the Ouya gaming system. FEL is a free open source hardware design and simulation platform that is dedicated to supporting the Electronic Design Automation (EDA) community through innovation and development [15]. FEL is important for the implementation of Ouya for various reasons. First, FEL “provides a complete electronic laboratory setup with reliable open source tools” to keep users current with technology [15]. FEL solves a major problem for the open source community by providing real life open source EDA solutions. FEL utilizes three methodologies – design, simulation and verification – in order to give a better hardware design. Also, FEL bridges the two major open source communities: open source software community and open source hardware community. Finally, Fedora is available in alternate
versions known as “spins” [15] The “Design-suite” spin for Fedora allows open creativity for users; “Security” spin has security analysis tools; “LXDE” spin is a faster, less demanding desktop environment; while “Games” spin is tailor-made for games in Fedora [15].

Fig. 3.(a) OUYA Gaming System (b) Raspberry Pi

Raspberry Pi is “a credit card sized single-board computer” developed in 2006 by Eben Upton and three of his colleagues. Their intention was to stimulate interest in teaching of basic computer science in schools. Raspberry Pi has a Broadcom BCM2835 system on a chip (SoC) that contains an ARM1176JZF-S; VideoCore IV GPU; and 256 megabytes of RAM [16]. Lastly, Raspberry Pi uses an SD card for booting and long-term storage. Currently, two versions are available, Model A, which cost $25 and has 256 Mb RAM, one USB port and no Ethernet connection and Model B, which cost $35 and has 512 Mb RAM, 2 USB port and an Ethernet connection [16].

3 OSALT & SOURCEFORGE

Open source as alternative (OSALT) provides open source alternatives to popular commercial products [10]. The open source programs OpenOffice Draw, StarUML and Avidemux respectively are open source alternatives for Adobe Photoshop, Dreamweaver and iTunes. Currently, OSALT is working on providing open source version of the Internet, Internet Protocol version 6, also known as IPv6 [10]. IPv6 resolves the issue of IP addresses by introducing an innovative IP address that can handle 3.4e+38-, an exponential number for billions of IP addresses.

Sourceforge is an open source development website that provides free services to aid developers create open source products and share it on a global scale [17]. Community collaboration is important for the proper implementation of open source projects. Consequently, Sourceforge’s directory provides the tools needed for 3.4 million developers to create open source software. This directory connects over 46 million consumers with various open source projects [17].

4 CONCLUSION

Open source technology is an avenue with unlimited potential to improve our educational system [18]. Virtualization is a way to teach intricate computer science, engineering, or IT problems using a virtual machine (VM) [18]. Also, VMs allows students to experiment with various OSSs without uninstalling the base OS. As mentioned earlier, this baseline OS can be equipped with tools that are needed for that discipline. Examples of these tools are statistics software, graphic design software, social marketing tools and case studies that are preloaded on to computers for business students. Cloud computation is a cost effective implementation of virtualization. Further, using Linux as the operating system will significantly reduce the cost of implementing virtualization into our educational system.

Since the majority of open source software is free, the money that is saved from technology can be used elsewhere. Open source is also gaining popularity overseas. In China and Russia, various versions of Linux are on the verge of becoming the main OS in the upcoming years. Open source software is prevalent in the Spanish educational system as well. Open source software is changing the nature of organizational industries in project management. Lastly, gaming industry is another avenue that can be utilized in today’s educational system. Ouya and Linux are cost effective open source alternatives to popular commercial gaming hardware and software, respectively. Gaming may be utilized to teach important skills such as thinking, planning and technical skills for today’s job market. Finally, Raspberry Pi is a revolutionary computing device that may change the way education and technology are used in our society. Raspberry Pi is a way for students to access cheap programmable computers for today’s society. Ultimately, open source software and/or hardware are low cost and is an excellent opportunity to integrate technology into academia [18].
REFERENCES


