By Woody Evans

The Struggle for Open Mathematics Software

Questions to contemplate: Are mathematical truths platonic forms, abstract entities floating in space, accessible to anyone who is willing to work to discover them? Or are they, like genes, patentable on the basis of the extraordinary processes involved in sufficiently isolating their signal from the surrounding noise?

These are not just philosophical questions. They reflect new legal and technological developments that affect at least two major for-profit companies: Google, Inc. and Wolfram Research.

Google announced in September 2014 that it would be working with SageMath to power the new SageMathCloud (cloud. sagemath.org). The collaboration throws down a gauntlet against claims of ownership of mathematical truths. As Craig Citro wrote in the Google Research blog (googleresearch.blogspot. com/2014/09/collaborative-mathematics-with.html):

> Modern mathematics research is distinguished by its openness. The notion of "mathematical truth" depends on theorems being published with proof, letting the reader understand how new results build on the old, all the way down to basic mathematical axioms and definitions. These new results become tools to aid further progress.

Why does Google take a philosophical position on mathematical processes? It seems to be aimed directly at Wolfram, which is sometimes viewed by advocates of open access in mathematics as a sort of miserly dragon, lying on hoarded code.

THE WOLFRAM DRAGON

Wolfram Research is arguably the world's dominant mathematics software provider. Since its release in 1988, its flagship Mathematica software has become "The world's definitive system for modern technical computing," as its own ad verbiage says (wolfram.com/mathematica). Mathematica contains libraries of mathematical functions, computational tools for everything from machine learning to data mining, and even "free-form" inputs for natural English queries.

But Mathematica was conceived in a pre-internet era. Although Wolfram moved into the web and social media through its Wolfram Alpha (wolframalpha.com) arm back in 2009, Wolfram is perhaps still less of the go-to math tool for average users on any given day than Google's calculator. Wolfram Alpha's Alexa rank sat at 2,117 in January 2015, while Google's Alexa rank remained steady at 1 (alexa.com/site info/wolframalpha.com; alexa.com/siteinfo/google.com).

It's not entirely fair to suggest some one-to-one comparison of Google Calculator to Wolfram Alpha, since both quantitative and qualitative differences exist between them. Google may be the top site in the world, but Google Calculator on its own is not, and Google's Calculator pointedly

lacks the functionality, range of tools, "graphy-ness," and intuitive (linguistic) input of Wolfram Alpha. In other words, exploration of the Moore-Penrose psuedoinverse matrix is fit for one tool, while simply adding 1+9+9+0 is fit for the other. Google's calculator is for arithmetic. Wolfram Alpha does that and a whole lot more.

Wolfram (like Google) is a for-profit enterprise (licenses for Mathematica start at $1,235 per year for the standard version for colleges and universities, although a personal, online-only, home use license is $149 per year). Thus, Wolfram is keen to protect its software, and even its software's calculations. Wolfram holds the position that, because the information generated by its software is novel, the results of calculations may be subject to copyright by Wolfram (see Neil McAllister's June 2009 piece in *InfoWorld*, "How Wolfram Alpha Could Change Software"; infoworld.com/article/2631401/patents/how-wolfram-alpha-could-change-software.html).

Like large biotech firms patenting genes or processes for curing diseases, Wolfram has worked very hard and spent a lot of money to develop tools that can give us answers that would not otherwise be accessible to us. And it stands by its right to patent processes and copyright results—even when those results take the form of eternal arithmetical truths.

As Richard M. Stallman (developer of GNU, founder of the Free Software Foundation) likes to point out, there is much confusion on the issue of copyright, copyleft, open source, and free software (gnu.org/philosophy/open-source-misses-the-point.html). Mathematica users have been wondering for some years whether there is, or whether there could be, a free and/or libre "open source implementation" of the Mathematica language. If so, what exactly does that mean for mathematics (mathematica.stackexchange.com/questions/4454/is-there-an-open-source-implementation-of-mathematica-the-language)? Is mathematics, as Google claims in its Sage announcement, inherently dependent on "openness"?

MathWorks is another company unconvinced by the open movement. Its MATLAB (mathworks.com/products/matlab) product is designed for engineers and scientists to use its "language of technical computing" for data analysis and visualization, numeric computation of large data sets, algorithm creation, and application development as code, executables, or software components. You must request a price quote; Mathworks does not put its price list on its website.

DRAGGING MATH INTO THE OPEN

Due to the cost and "closedness" of proprietary software such Mathematica and MATLAB, many "open" mathematics software projects have begun to appear. Beginning in the 1990s, the advent of BSD (Berkley Software Distribution) licenses have allowed flexibility, general openness, and compatibility with GPL (the "General Public License" of the GNU Project) for many new mathematics software projects. The further promulgation of related GPL licenses has helped a number of numerical and statistical software suites to become much more widely known. OpenFOAM (openfoam.com), R (r-project.org), Maxima (maxima.sourceforge.net), GNU Octave (gnu.org/software/octave), FreeFem++ (freefem.org/ff++), Euler Math Toolbox (euler.rene-grothmann.de), and ADMB (admb-project.org), which all had origins or initial releases in the 1990s or earlier, have been followed by a number of new tools—many of which have only just appeared in the last couple of years.

Some of these are quite overt about their aims; Mathics (mathics.org), for example, "is a free, general-purpose online computer algebra system featuring Mathematica-compatible syntax and functions. It is backed by highly extensible Python code, relying on SymPy for most mathematical tasks." It appears that SageMathCloud has come along at just the right time, and that Google and Sage together might take advantage of a new "open source moment" in the mathematics community.

Marshall Hampton, associate professor in the department of mathematics and statistics at the University of Minnesota–Duluth, advocates "open math." He uses R in his bioinformatics work and tells his readers, "I use the free, open-source program/environment Sage in all of my work; I encourage you to try it and contribute to it if you can" (d.umn.edu/~mhampton).

R is included in Sage, as are many other independent open projects, including Gfan (home.math.au.dk/jensen/software/gfan/gfan.html) and Biopython (biopython.org/
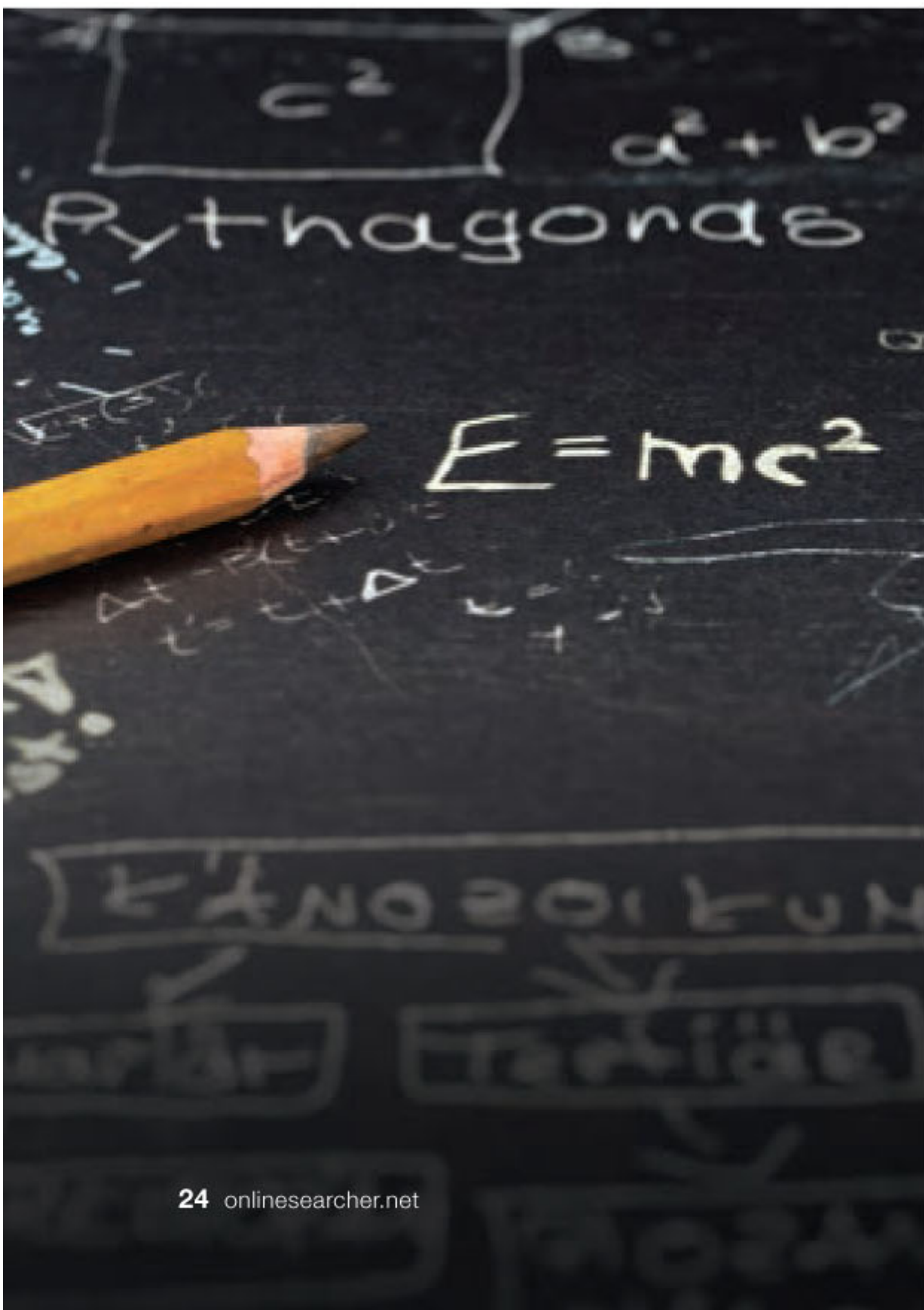
Free also often means 'not for sale' or 'Take it without paying us—it's free!'...

wiki/Main_Page). Hampton is also a fan of the typesetting language LaTeX (latex-project.org). Hampton expresses a critical view toward the idea that Wolfram or anyone else can copyright math: "I think any claim of copyright on a calculation is pretty ridiculous." He concedes that graphical or interactive output, although not the content of calculation, could be copyrightable.

With advocacy by the likes of Hampton, his peers, and students, the new open-licensed and open-source languages have quickly gained ground. Julia (julialang.org), SALOME (salome-platform.org), ScicosLab (scicoslab.org), X10 (x10-lang.org), Scilab (scilab.org), Cray Chapel (chapel.cray.com), Gmsh (geuz.org/gmsh), and FreeMat (freemat.sourceforge. net) are all available under GNU-compatible licensing. By using the Google Cloud Platform, Sage is in a powerful position to lead in the realm of open source mathematics projects. Google, a for-profit corporation, is clearly facilitating the growth of potential not-for-profit and free/libre competitors to Wolfram.

TWIN DRAGONS OF MATHEMATICS AND LAW

But there is a squishy liminal space here between the twin dragons of mathematics and law, between philosophy and software. And that space is where Richard Stallman lives, works, and travels.

In a recent email exchange I had with Stallman, he was very concerned that I use my terms correctly when writing about "open source" and "free software." Even a cursory examination of popular discussions surrounding these topics reveals much confusion (and I have certainly been confused about them in the past). When we talk about SageMathCloud as "open," or Wolfram's Mathematica as "closed," there are implied claims in both technical and legal dimensions.

It may help to briefly revisit some definitions. But even in trying to simply define these ideas, you quickly run into subjective and value-loaded views. For example, the primer site at the Free Software Foundation (fsf.org) begins its definition of "free software" with this statement: "Free software is software that gives you the user the freedom to share, study and modify it. We call this free software because the user is free." The statement may be true, but it is also certainly biased. The Foundation goes on to make the following statements:

> To use free software is to make a political and ethical choice asserting the right to learn, and share what we learn with others. Free software has become the foundation of a learning society where we share our knowledge in a way that others can build upon and enjoy.

Currently, many people use proprietary software that denies users these freedoms and benefits. If we make a copy and give it to a friend, if we try to figure out how the program works, if we put a copy on more than one of our own computers in our own home, we could be caught and fined or put in jail. That's what's in the fine print of the license agreement you accept when using proprietary software.

The corporations behind proprietary software will often spy on your activities and restrict you from sharing with others. And because our computers control much of our personal information and daily activities, proprietary software represents an unacceptable danger to a free society.

LOGOS AND ETHOS

To return, briefly, to philosophy: The Aristotelian categories of persuasion are logos, ethos, and pathos. Logos uses logical reasoning to prove an argument; ethos sways by asserting the moral credibility of the author; and pathos relies on an emotional response to the argument. More than the logos button is being triggered by the Free Software Foundation. We have an appeal to ethos in the idea that "proprietary software" represents dreadful dangers to our republic, and even a touch of auto-pathos in imagining yourself getting "caught" by The Man and put in jail. In any case, this is only one definition of free within this conversation about free software.

Free also often means "not for sale" or "Take it without paying us—it's free!" or "free as in free beer," and this causes some consumer confusion. Apple decided some years ago to make its software upgrades free—available without cost to consumers, but it has never (and may never) make its software free.

Dennis Howe's Free On-Line Dictionary of Computing (FOLDOC.org) defines free software this way:

> Software that everyone is free to copy, redistribute and modify. That implies free software must be available as source code, hence "free open source software"— "FOSS". It is usually also free of charge, though anyone can sell free software so long as they don't impose any new restrictions on its redistribution or use. The widespread acceptance of this definition and free software itself owes a great deal to Richard Stallman and the Free Software Foundation.

Already we see the apparently necessary conflation of "free" with "open source" that Stallman wishes we would

avoid. In his detailed piece on the differences between these two, cited earlier in this article, Stallman's case rests mainly on highlighting philosophical differences. The practical differences are comparatively minimal. He writes:

> In practice, open source stands for criteria a little weaker than those of free software. As far as we know, all existing free software would qualify as open source. Nearly all open source software is free software, but there are exceptions … Some open source licenses are too restrictive, so they do not qualify as free licenses. Fortunately, few programs use those licenses.

DEVELOPING TRUTHS

Google makes most of its money from advertising and from facilitating the Android marketplace for mobile apps. Wolfram Research makes most of its money by selling powerful software that lets mathematicians and researchers explore data, experiment with ideas, and visualize difficult problems and solutions. The two companies are not competing for the same customers and are not interested in pushing each other out of a limited market. The bazaar is big enough for both stalls.

It would seem, then, that to whatever degree Google's empowerment of SageMathCloud steps on Wolfram Research's toes, Google is doing so less for reasons that immediately affect its bottom line than for reasons of ideology.

Code is code, though, and in a world where software and law increasingly affect each other, it seems that ideology can also impact profit. Google's Open Source Programs Office does much to maintain "a healthy relationship" with coders in the open source community. Sharing software, making it free (as in freedom to tinker with it), and supporting other such free projects in no way harms Google's profitability. In fact, gathering these partners together into its big "don't be evil" tent keeps them close. Closer to Google may mean farther from the likes of Google's competitors, and it certainly means Google gets first choice for many cool new tools. It's always a party over there in Mountain View, and Google has found strategies for guaranteeing itself the first piece of cake.

But then again, maybe this love-in of open source projects and this careful fostering of (and investment in) projects such as SageMathCloud is all just an exercise in angry-nerd ranting about the nature of mathematical truths—and the proud, positive, and optimistic evangelism for the good news of a new kind of coding culture. Google can afford to play it either way it likes.

Wolfram Research, on the other hand, has a lot invested in being closed—"proprietary" in Stallman's terms—and it cannot join the party without having its coat pockets picked on the way to the closet.

If Google is trying to extract code from the Wolfram dragon's hoard and position itself as the open alternative to proprietary mathematical software companies, it will have to do more than pose a philosophical assertion to ownership of mathematical truths.

NOTE: This article expands on a NewsBreak ("Big Numbers: Google Challenges Wolfram to Open Up Math") published on Nov. 11, 2014 (newsbreaks.infotoday.com/NewsBreaks/Big-Numbers-Google-Challenges-Wolfram-to-Open-Up-Math-100461.asp). Special thanks to Richard Stallman and Marshall Hampton.

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