SageMathCloud: realtime collaborative web-based technical computation

William Stein

February 6, 2017

Outline

1. Background

2. Tour

Who Am I?

1. 1995–now: Number theorist (Berkeley Ph.D.; Harvard Asst. Prof.)
2. 2004–now: Founder of SageMath
3. 2005–now: Prof at UCSD, then Univ of Washington (on unpaid leave)
4. 2015–now: CEO of SageMath, Inc. (current fulltime job)

2012: I Started SMC - why?

1. Frustration with funding for Sage after Simons Foundation meeting
2. Need to make Sage easily available to the masses
3. SMC: next generation successor to sagenb
4. Taught course on Sage/LaTeX/etc. *many* times, and wanted ideal environment.
5. Spent a year learning web development, scalable distributed systems, building prototypes, mastering new programming languages, etc. (just like with Sage), before I had anything.
6. Key inspiration: bought Chromebook – decided to **dogfood**!

What is SMC?

1. Sandboxed collaborative browser-based "projects" (=Linux accounts).
2. LaTeX, Sage, Jupyter, Terminals, Chat, File editing, etc., all with full history tracking, collaboration, and chat.
3. SMC entirely written inside SMC!
4. **Longterm Goal:** *Create the canonical platform for realtime collaborative web-based technical computing.*
5. SMC directly competes with...? Some products do technical computing, but not realtime collaboration (e.g., JupyterHub, Wolfram Cloud, JuliaBox), and others do realtime collaboration but not technical computing (e.g., Cloud9.io IDE, Codenvy).

SageMath, Inc.

1. **Feb 2015:** SageMath, Inc. – a Delaware C Corp
   - Founded with outside angel investment
   - Need an entity from which people can "buy support"
   - For SMC to be *viable* for millions of users, we absolutely need 50+ people doing support, operations, and dev; a private company is a viable way to build such a thing.
2. **June 2016:** Start working fulltime for SageMath, Inc.; additional outside investment.
3. **Jan 2017:** SMC is a powerful collaborative browser-based environment optimized for technical computation.
4. **SMI employees:** me, Harald Schilly, John Jeng, Hal Snyder and Tim Clemans.

2017 SageMath, Inc. Plans

1. Build a major company during the next five years.
2. Company will eventually fund work on open source math software.
3. Current market focus:

Professors teaching STEM courses using open source software

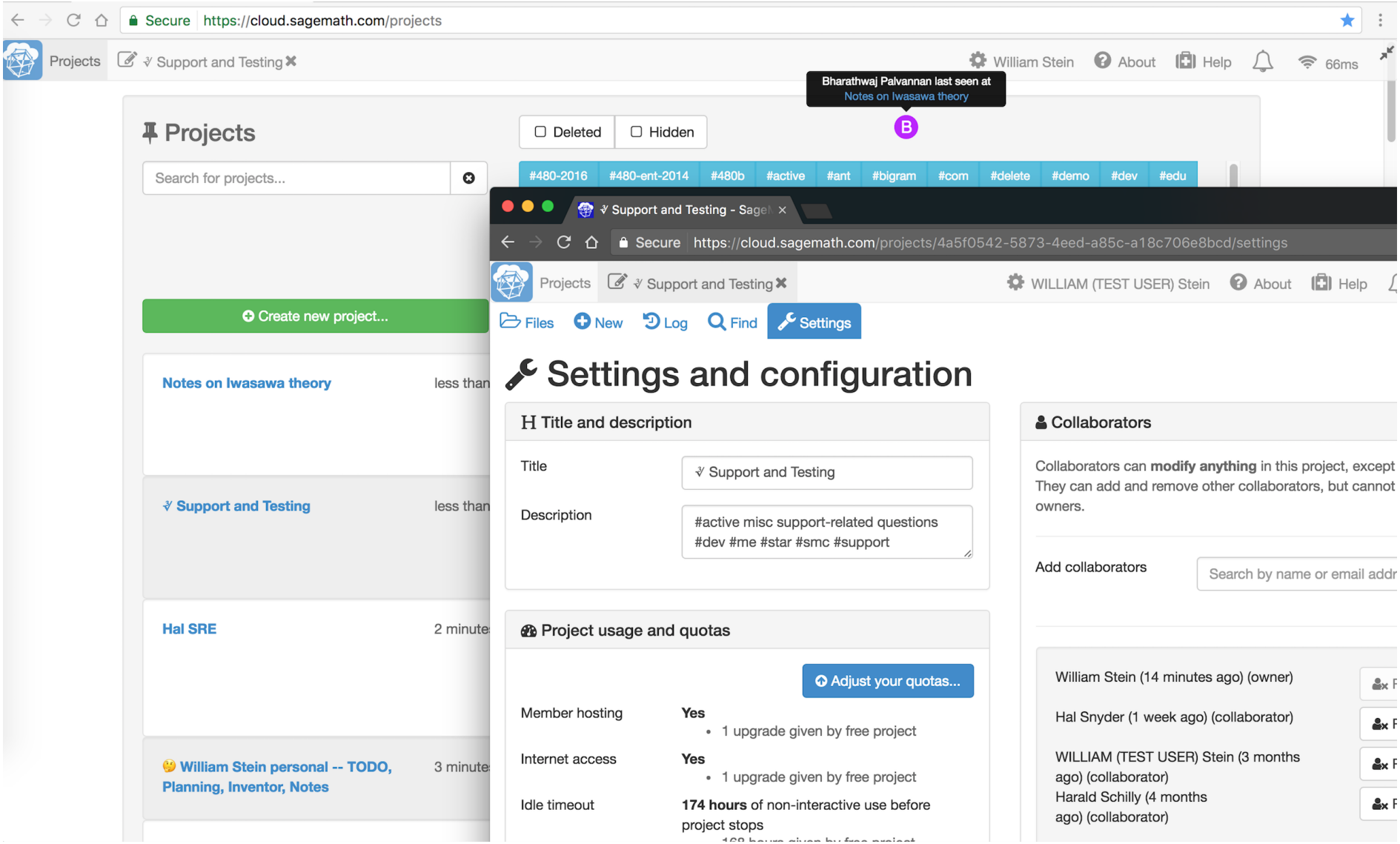
4. Priority: LaTeX editing, course management, quality of service.
5. Our focus is *not* on: companies, supported private installs, data science, being an application platform, etc...

Demo Time

Tour

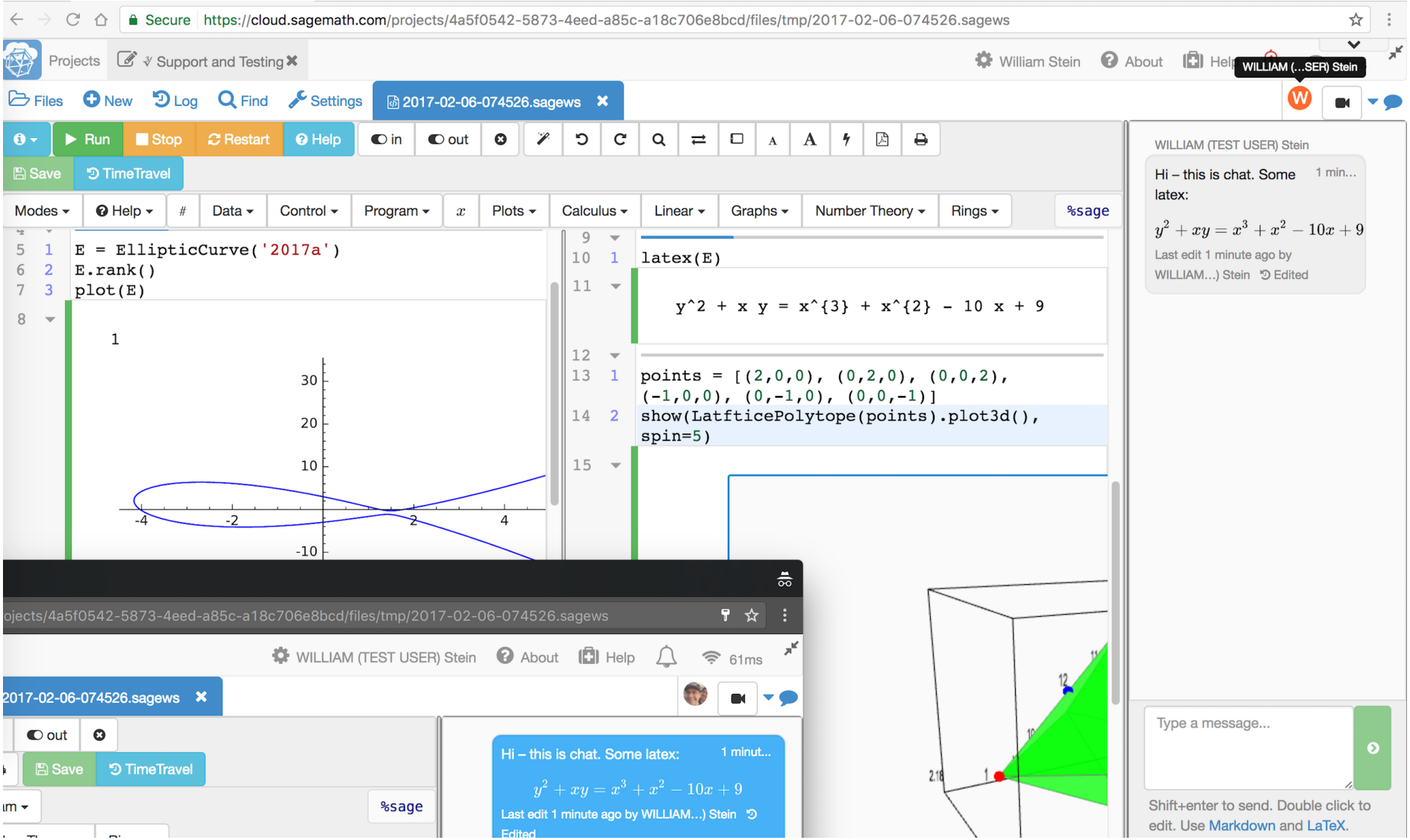
Demo: Setup

1. Be signed in under two accounts in two browsers
2. Create project
3. Add/remove other user as collaborator


Secure https://cloud.sagemath.com/projects
Projects
Support and Testing
William Stein
About
Help
66ms
Bharathwaj Palvannan last seen at
Notes on Iwasawa theory
Projects
Deleted
Hidden
Search for projects...
#480-2016
#480-ent-2014
#480b
#active
#ant
#bigram
#com
#delete
#demo
#dev
#edu
Create new project...
Notes on Iwasawa theory
less than
Support and Testing
less than
Hal SRE
2 minute
William Stein personal -- TODO, Planning, Inventor, Notes
3 minute
Support and Testing - Sage
Secure https://cloud.sagemath.com/projects/4a5f0542-5873-4eed-a85c-a18c706e8bcd/settings
Projects
Support and Testing
WILLIAM (TEST USER) Stein
About
Help
Files
New
Log
Find
Settings
Settings and configuration
Title and description
Title
Support and Testing
Description
#active misc support-related questions
#dev #me #star #smc #support
Project usage and quotas
Adjust your quotas...
Member hosting
Yes
1 upgrade given by free project
Internet access
Yes
1 upgrade given by free project
Idle timeout
174 hours of non-interactive use before project stops
Collaborators
Collaborators can modify anything in this project, except
They can add and remove other collaborators, but cannot
owners.
Add collaborators
Search by name or email addr
William Stein (14 minutes ago) (owner)
Hal Snyder (1 week ago) (collaborator)
WILLIAM (TEST USER) Stein (3 months ago) (collaborator)
Harald Schilly (4 months ago) (collaborator)

Demo: Sage Worksheet

1. Evaluate some examples, including graphics
2. TimeTravel history, changes diff.
3. Cut/paste to another worksheet (including graphics)
4. Split screen
5. Print
6. Explain line numbers on the left
7. Code folding
8. Modes: time, md, html, latex (include sagetex), r, octave, cython
9. Show `jupyter('...')`
10. Show how to make your own new % mode.
11. Side chat
12. Multiple cursors
13. Editor settings: color themes, font size, keybindings


Secure https://cloud.sagemath.com/projects/4a5f0542-5873-4eed-a85c-a18c706e8bcd/files/tmp/2017-02-06-074526.sagews
Projects
Support and Testing
William Stein
About
WILLIAM (...SER) Stein
Files
New
Log
Find
Settings
2017-02-06-074526.sagews
Run
Stop
Restart
Help
in
out
Save
TimeTravel
Modes
Help
Data
Control
Program
Plots
Calculus
Linear
Graphs
Number Theory
Rings
%sage
E = EllipticCurve('2017a')
E.rank()
plot(E)
latex(E)
y^2 + x y = x^{3} + x^{2} - 10 x + 9
points = [(2,0,0), (0,2,0), (0,0,2),
(-1,0,0), (0,-1,0), (0,0,-1)]
show(LatfticePolytope(points).plot3d(),
spin=5)
WILLIAM (TEST USER) Stein
Hi – this is chat. Some latex:
1 min...
$y^2 + xy = x^3 + x^2 - 10x + 9$
Last edit 1 minute ago by WILLIAM...) Stein
Edited
Type a message...
Shift+enter to send. Double click to edit. Use Markdown and LaTeX.
61ms

Demo: LaTeX Document

1. Make a folder, then latex file in folder
2. Change title and author
3. Put in some random paragraphs and illustrate forward/inverse search.
4. SageTex
5. Illustrate error handling (on right; on left with error hover)
6. Split display
7. All panels are resizable (chat, etc.)
8. Customize: build command, preview resolution

Projects | Support and Testing | SMC Omnibase -... | William Stein | About | Help | 59ms

Files | New | Log | Find | Settings | 2017-02-06-075641.tex

Save | TimeTravel | Forward | Inverse

```
10  \maketitle
11
12  \section{What Now?}
13  This year's elliptic curve:
14
15  \sageplot[width=.6\textwidth]
    {EllipticCurve('2017a').plot()}
16
17  Mistake: 2^
18
19  \section{What Next?}
20
```

```
15  \sageplot[width=.6\textwidth]
        '2017a').plot()}
16
17
18
19      ext?}
20
21  Not surprisingly,
22  $$
23   2018 = \sage{factor(2018)}
24  $$
25
26  \end{document}
27
28
29
```

Missing $ inserted.

<inserted text>
$
l.17 Mistake: 2^

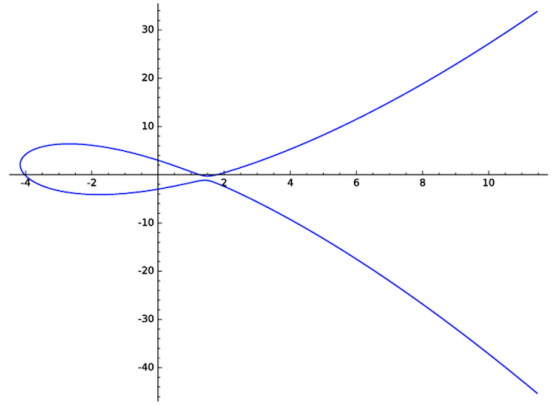
Preview | Issues (4) | PDF | Build | Build preview

William Stein

February 6, 2017

1 What Now?

This year's elliptic curve:

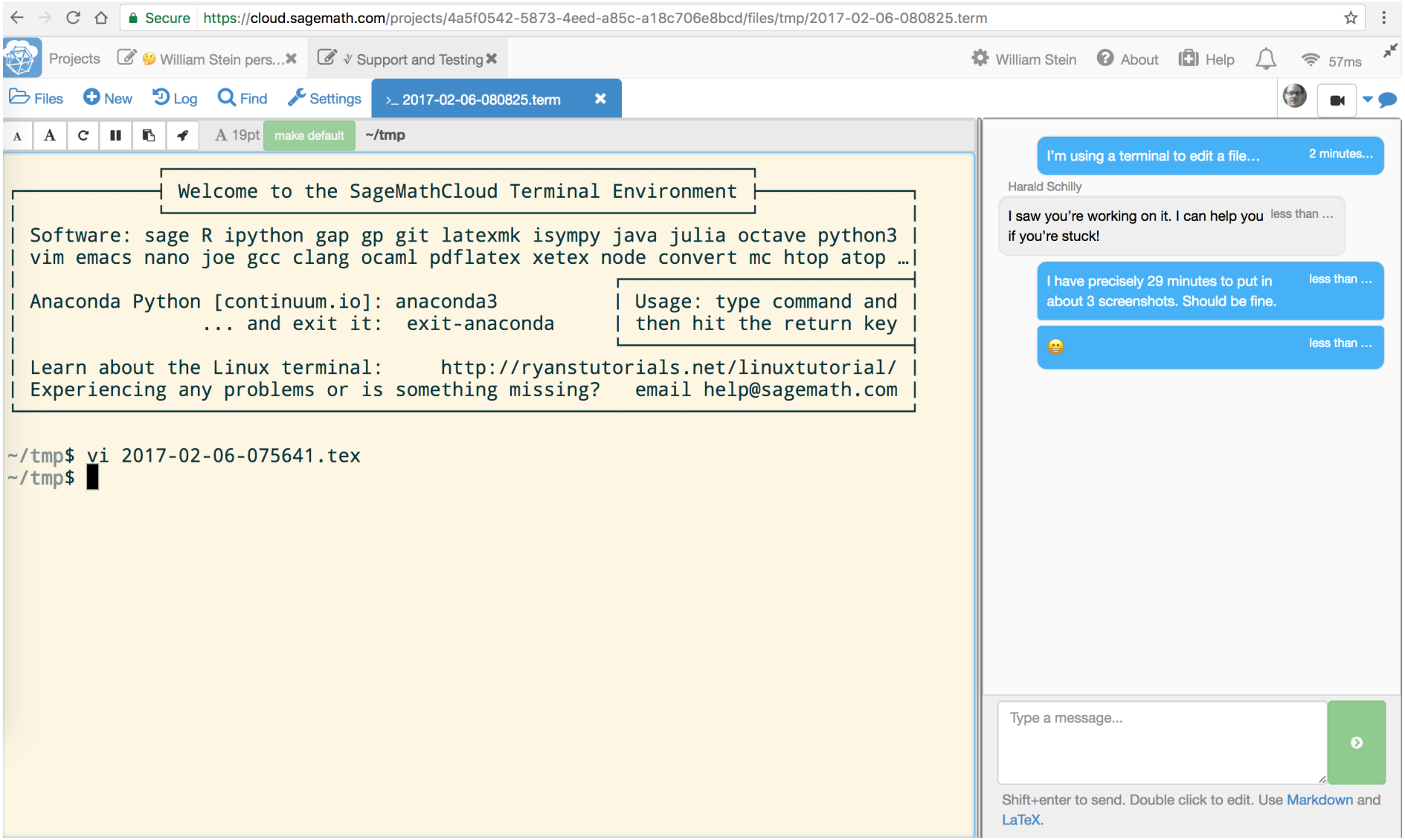


Mistake: 2

2 What Next?

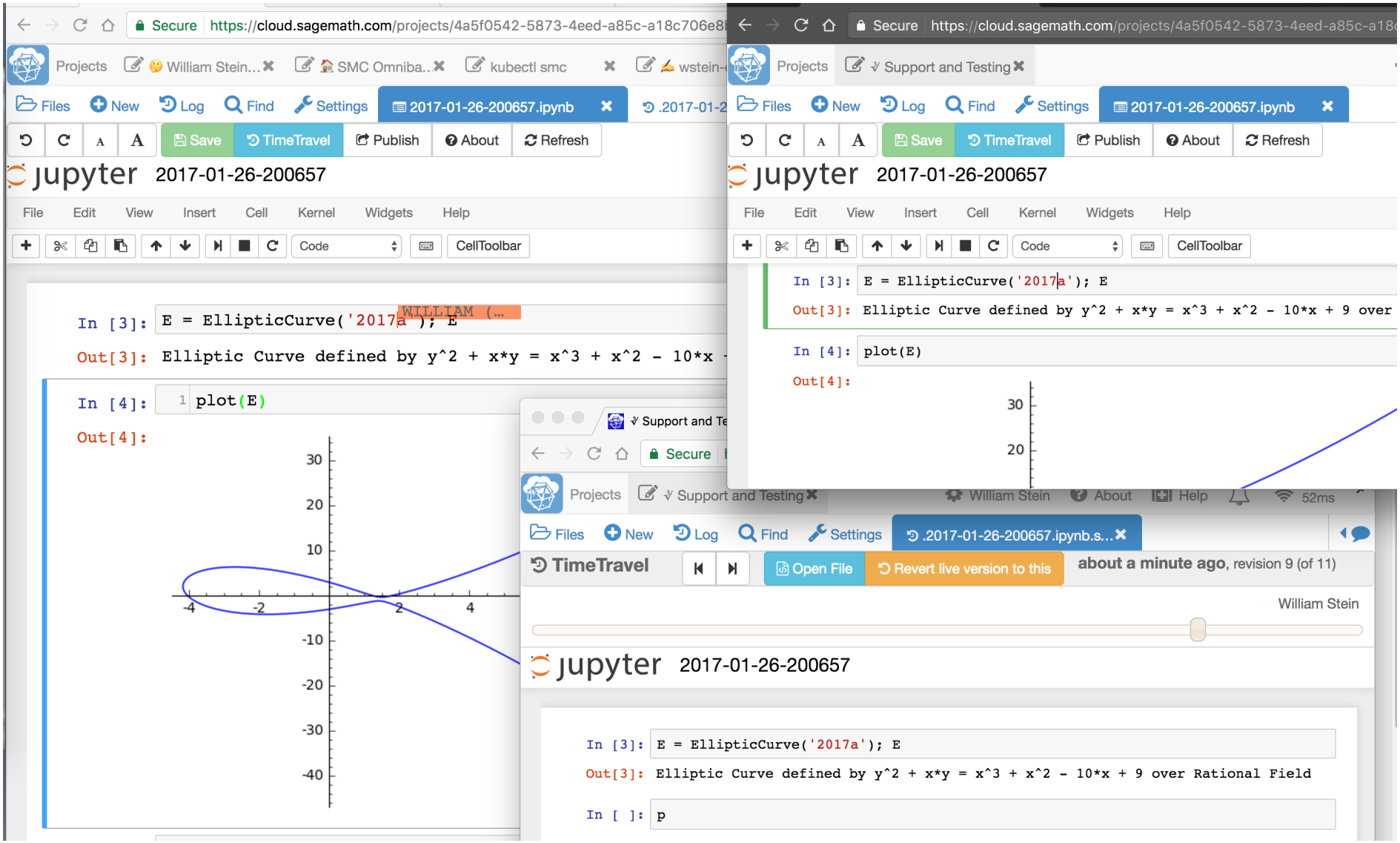
Demo: Terminal

1. Create a terminal: ls, top, etc. – it's Linux.
2. Run vim and emacs on our tex file from above (see saved changes update browser view)
3. Use the terminal from other browser (and see sync)
4. Run sage
5. Side chat
6. Close/open preserves session


Secure https://cloud.sagemath.com/projects/4a5f0542-5873-4eed-a85c-a18c706e8bcd/files/tmp/2017-02-06-080825.term
Projects
William Stein pers...
Support and Testing
William Stein
About
Help
57ms
Files
New
Log
Find
Settings
2017-02-06-080825.term
19pt
make default
~/tmp
Welcome to the SageMathCloud Terminal Environment
Software: sage R ipython gap gp git latexmk isympy java julia octave python3
vim emacs nano joe gcc clang ocaml pdflatex xetex node convert mc htop atop …
Anaconda Python [continuum.io]: anaconda3
... and exit it: exit-anaconda
Usage: type command and
then hit the return key
Learn about the Linux terminal: http://ryanstutorials.net/linuxtutorial/
Experiencing any problems or is something missing? email help@sagemath.com
~/tmp$ vi 2017-02-06-075641.tex
~/tmp$
I'm using a terminal to edit a file...
2 minutes...
Harald Schilly
I saw you're working on it. I can help you if you're stuck!
less than ...
I have precisely 29 minutes to put in about 3 screenshots. Should be fine.
less than ...
less than ...
Type a message...
Shift+enter to send. Double click to edit. Use Markdown and LaTeX.

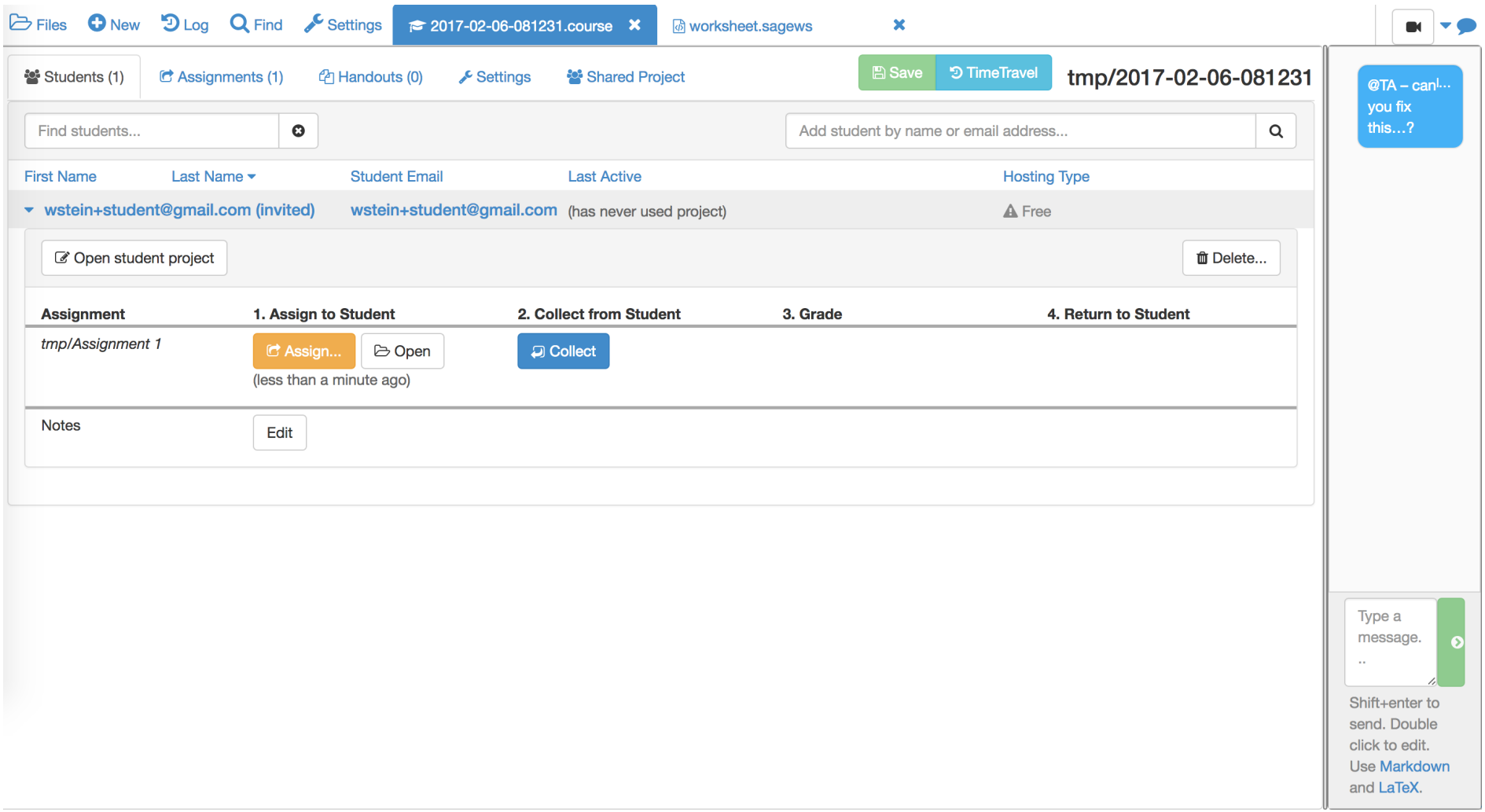
Demo: Jupyter Notebook

1. Create notebook and do a simple computation
2. Switch to Sage kernel and draw a plot
3. Some markdown text
4. Illustrate that sync works, with multiple cursors
5. TimeTravel
6. Other kernels, e.g., R?
7. Mention how we handle issues with large graphics
8. The vanilla Jupyter server:
   `https://cloud.sagemath.com/[project_id]/port/jupyter/`


Secure https://cloud.sagemath.com/projects/4a5f0542-5873-4eed-a85c-a18c706e8
Projects William Stein... SMC Omniba.. kubectl smc wstein-
Files New Log Find Settings 2017-01-26-200657.ipynb .2017-01-2
Save TimeTravel Publish About Refresh
jupyter 2017-01-26-200657
File Edit View Insert Cell Kernel Widgets Help
Code CellToolbar
In [3]: E = EllipticCurve('2017a'); E
WILLIAM (...
Out[3]: Elliptic Curve defined by y^2 + x*y = x^3 + x^2 - 10*x
In [4]: 1 plot(E)
Out[4]:
30
20
10
-10
-20
-30
-40
-4
-2
2
4
Secure https://cloud.sagemath.com/projects/4a5f0542-5873-4eed-a85c-a18
Projects Support and Testing
Files New Log Find Settings 2017-01-26-200657.ipynb
Save TimeTravel Publish About Refresh
jupyter 2017-01-26-200657
File Edit View Insert Cell Kernel Widgets Help
Code CellToolbar
In [3]: E = EllipticCurve('2017a'); E
Out[3]: Elliptic Curve defined by y^2 + x*y = x^3 + x^2 - 10*x + 9 over
In [4]: plot(E)
Out[4]:
30
20
Support and Te
Secure
Projects Support and Testing
William Stein About Help 52ms
Files New Log Find Settings .2017-01-26-200657.ipynb.s...
TimeTravel Open File Revert live version to this about a minute ago, revision 9 (of 11)
William Stein
jupyter 2017-01-26-200657
In [3]: E = EllipticCurve('2017a'); E
Out[3]: Elliptic Curve defined by y^2 + x*y = x^3 + x^2 - 10*x + 9 over Rational Field
In [ ]: p

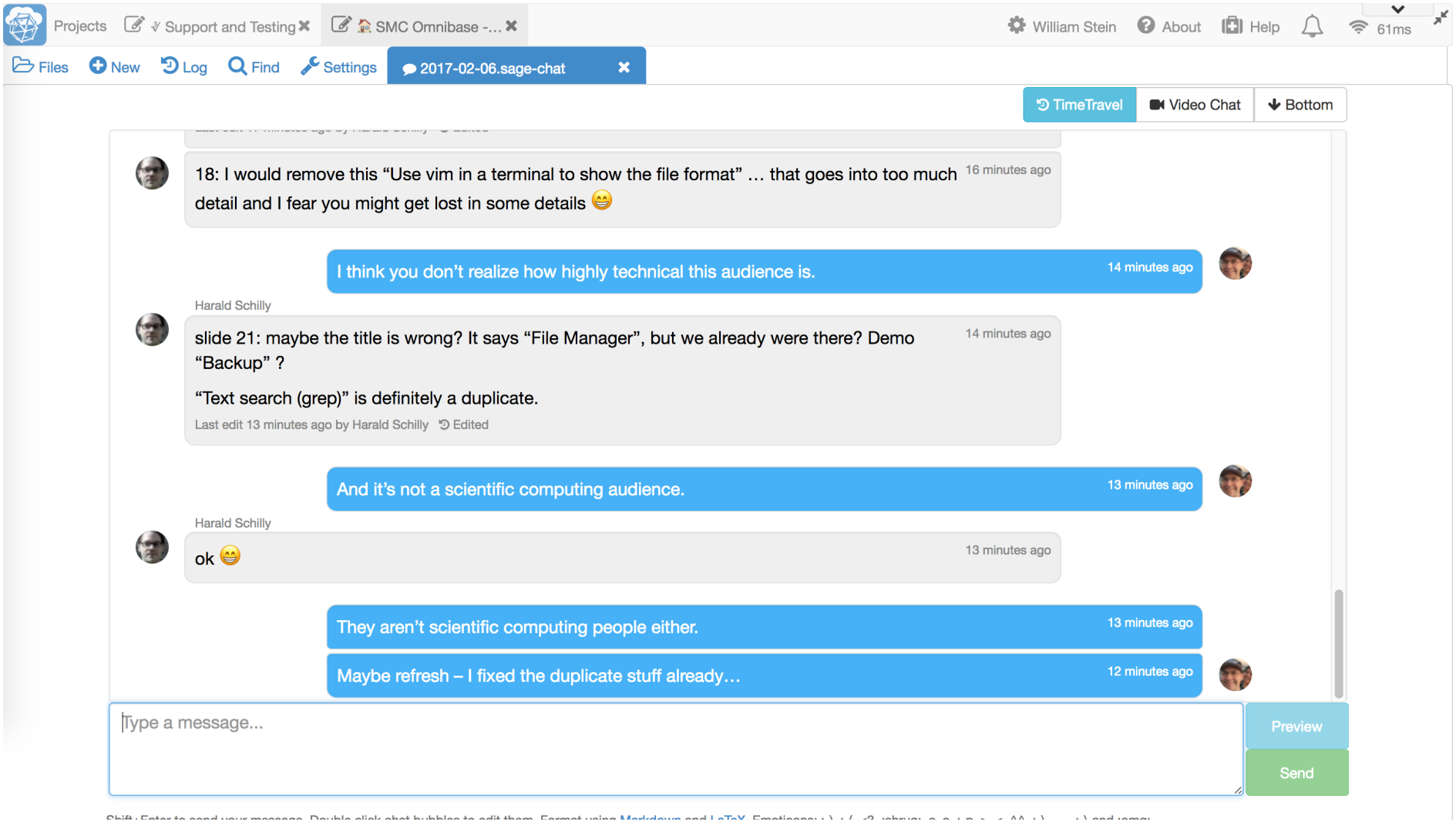
Demo: Course Management

1. Create a new course
2. Add user as a student
3. Create an assignment
4. Push out
5. Edit in the student's project
6. Collect
7. Grade
8. Return


Files
New
Log
Find
Settings
2017-02-06-081231.course
worksheet.sagews
Students (1)
Assignments (1)
Handouts (0)
Settings
Shared Project
Save
TimeTravel
tmp/2017-02-06-081231
@TA – can... you fix this...?
Find students...
Add student by name or email address...
First Name
Last Name
Student Email
Last Active
Hosting Type
wstein+student@gmail.com (invited)
wstein+student@gmail.com
(has never used project)
Free
Open student project
Delete...
Assignment
1. Assign to Student
2. Collect from Student
3. Grade
4. Return to Student
tmp/Assignment 1
Assign...
Open
Collect
(less than a minute ago)
Notes
Edit
Type a message. ..
Shift+enter to send. Double click to edit. Use Markdown and LaTeX.

Demo: Chatrooms

1. Create a chatroom
2. Type a message and see notification
3. Put some math in a message
4. Edit a past message
5. Use vim in a terminal to show the file format.


Projects
Support and Testing
SMC Omnibase -...
William Stein
About
Help
61ms
Files
New
Log
Find
Settings
2017-02-06.sage-chat
TimeTravel
Video Chat
Bottom
18: I would remove this “Use vim in a terminal to show the file format” … that goes into too much detail and I fear you might get lost in some details
16 minutes ago
I think you don’t realize how highly technical this audience is.
14 minutes ago
Harald Schilly
slide 21: maybe the title is wrong? It says “File Manager”, but we already were there? Demo “Backup” ?
“Text search (grep)” is definitely a duplicate.
Last edit 13 minutes ago by Harald Schilly
Edited
14 minutes ago
And it’s not a scientific computing audience.
13 minutes ago
Harald Schilly
ok
13 minutes ago
They aren’t scientific computing people either.
13 minutes ago
Maybe refresh – I fixed the duplicate stuff already…
12 minutes ago
Type a message...
Preview
Send

Demo: Markdown and HTML Editors

1. Create a .md file
2. Type some things see realtime preview
3. Include math and see it in output
4. Bar at the top with snippets
5. Links/images work properly
6. Same for HTML
7. Show tag matching
8. Click on right to get position on left in HTML.

Projects | Support and Testing | William Stein | About | Help | 54ms

Files | New | Log | Find | Settings | 2017-02-06-081846.md

Save | TimeTravel | Preview

```
# This is a Markdown File

## Introduction

- There is a preview to the right

- You can typeset math: $y^2 = x^3 + \alpha x + \beta$


## A folded section↔
## Each section can be folded and expanded

- Another section here

- You can embed images: <img width=300 src='a.png'>

- And you can [link to files](2017-02-06-074526.sagews)
```

This is a Markdown File

Introduction

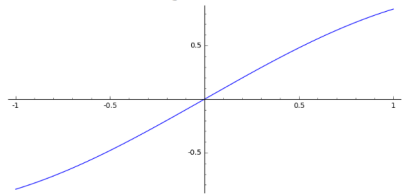
- There is a preview to the right
- You can typeset math: $y^2 = x^3 + \alpha x + \beta$

A folded section

- nothing to see here

Each section can be folded and expanded

- Another section here
- You can embed images:



- And you can link to files

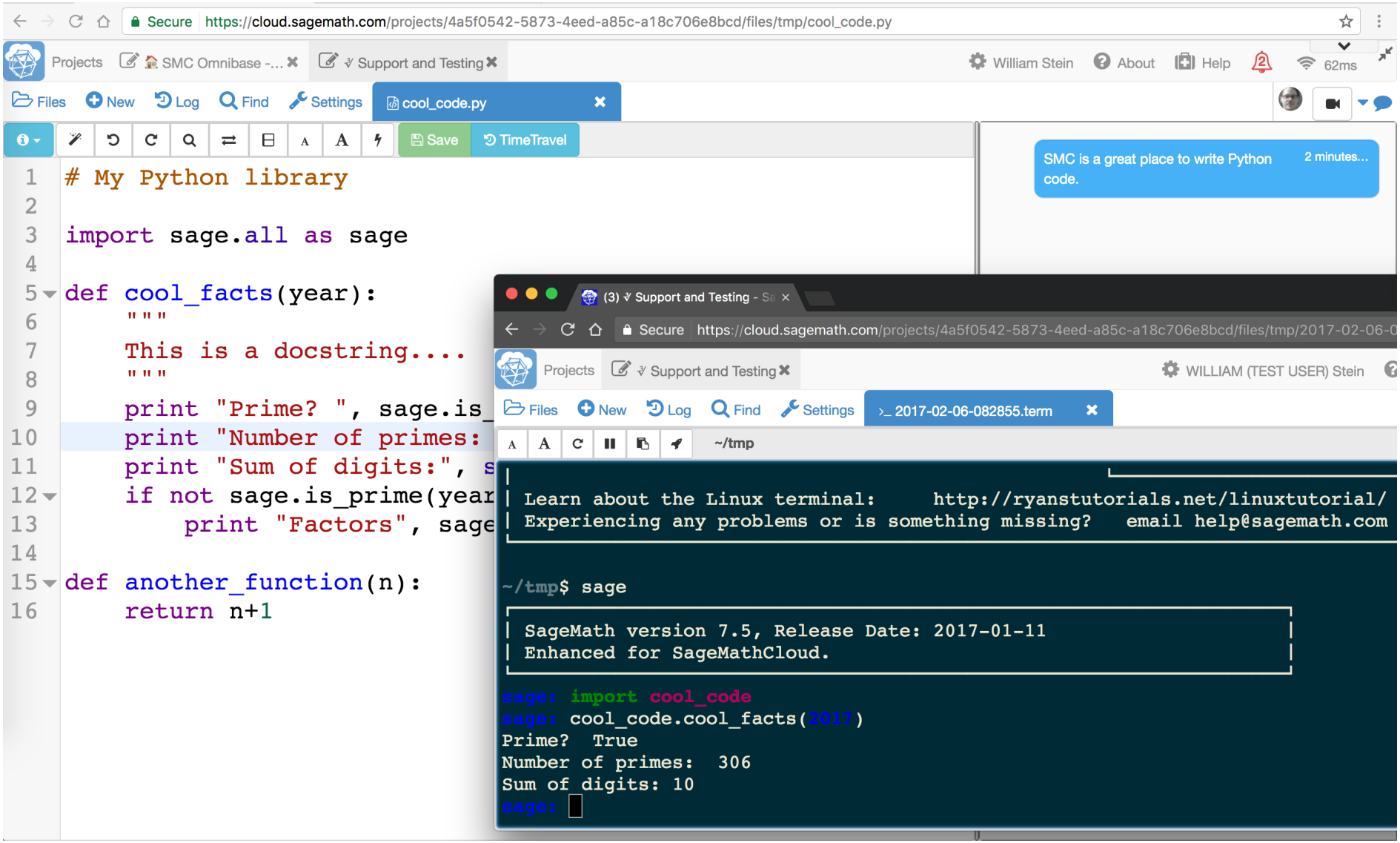
This is a Markdown file chat... less tha...

Type a message...

Shift+enter to send. Double click to edit. Use Markdown and LaTeX.

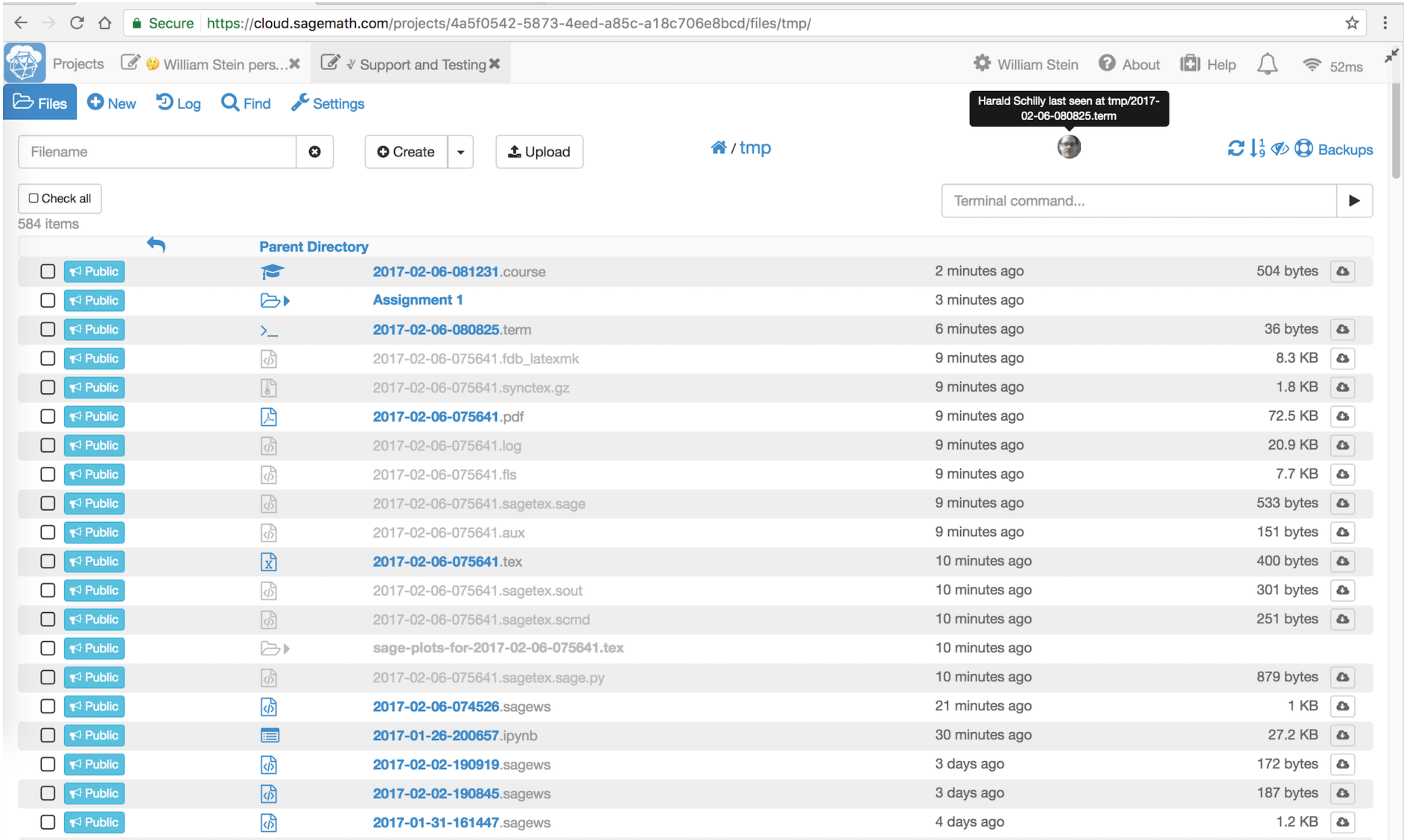
Demo: Coding in Python

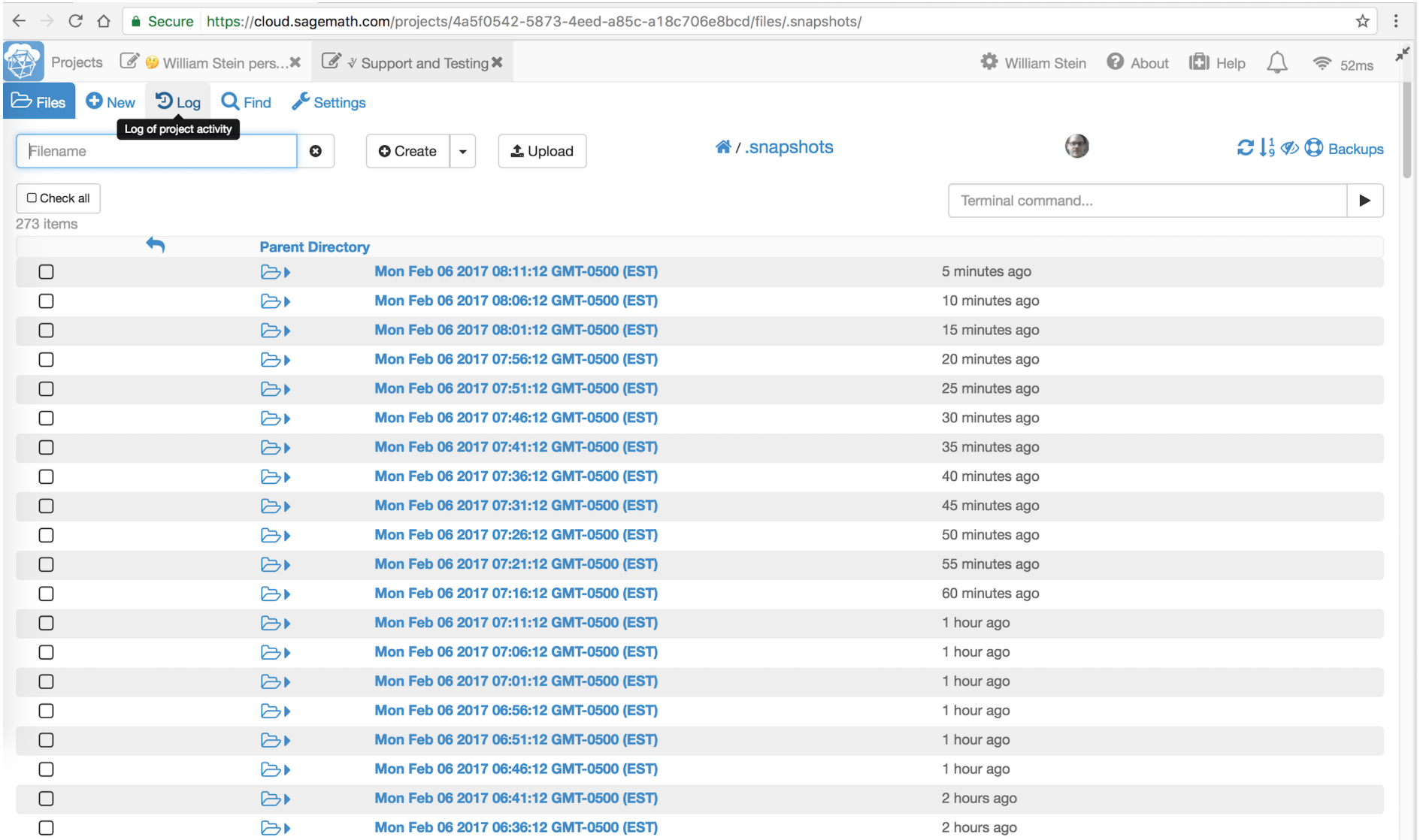
1. Create a .py file
2. Define a function
3. Attach to a Sage worksheet
4. Make changes and evaluate
5. Also import in a terminal
6. And in that Jupyter notebook


Secure https://cloud.sagemath.com/projects/4a5f0542-5873-4eed-a85c-a18c706e8bcd/files/tmp/cool_code.py
Projects
SMC Omnibase -...
Support and Testing
William Stein
About
Help
62ms
Files
New
Log
Find
Settings
cool_code.py
Save
TimeTravel
SMC is a great place to write Python code.
2 minutes...
# My Python library
import sage.all as sage
def cool_facts(year):
"""
This is a docstring....
"""
print "Prime? ", sage.is_
print "Number of primes:
print "Sum of digits:", s
if not sage.is_prime(year
print "Factors", sage
def another_function(n):
return n+1
(3) Support and Testing - Sa
Secure https://cloud.sagemath.com/projects/4a5f0542-5873-4eed-a85c-a18c706e8bcd/files/tmp/2017-02-06-0
Projects
Support and Testing
WILLIAM (TEST USER) Stein
Files
New
Log
Find
Settings
2017-02-06-082855.term
~/tmp
Learn about the Linux terminal: http://ryanstutorials.net/linuxtutorial/
Experiencing any problems or is something missing? email help@sagemath.com
~/tmp$ sage
SageMath version 7.5, Release Date: 2017-01-11
Enhanced for SageMathCloud.
sage: import cool_code
sage: cool_code.cool_facts(2017)
Prime? True
Number of primes: 306
Sum of digits: 10
sage:

Demo: File Manager

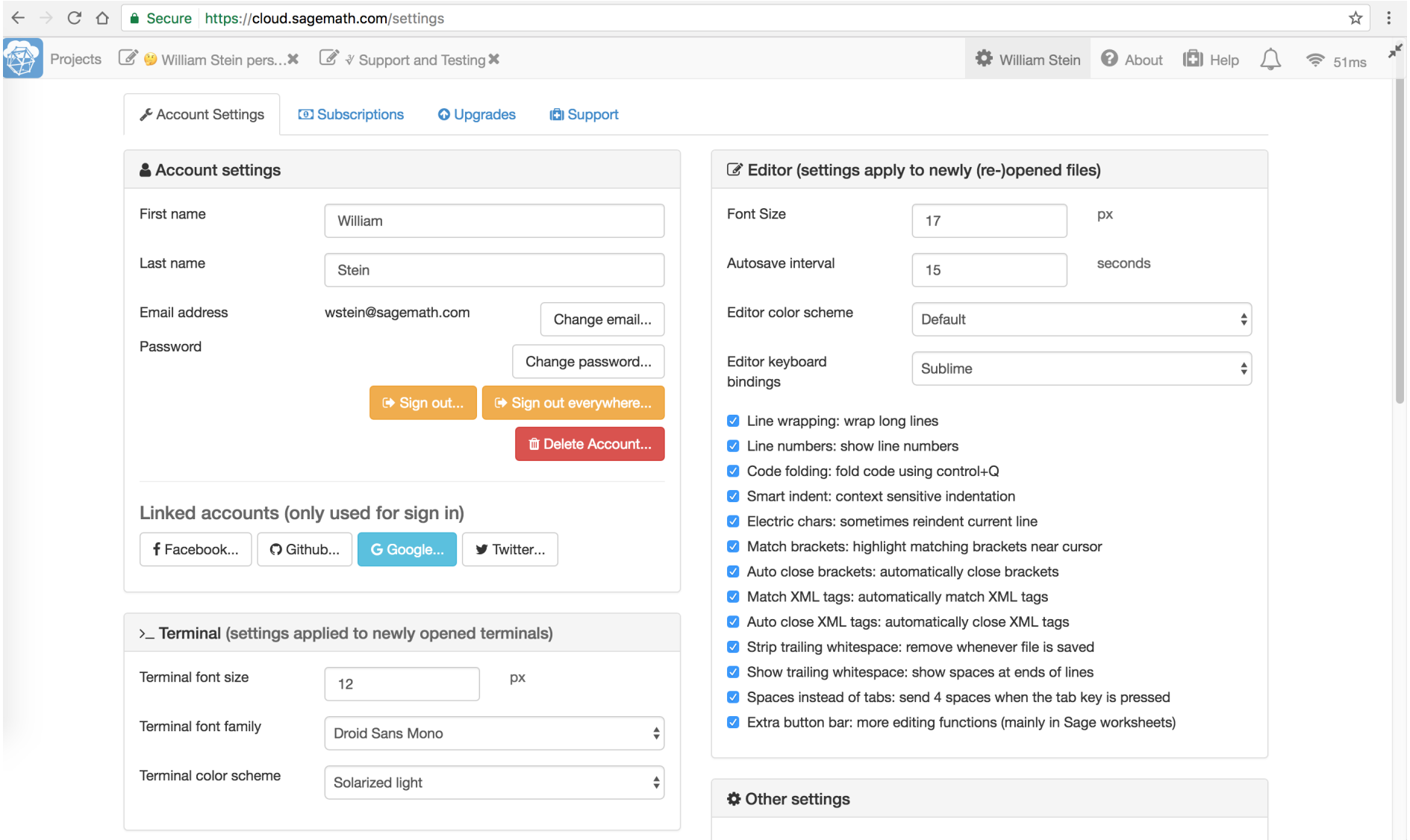
1. Navigating and finding files
2. Creating files
3. Operations with files
4. Snapshots (the "Backups" button)
5. Log of project activities
6. Text search (grep)


Secure https://cloud.sagemath.com/projects/4a5f0542-5873-4eed-a85c-a18c706e8bcd/files/tmp/
Projects
William Stein pers...
Support and Testing
William Stein
About
Help
52ms
Files
New
Log
Find
Settings
Harald Schilly last seen at tmp/2017-02-06-080825.term
Filename
Create
Upload
/ tmp
Backups
Check all
584 items
Terminal command...
Parent Directory
Public 2017-02-06-081231.course 2 minutes ago 504 bytes
Public Assignment 1 3 minutes ago
Public 2017-02-06-080825.term 6 minutes ago 36 bytes
Public 2017-02-06-075641.fdb_latexmk 9 minutes ago 8.3 KB
Public 2017-02-06-075641.synctex.gz 9 minutes ago 1.8 KB
Public 2017-02-06-075641.pdf 9 minutes ago 72.5 KB
Public 2017-02-06-075641.log 9 minutes ago 20.9 KB
Public 2017-02-06-075641.fls 9 minutes ago 7.7 KB
Public 2017-02-06-075641.sagetex.sage 9 minutes ago 533 bytes
Public 2017-02-06-075641.aux 9 minutes ago 151 bytes
Public 2017-02-06-075641.tex 10 minutes ago 400 bytes
Public 2017-02-06-075641.sagetex.sout 10 minutes ago 301 bytes
Public 2017-02-06-075641.sagetex.scmd 10 minutes ago 251 bytes
Public sage-plots-for-2017-02-06-075641.tex 10 minutes ago
Public 2017-02-06-075641.sagetex.sage.py 10 minutes ago 879 bytes
Public 2017-02-06-074526.sagews 21 minutes ago 1 KB
Public 2017-01-26-200657.ipynb 30 minutes ago 27.2 KB
Public 2017-02-02-190919.sagews 3 days ago 172 bytes
Public 2017-02-02-190845.sagews 3 days ago 187 bytes
Public 2017-01-31-161447.sagews 4 days ago 1.2 KB


Secure https://cloud.sagemath.com/projects/4a5f0542-5873-4eed-a85c-a18c706e8bcd/files/.snapshots/
Projects
William Stein pers...
Support and Testing
William Stein
About
Help
52ms
Files
New
Log
Find
Settings
Log of project activity
Filename
Create
Upload
/ .snapshots
Backups
Check all
Terminal command...
273 items
Parent Directory
Mon Feb 06 2017 08:11:12 GMT-0500 (EST) 5 minutes ago
Mon Feb 06 2017 08:06:12 GMT-0500 (EST) 10 minutes ago
Mon Feb 06 2017 08:01:12 GMT-0500 (EST) 15 minutes ago
Mon Feb 06 2017 07:56:12 GMT-0500 (EST) 20 minutes ago
Mon Feb 06 2017 07:51:12 GMT-0500 (EST) 25 minutes ago
Mon Feb 06 2017 07:46:12 GMT-0500 (EST) 30 minutes ago
Mon Feb 06 2017 07:41:12 GMT-0500 (EST) 35 minutes ago
Mon Feb 06 2017 07:36:12 GMT-0500 (EST) 40 minutes ago
Mon Feb 06 2017 07:31:12 GMT-0500 (EST) 45 minutes ago
Mon Feb 06 2017 07:26:12 GMT-0500 (EST) 50 minutes ago
Mon Feb 06 2017 07:21:12 GMT-0500 (EST) 55 minutes ago
Mon Feb 06 2017 07:16:12 GMT-0500 (EST) 60 minutes ago
Mon Feb 06 2017 07:11:12 GMT-0500 (EST) 1 hour ago
Mon Feb 06 2017 07:06:12 GMT-0500 (EST) 1 hour ago
Mon Feb 06 2017 07:01:12 GMT-0500 (EST) 1 hour ago
Mon Feb 06 2017 06:56:12 GMT-0500 (EST) 1 hour ago
Mon Feb 06 2017 06:51:12 GMT-0500 (EST) 1 hour ago
Mon Feb 06 2017 06:46:12 GMT-0500 (EST) 1 hour ago
Mon Feb 06 2017 06:41:12 GMT-0500 (EST) 2 hours ago
Mon Feb 06 2017 06:36:12 GMT-0500 (EST) 2 hours ago

Demo: Settings

1. Project settings: ssh to project
2. Account settings: name, editor preferences (color schemes, keybindings, font size), terminal preferences (color, font)


Secure https://cloud.sagemath.com/settings
Projects
William Stein pers...
Support and Testing
William Stein
About
Help
51ms
Account Settings
Subscriptions
Upgrades
Support
Account settings
First name
William
Last name
Stein
Email address
wstein@sagemath.com
Change email...
Password
Change password...
Sign out...
Sign out everywhere...
Delete Account...
Linked accounts (only used for sign in)
Facebook...
Github...
Google...
Twitter...
Terminal (settings applied to newly opened terminals)
Terminal font size
12
px
Terminal font family
Droid Sans Mono
Terminal color scheme
Solarized light
Editor (settings apply to newly (re-)opened files)
Font Size
17
px
Autosave interval
15
seconds
Editor color scheme
Default
Editor keyboard bindings
Sublime
Line wrapping: wrap long lines
Line numbers: show line numbers
Code folding: fold code using control+Q
Smart indent: context sensitive indentation
Electric chars: sometimes reindent current line
Match brackets: highlight matching brackets near cursor
Auto close brackets: automatically close brackets
Match XML tags: automatically match XML tags
Auto close XML tags: automatically close XML tags
Strip trailing whitespace: remove whenever file is saved
Show trailing whitespace: show spaces at ends of lines
Spaces instead of tabs: send 4 spaces when the tab key is pressed
Extra button bar: more editing functions (mainly in Sage worksheets)
Other settings