

FREE AND OPEN SOURCE SOFTWARE APPLICATIONS IN MATHEMATICS AND EDUCATION

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ABSTRACT

Free and Open Source Software (FOSS) is rapidly gaining popularity on the home desktop. We explore the possibilities of employing these software tools in an academic environment. We will discuss various mathematical and educational tools that are available on a typical Linux operating system.

1 Introduction

We have recently migrated to a Linux operating system for use in the academic environment. We use FOSS software applications in the office, classroom and for research purposes. Our goal of this project is to examine the utility of these applications, and to describe their function. Most of the applications described in this paper are licensed under some form of the GNU General Public License (GPL), and are free to use and modify (with some restrictions). Many are available on multiple platforms (e.g. Mac OS X and Microsoft Windows), and all are available on the major Linux distributions. Specifically, we currently use Ubuntu 9.04, and all of the applications discussed below are available in their repositories.

2 Applications for Daily Use

Several full-featured open source web browsers and email clients are available. Firefox, part of the Mozilla project, is one of the more popular web browsers, and is actively being developed with a multitude of extensions available as well. Additionally, Epiphany is a very lightweight web browser that is useful on older computer systems. The Mozilla email client, Thunderbird, is also well supported. It includes a calendar plug-in (Lightning), and together these provide a robust personal information management system. While Thunderbird does not have complete integration with Microsoft Exchange, it functions well with IMAP and SMTP servers. Evolution is a similar email client, and does provide support for Exchange.

OpenOffice.org is a robust office suite, featuring a word processor, spreadsheet, presentation software, database software, graphics, an equation editor, and HTML and pdf export. It uses the OASIS approved standard OpenDocument format (e.g. odf,

ods, etc.), and is compatible with many proprietary formats as well. In particular, OpenOffice.org is able to read the Microsoft doc, docx, xls and xlsx formats, and can write to the formats doc and xls. The OpenOffice.org suite is fully integrated, and we find it completely acceptable as an office software suite. Moreover, we have always been successful at translating the Microsoft formats that are often found in email attachments and web downloads. Suitable FOSS alternatives to OpenOffice.org include Abiword for word processing, the spreadsheet package Gnumeric, and KPresenter for creating presentations.

LaTeX is an essential tool for most working mathematicians. The complete package TexLive is available through most Linux repositories. Presentation add-ons such as Beamer are available as well. The author currently uses the graphical front-end Kile to create documents. While Kile is not a full-fledged WYSIWYG editor, it does provide many one-click shortcuts to standard TeX/LaTeX commands. There exist several WYSIWYG TeX/LaTeX front-end environments, with LyX being one of the most popular.

Some of the other daily tools we have found useful in the academic environment: Scribus, a professional page layout desktop publishing software similar to Adobe PageMaker, Inkscape, a vector graphics editor similar to Adobe Illustrator, and the Gimp, an image manipulation program with many features similar to Adobe Photoshop.

3 Mathematics and Statistics Applications

The major part of this project has been identifying open source applications for use in the mathematics and statistics classroom, and tools for mathematical research. In the past we have used the proprietary Maple computer algebra system, Fathom statistical software, and Geometer's Sketchpad for these tasks. Our goal was to identify suitable open source replacements for these proprietary packages.

Maxima is an open source descendant of the computer algebra system Macsyma, developed in the late 1960's at MIT. Maxima provides much of the functionality as Maple for the calculus and linear algebra classrooms, with advanced tools (e.g. ODE's) as well. Two and three dimensional plotting, arbitrary precision arithmetic, and symbolic manipulation are supported. Furthermore, a graphical front-end, wxMaxima, is available.

R is a very robust statistical analysis package similar to the programming language S, which was developed in the late 1970's at Bell Laboratories. It provides an integrated environment for data manipulation, statistical analysis, graphical display, and more. The graphical front-end Rkward provides a spreadsheet-like interface and wizard tools for statistical tests and graphics. Additionally, Rkward provides integration with CRAN, the Comprehensive R Archive Network. By accessing the CRAN archive, one can update packages and install hundreds of additional tools and add-on packages

to R.

GeoGebra is a dynamic interactive geometry and algebra software package, that includes calculus tools as well. Users can create and manipulate a variety of two-dimensional geometric objects. Additionally, basic function plotting and analysis are available, and the algebra and calculus tools can be integrated into the geometric viewing window. GeoGebra also offers simple dynamic webpage export functionality. With this capability, users can create dynamic and interactive webpages to display their content created in GeoGebra. There are also many other open source geometry programs comparable to Geometer's Sketchpad, including KIG, Dr. Geo, KSeg, and Geomview.

Extcalc is a scientific calculator and graphing utility. It provides graphical interfaces for a calculator, two and three dimensional plotting, tables, matrices and statistics. It handles all standard mathematical operations, and has special functions like integration and differentiation.

There exist a handful of FOSS numerical computation packages that are similar in functionality to Matlab. While we have not used these packages extensively, we mention them for completeness: QtiPlot, Scilab, FreeMat and Octave.

One of the most exciting new software projects is Sage, a powerful and flexible FOSS mathematical software project. Sage combines many of the best existing open source mathematical software tools (e.g. GAP) into a single package. Sage was first released under the GNU GPL in 2005, with lead developer William Stein, a mathematician at the University of Washington. The mission statement of the Sage project is to *create a viable open source alternative to Magma, Maple, Mathematica and Matlab*. Sage is a very robust package, useful not only in the classroom, but as a research tool as well. A brief sampling of some of the functionality of Sage: computational discrete algebra and group theory, computational linear algebra, symbolic and numeric computer algebra, networks and graph theory, number theory, statistical computing and graphics, commutative algebra and algebraic geometry, combinatorics, finite groups and representation theory.

Sage can be accessed either via the command line or through a notebook interface in a web-browser. The notebook interface provides the ability to display high-quality mathematical expressions (using LaTeX) and graphics, and interact with the various component programs to perform calculations. Sage can be run either locally or on a Sage server on a network. Currently, there are several internet sites that provide open access to a Sage server (e.g. www.sagenb.org) and host repositories of contributed notebooks covering a variety of topics. Additionally, Sage and its components are now available in the repositories of many Linux distributions, including Ubuntu 9.04.

In the recent past, we have used Maple (and Maplets) to create tutorials, labs and demonstrations for the classroom. One of the goals of this project is to explore

the feasibility of doing the same using Sage. We currently have converted many of these classroom demonstrations to Sage, and plan to use them in future classes. Additionally, we have integrated Sage into a current course, Numerical Analysis. This course has made extensive use of Maple in the past, both with exploratory labs and classroom demonstrations. This semester, we have begun migrating these tools to Sage. We have provided many of the classroom demonstrations in Sage, and students have used both Maple and Sage to complete the labs.

4 Web Applications

The author is currently a webmaster for three professional websites, and has used the Angel content management system to teach an online course. We've investigated open source web applications in these settings.

Drupal is a content management system for creating, publishing and maintaining an entire website. Administration of Drupal is done via a web browser, and users can obtain a user account with a variety of administrative rights. Drupal allows for a wide variety of content through add-on modules, including blogs, forums, polls, podcasting, and collaborative authoring. The author currently maintains his personal website with Drupal, and has found it to be full-featured, easy to use, and a very powerful platform.

Moodle is an open source course management system, with much of the functionality of Angel or Blackboard. It is also extensible via add-on modules, providing tools such as assignments, quizzes, forums, wikis, databases and gradebooks. Both Moodle and Drupal run on servers utilizing the open source tools Apache (web server), MySQL (database) and PHP (dynamic web page scripting language).

The author currently edits static HTML web pages with either Seamonkey Composer, or its descendant KompoZer. Seamonkey is another project descended from the Mozilla foundation, and provides WYSIWYG HTML editing. Furthermore, KompoZer provides integrated file management via FTP.

5 Summary

The benefits of open source software are many. The term open source refers to the fact that the source code is available to the user. The user is thus free to use it as they wish (with sometimes minor restrictions, depending on the licensing). While this kind of freedom of use is desirable, all of the software described above is also free in cost. This is a tremendous benefit. There exist large communities of developers and users surrounding each of these open source projects, and the *distributed peer review* model of software development provides for more individuals to be editing and observing changes to the code. Finally, there is the issue of transparency. Because

users have the ability to access the source code, output from these programs can be verified. In particular, important calculations can be checked for accuracy since the code is available. This is not the case with proprietary software, where the user must trust that the distributor of the program has provided a tool that works correctly.

We've found the above mentioned FOSS software packages to be a completely acceptable replacement for running a proprietary system with proprietary packages. Our migration to the Linux desktop in the academic environment is complete, and we find no need to run other operating systems in the workplace. Moreover, Maple supports the Linux operating system, and both Geometer's Sketchpad and Fathom can be run on a Linux desktop using Wine, a FOSS program to run native Windows applications in Linux. So while we still have licenses for these proprietary programs, we are able to run them under Linux. But as mentioned above, there are open source packages freely available under Linux that provide a capable replacement as well.

6 Appendix

In summary, we identify the recommended FOSS programs and, where applicable, their graphical frontend (GUI).

Function	Project Name	Website
Web Browser	Firefox	www.mozilla.com/firefox
Email Client	Thunderbird	www.mozilla.com/thunderbird
Office Suite	OpenOffice.org	www.openoffice.org
LaTeX (GUI)	TexLive Kile	www.tug.org/texlive kile.sourceforge.net
Computer Algebra (GUI)	Maxima wxMaxima	maxima.sourceforge.net wxmaxima.sourceforge.net
Statistics (GUI)	R RKWard	www.r-project.org rkward.sourceforge.net
Geometry	GeoGebra	www.geogebra.org
Scientific Calculator	Extcalc	extcalc-linux.sourceforge.net
Mathematics	Sage	www.sagemath.org
Content Management System	Drupal	drupal.org
Course Management System	Moodle	moodle.org
HTML Editor	Seamonkey Composer	www.seamonkey-project.org