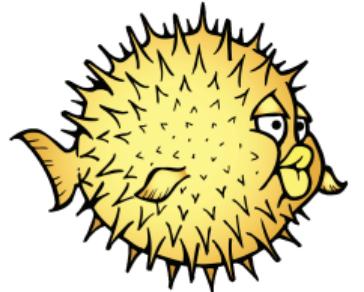


2019-05-16





***Open*BSD**

Building an accessible OpenBSD laptop

Stefan Sperling <stsp@openbsd.org>

Maurice Jones <mauricejones0044@gmail.com>

BSDcan 2019



- 1. My friend Maurice uses a Windows PC
- 2. Maurice dreams of having a “Macintosh” laptop
- 3. But Maurice cannot afford a Mac...
- 4. And I don't want to invest my time into Windows and Mac...
- 5. Can we build an OpenBSD laptop Maurice will want to use?
- 6. Is this feasible? What needs to be done to achieve this?
- 7. What will we learn about OpenBSD by doing this?

Motivation



1. Let's get to know Maurice a bit...

└ Maurice is an actor

Maurice is an actor



Maurice is an actor



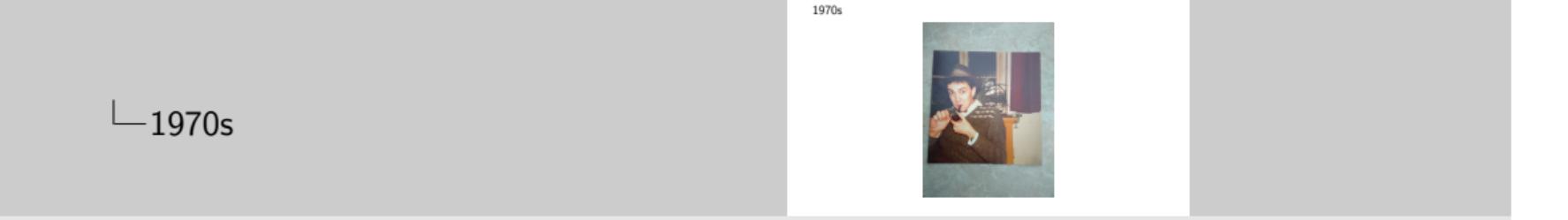
└ Maurice is a painter



1. Painting Maurice made for me as a birthday gift

Maurice is a painter

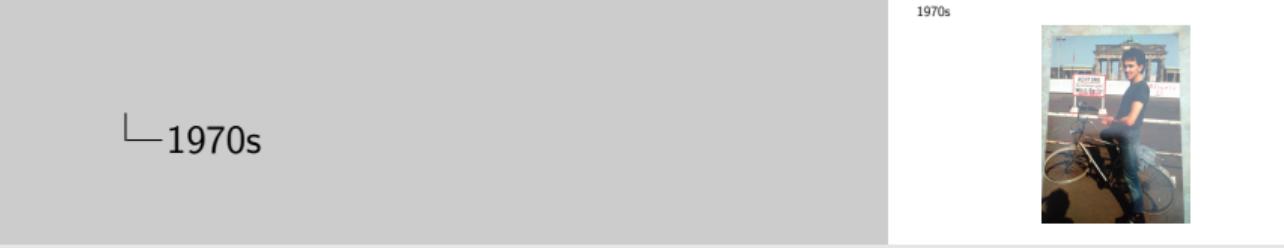




1. European studies + Economics + German in Brighton

1970s





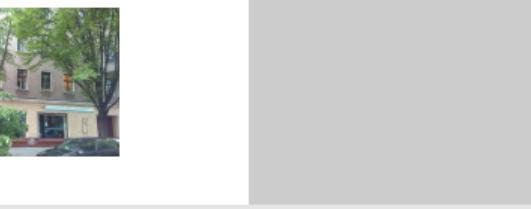
- 1. Spent one year abroad at Free University Berlin
- 2. Moved to Berlin in 1982 after graduation in Brighton



1970s



└ Maurice's first home in Berlin Kreuzberg (as it appears today)

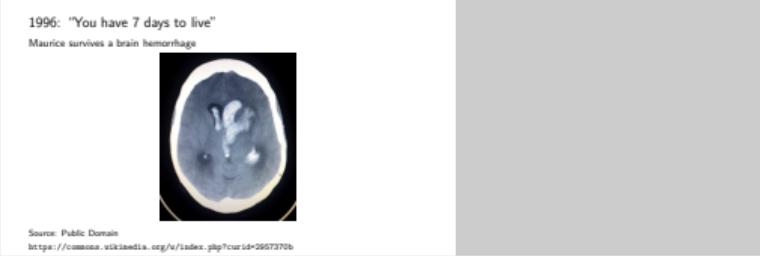


1. Maurice's first flat was in this building
2. Around the corner from where I live today

Maurice's first home in Berlin Kreuzberg (as it appears today)

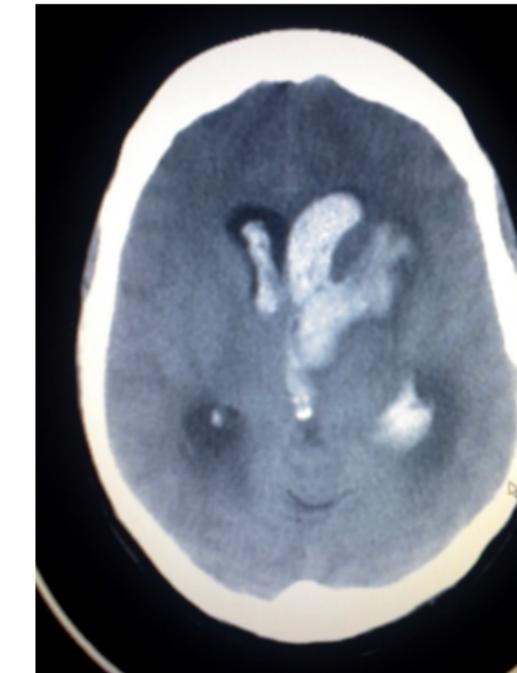


└ 1996: "You have 7 days to live"



1. Two days of brain surgery
2. In coma for a week
3. Hospital bug infection, diarrhea for a month
4. Remains in intensive care at hospital for one year

1996: "You have 7 days to live"
Maurice survives a brain hemorrhage



Source: Public Domain
<https://commons.wikimedia.org/w/index.php?curid=2957370b>

Consequences



1. had to relearn how to walk, speak, read, and write
2. stiff left leg
3. unable to control left arm; stiff and cramped left hand
4. bad short-term memory; limited attention span
5. speech and writing slowed down

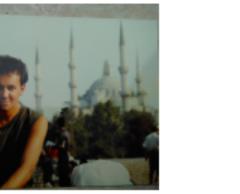
Consequences



Source: Public Domain

<https://commons.wikimedia.org/w/index.php?curid=1208074>

└ What does Maurice need computers for?



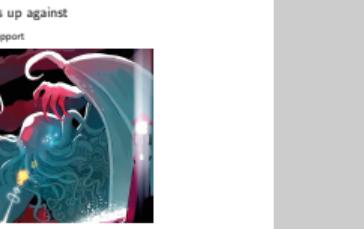
1. send and receive email (gmail)
2. follow friends and acquaintances on social media (facebook)
3. talk to friends over video chat (skype)
4. listen to the radio (BBC)
5. read the news (various)
6. wants to write a book

What does Maurice need computers for?



└ Requirements OpenBSD is up against

1. reliably start up, halt, suspend, resume
2. working I/O devices
3. keyboard, mouse
4. display
5. speakers, microphone
6. camera
7. reliable network connection (wifi)
8. good battery life



Requirements OpenBSD is up against

- Virtually perfect hardware support



└ Requirements OpenBSD is up against

1. desktop environment
2. web browser for gmail, facebook, web radio, news sites
3. solution for video chat (skype won't run)
4. The ideal computer for Maurice is an **appliance**.



Requirements OpenBSD is up against

- Suitable and stable applications



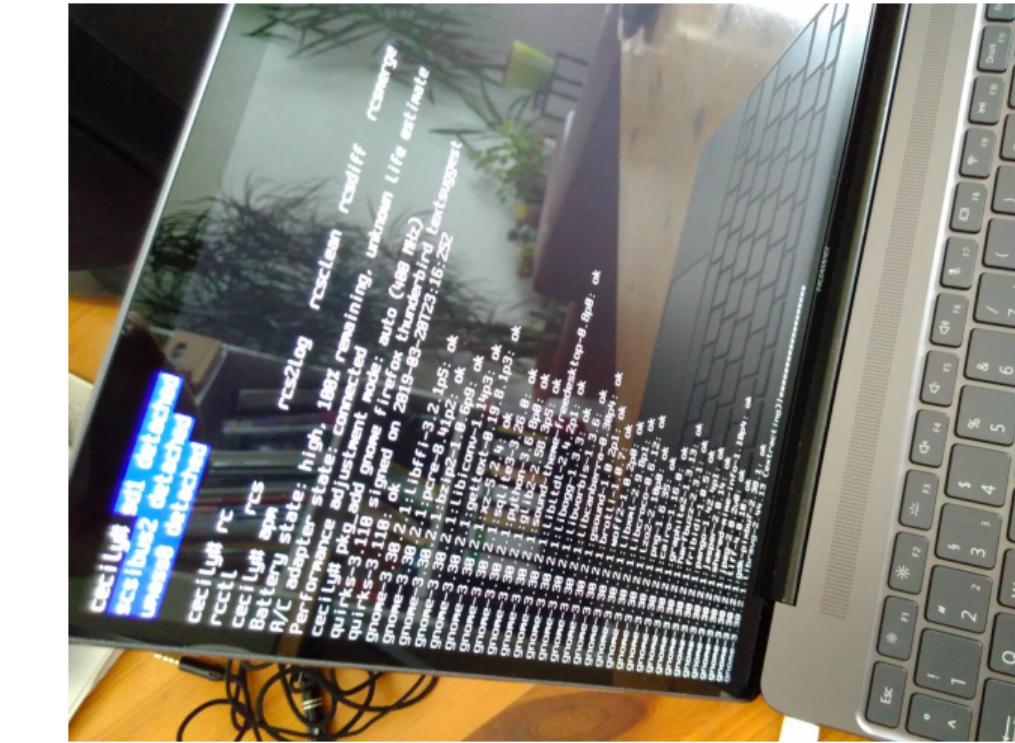
those to try the Matebook X.



Hardware: We chose to try the Matebook X

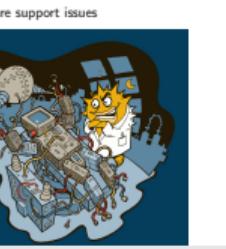
1. laptop lid can be opened with one hand
 2. Mac-like appearance
 3. standard PC components
 4. relatively good hardware support in OpenBSD 6.4

Hardware: We chose to try the Matebook X



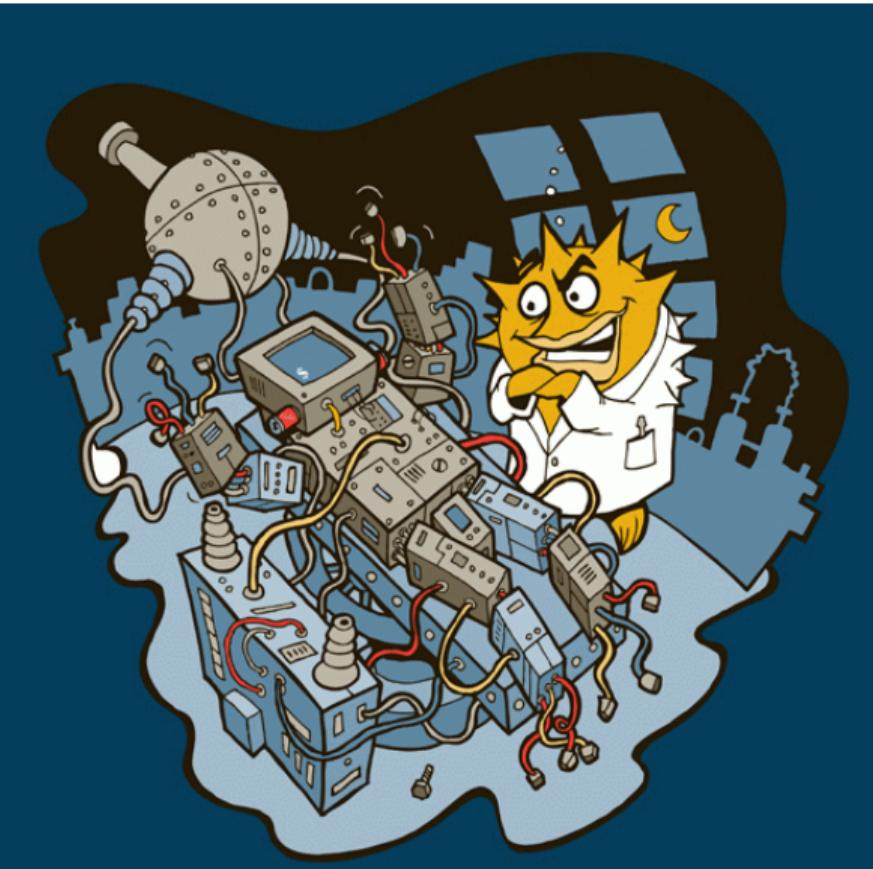
<https://jcs.org/2017/07/14/matebool>

└ OpenBSD 6.4 hardware support issues



1. webcam not working (isochronous USB transfers not implemented)
2. sound from one speaker only
3. microphone not working out of the box
4. no support for bluetooth speakers

OpenBSD 6.4 hardware support issues



└ OpenBSD 6.4 software issues

1. OpenBSD base install
2. pkg_add gnome firefox
3. user account for Maurice added after installation



OpenBSD 6.4 software issues

- First out of the box experience was disappointing
- Gnome desktop came up as **dark blank screen**



Getting Gnome to run

1. Default resource limits prevent gnome-shell's JS engine from starting
2. Need login class with at least 1GB datasize
3. User account created during install not affected (in 'staff' class)
4. Antoine Jacoutot amended pkg-readmes/gnome accordingly

```
Getting Gnome to run

Create a login class with sufficiently high data-size limit in /etc/login.conf:
gnome:\n    :datasize-cur=1024M:\n    :tc=default:
Add the user account to this login class:
usermod -L gnome maurice
```

Getting Gnome to run

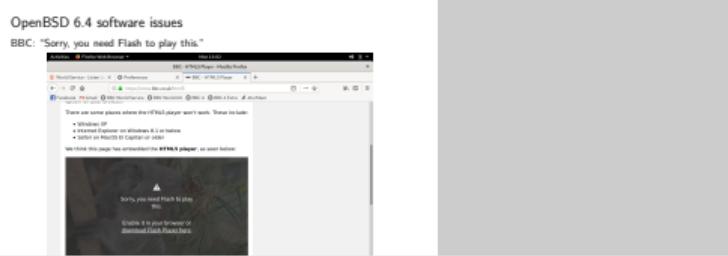
Create a login class with sufficiently high data-size limit in /etc/login.conf:

```
gnome:\n    :datasize-cur=1024M:\n    :tc=default:
```

Add the user account to this login class:

```
usermod -L gnome maurice
```

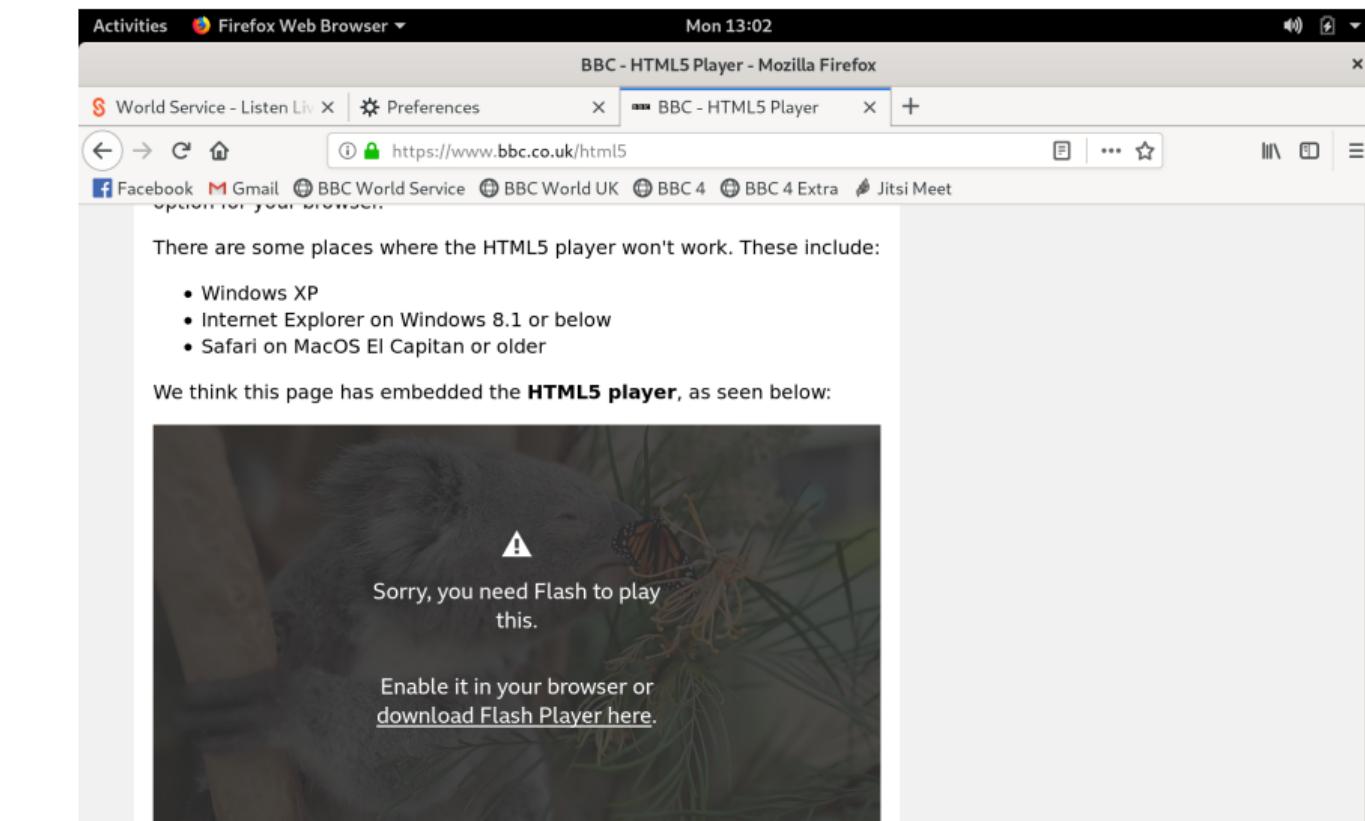
└ OpenBSD 6.4 software issues



1. BBC website broken in firefox out of the box
2. So we fell back to bootleg MP3 BBC streams for a while
3. Silly problem; took me days to figure out...
4. Missing ffmpeg package! must follow pkg-readmes/firefox, duh

OpenBSD 6.4 software issues

BBC: "Sorry, you need Flash to play this."



└ Matebook X hardware issues

1. hardware clock resets to Jan 2016
2. flickering screen; laptop replaced

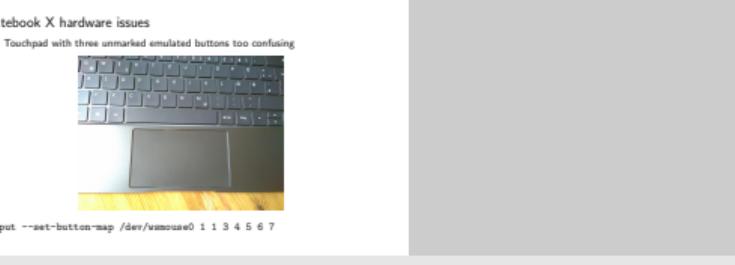
- Hardware clock resets to January 1 2016 if battery is discharged.
 - Maurice is forgetful; laptop often discharged
 - Symptom: Firefox complains loudly about SSL certificates
 - Must use 'ntpd -s' and disable NTP constraints...
- HW defect: flickering screen backlight (laptop replaced under warranty)

Matebook X hardware issues

- Hardware clock resets to January 1 2016 if battery is discharged.
 - Maurice is forgetful; laptop often discharged
 - Symptom: Firefox complains loudly about SSL certificates
 - Must use 'ntpd -s' and disable NTP constraints...
- HW defect: flickering screen backlight (laptop replaced under warranty)

└ Matebook X hardware issues

1. The Matebook X has no markings for button areas
2. For Maurice, middle-click paste happens accidentally; never intentionally
3. Ulf Brosziewski suggests disabling mouse button 2 with xinput
4. Joshua Stein suggests putting sickey-tape below touchpad to make it more firm



Matebook X hardware issues

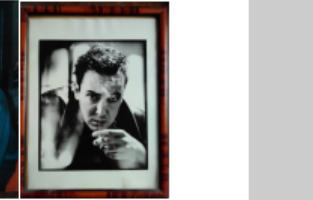
- Touchpad with three unmarked emulated buttons too confusing



xinput --set-button-map /dev/wsmouse0 1 1 3 4 5 6 7

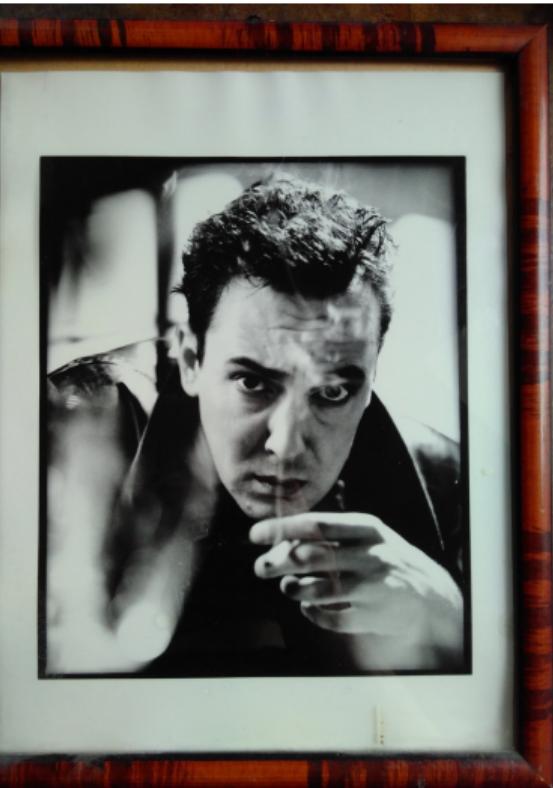
└ 1980s

1980s



1. Parties and clubbing in West Berlin throughout the 80s
2. Hangs out with Blixa Bargeld and Nick Cave at 3am

1980s



└ 1980s

1980s



1. Became an actor with the Berlin Play Actors
2. Acted, directed, and produced theatre plays

1980s



—1980s

1. Lots of touring, including US
2. Parties, parties, parties...



1980s



Per la prima volta in Italia al Nuovo
tre sere con il Berlin Play Actors

Da tutto il mondo per "L'importanza" di Oscar Wilde

Our Play Actors

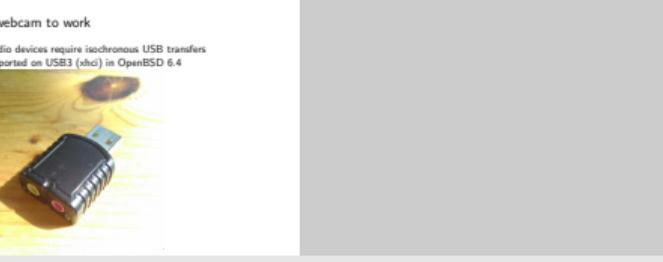
el testo
aurice
o filolo-
olo nel
orini no-
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amicca-
un musi-
di Ma-
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ese e un po'
parte della se
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ra parte pa
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citato in ingle
sceniche son
re anche qui
pur non conos
potrà comun
tonia con le
sceniche. Q
ra certezza, pa
anza, e pensia
verificare prop
a Napoli.

Getting the laptop's webcam to work

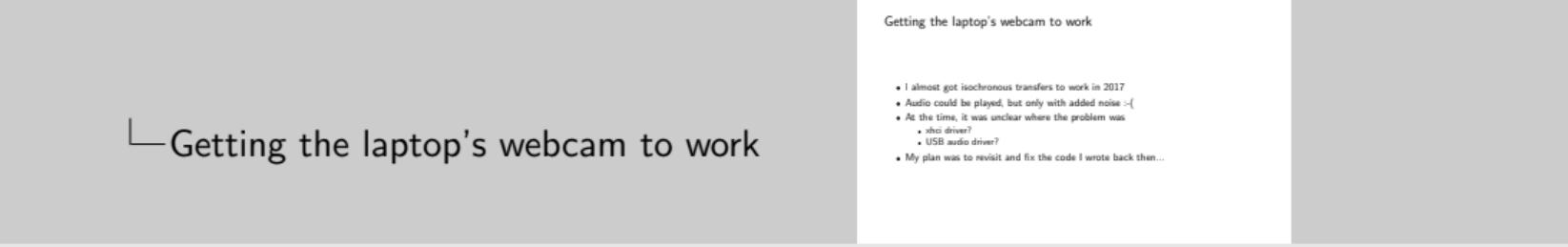
1. Video and audio USB devices require isochronous USB transfers
2. streaming data vs bulk/interrupt data
3. needs special isoch of driver code path
4. isochronous error handling differs
5. not yet supported by our USB 3 host controller driver (xhci)



Getting the laptop's webcam to work

Video and audio devices require isochronous USB transfers
Not supported on USB3 (xhci) in OpenBSD 6.4



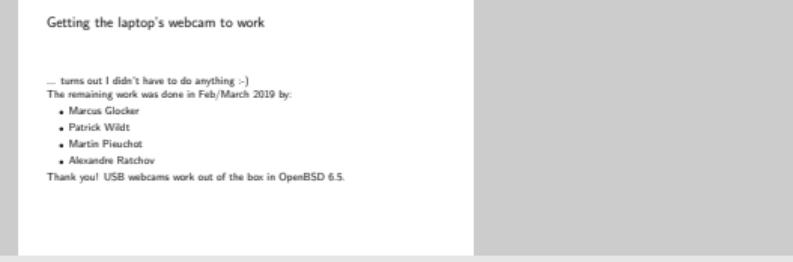


- 1. I added initial isochronous support in 2017
- 2. based on a work-in-progress diff from Martin
- 3. driver could now play audio, but with clicking noises and eventually static noise
- 4. so my new code remained disabled by default
- 5. plan was to revisit and fix this code...

Getting the laptop's webcam to work

- I almost got isochronous transfers to work in 2017
- Audio could be played, but only with added noise :-(
- At the time, it was unclear where the problem was
 - xhci driver?
 - USB audio driver?
- My plan was to revisit and fix the code I wrote back then...

└ Getting the laptop's webcam to work



1. Jan 2019: Marcus Glocker asks questions about isochronous transfers.
2. Feb 2019: Patrick Wildt fixes a curious xhci bug on an i.MX8M machine with help from a USB bus analyzer
3. I ask: “Is this why my code didn’t work?”
4. Patrick replies “Not really, it’s because...” and suggests a new diff
5. I forward Patrick’s diff to Marcus
6. March 2019: Patrick, Marcus, and Martin fix and extend the code
7. Isochronous transfers are enabled by default in -current
8. Alexandre Ratchov was already working on new USB audio driver
9. Alexandre fixes several bugs in new xhci code

Getting the laptop's webcam to work

... turns out I didn't have to do anything :-)

The remaining work was done in Feb/March 2019 by:

- Marcus Glocker
- Patrick Wildt
- Martin Pieuchot
- Alexandre Ratchov

Thank you! USB webcams work out of the box in OpenBSD 6.5.

Getting both laptop speakers to work



1. dolby atmos init sequence reverse-engineered by Joshua Stein
2. sequence contains 620 commands; no clue how to trim it down
3. jcs patch added 13Kb to the kernel so he didn't want to commit it
4. sequence was optimized by Thomas Espeleta for Linux
5. Thomas' loop adapted by me to azalia(4); added 3Kb to kernel
6. Vendors, please publish hardware programming documentation!

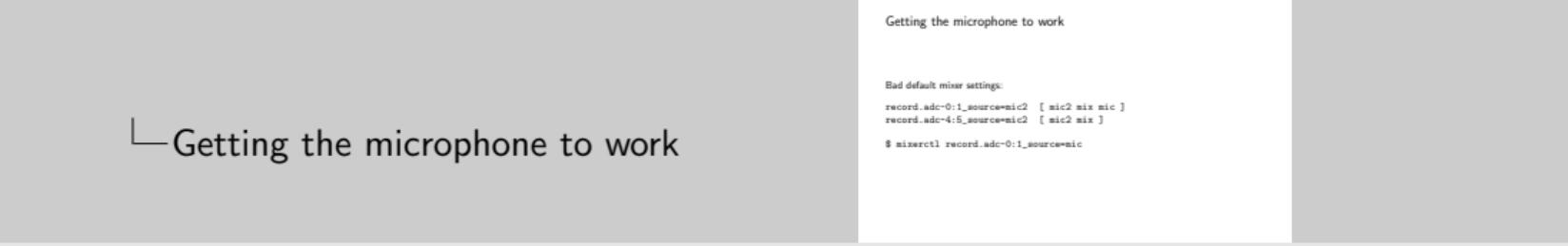
Getting both laptop speakers to work

Matebook X Windows sound driver was reverse-engineered by Joshua Stein

```
156801542066424,769855:vflc_region.read (0000:00:1f.3:region+0x20, 4) = 0x40000000
156801542066424,758277:vflc_region.write (0000:00:1f.3:region+0x20, 0x00000000, 4)
156801542066424,769382:vflc_region.read (0000:00:1f.3:region+0x1030, 0x40570000, 4)
156801542066424,769227:vflc_pci_read_config (0000:00:1f.3, 0x40, len=0x4) 0x693200f7
156801542066424,769227:vflc_pci_write_config (0000:00:1f.3, 0x40, len=0x4) 0x693200f7
156801542066424,769376:vflc_pci_read_config (0000:00:1f.3, 0x40, len=0x4) 0x693200f7
156801542066424,769428:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x0
156801542066424,769471:vflc_region.write (0000:00:1f.3:region+0x80, 0x0, 1)
156801542066424,769471:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x0
156801542066424,769492:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x0
156801542066424,769513:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x0
156801542066424,769513:vflc_region.write (0000:00:1f.3:region+0x80, 1) = 0x1
156801542066424,769540:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x1
156801542066424,769567:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x1
156801542066424,769589:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x1
156801542066424,769606:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x1
156801542066424,769627:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x0
156801542066424,769649:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x0
156801542066424,769676:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x0
156801542066424,769687:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x1
156801542066424,769707:vflc_region.write (0000:00:1f.3:region+0x80, 0x10103002, 4)
156801542066424,769728:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x1
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156801542066424,769765:vflc_region.read (0000:00:1f.3:region+0x80, 1) = 0x1
156801542066424,769823:vflc_region.write (0000:00:1f.3:region+0x84, 0x10103003, 4)
156801542066424,769843:vflc_region.read (0000:00:1f.3:region+0x84, 0x10103003)
156801542066424,769864:vflc_region.read (0000:00:1f.3:region+0x84, 0x10103003)
156801542066424,769885:vflc_region.read (0000:00:1f.3:region+0x84, 0x10103003)
156801542066424,769924:vflc_region.write (0000:00:1f.3:region+0x85, 0x0, 4)
156801542066424,769943:vflc_region.read (0000:00:1f.3:region+0x85, 0x10103003)
156801542066424,769961:vflc_region.write (0000:00:1f.3:region+0x85, 0x0, 4)
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156801542066424,809461:vflc_region.write (0000:00:1f.3:region+0x44, 0x10103002)
156801542066424,809513:vflc_region.read (0000:00:1f.3:region+0x44, 0x10103002)
156801542066424,829530:vflc_region.write (0000:00:1f.3:region+0x80, 0x3, 2)
156801542066424,829548:vflc_region.read (0000:00:1f.3:region+0x80, 0x6, 2)
156801542066424,829577:vflc_region.read (0000:00:1f.3:region+0x44, 0x10103002)
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156801542066424,829620:vflc_region.write (0000:00:1f.3:region+0x44, 0x10103002)
156801542066424,829706:vflc_region.write (0000:00:1f.3:region+0x44, 0x10103002)
156801542066424,829729:vflc_region.read (0000:00:1f.3:region+0x44, 0x10103002)
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156801542066424,829913:vflc_region.write (0000:00:1f.3:region+0x80, 0x1, 4)
156801542066425,829913:vflc_region.write (0000:00:1f.3:region+0x80, 0x1, 4)
```

linux/include/sound/hda_verbs.h

<https://jcs.org/2018/11/12/vfio>



- 1. Bad default mixer settings for mic input on Matebook X
- 2. both recording sources are routed from “mic2” which is silent
- 3. can be fixed by adjusting mixer configuration
- 4. Alexandre Ratchov has plans to fix the default config

Getting the microphone to work

Bad default mixer settings:

```
record.adc-0:1_source=mic2 [ mic2 mix mic ]  
record.adc-4:5_source=mic2 [ mic2 mix ]
```

```
$ mixerctl record.adc-0:1_source=mic
```

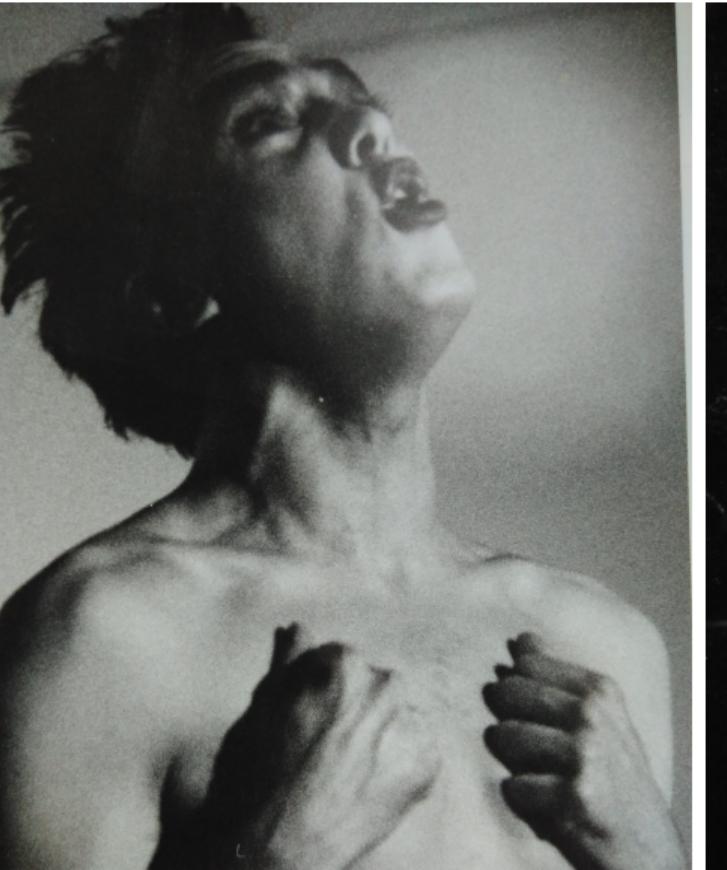
└ Acting in the 90s

Acting in the 90s



1. Maurice directs plays at Academy of Arts in Berlin
2. Sketches on the "Maurice and Boris Show" on pirate radio in Berlin

Acting in the 90s



└ Sobering up in the 90s

1. Stops smoking, sobers up
2. becomes avid aerobics athlete and cyclist
3. has more or less steady relationships

Sobering up in the 90s



Maurice with his parents

Sobering up in the 90s



Maurice with his parents

└ 1996: Maurice survives brain hemorrhage



1. “Simone is a hero and a saint”
2. Maurice started taking painting classes before re-learning to speak
3. Maurice is still in the process of retraining lost skills today

1996: Maurice survives brain hemorrhage

- his girlfriend Simone helped him through the aftermath
- settled in Berlin ever since; not moving back to England



└ Maurice's opinion on passwords

Maurice's opinion on passwords



1. Maurice cannot remember passwords; must be written down
2. Maurice cannot reliably type long words and phrases
3. Laptop requires several passwords:
 4. A) full disk encryption passphrase (softraid boot)
 5. B) root password
 6. C) regular user password
 7. D) password manager master passwords (firefox, gnome-keyring)
 8. Maurice expects visual feedback when keys are pressed

Maurice's opinion on passwords





1. Repeated bad login attempts cause frustration
2. Gnome was crashing at start-up sometimes
3. Minor annoyance for most users
4. But for Maurice, this was a deal-breaker

Problems exacerbated by software bugs

Gnome: "Sorry, I've crashed at startup! :-P Try again, Maurice!"

Maurice: "Sorry, having to log in over and over again is a **deal-breaker**"



- 1. Restarting Gnome repeatedly resulted in core dumps
- 2. Core dump exposed use-after-free bug in glib; detected by OpenBSD's malloc()
- 3. GIO async flush implementation ignored an internal API contract
- 4. Item on flush list was freed while thread was waiting to use it

Making Gnome start up reliably

```
$ du -h gnome*.core  
2.2M  gnome-session-bi.core  
389M  gnome-shell.core
```

- API contract violation: “g_cond_wait() must always be used in a loop”
- Now fixed: https://gitlab.gnome.org/GNOME/glib/merge_requests/741/

```
We should really be taking core dumps more seriously

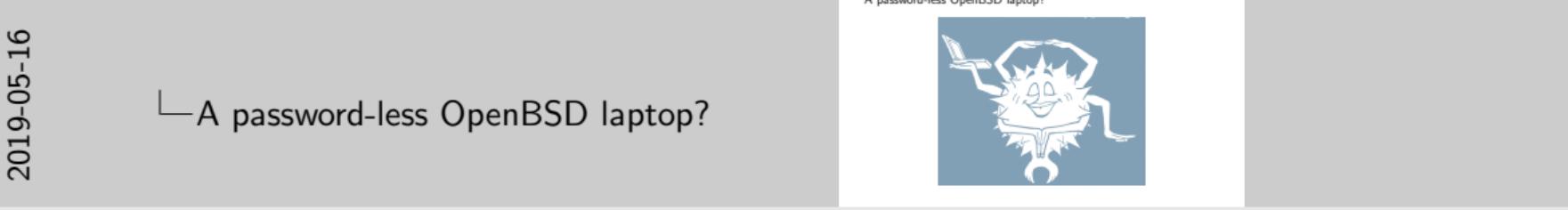
Maurice's home directory:
$ du -hcs *.core
2.9M    caribou.core
1.2G    firefox.core
2.2M    gnome-session-bi.core
389M    gnome-shell.core
2.3M    gsd-xsettings.core
1.5M    ibus-daemon.core
91.4M   kwin.core
9.5M    tracker-miner-fs.core
1.7G    total
```

- 1. OpenBSD base system is hostile to buggy applications – good!
- 2. But more attention should be given to resulting core dumps
- 3. We should be more actively fixing such bugs
- 4. Instead, we allow them to infest our ports tree
- 5. We also need better debugging tools

We should really be taking core dumps more seriously

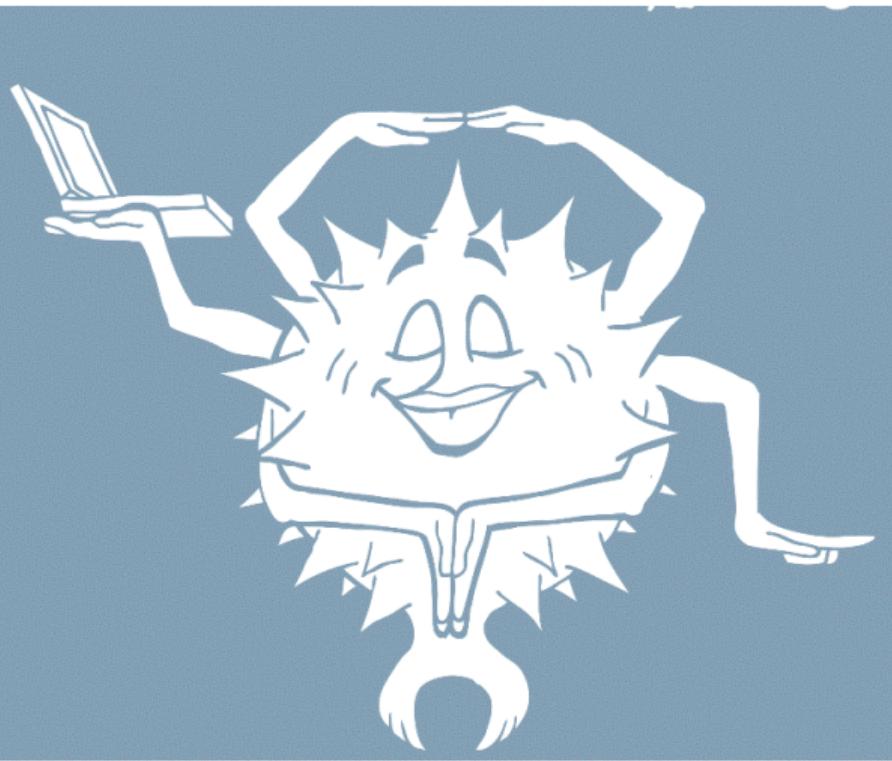
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- 1. Configure softraid with a keydisk instead of a passphrase
- 2. Configure automatic login to X11 desktop
- 3. Disable desktop lock screen
- 4. Disable password manager master password
- 5. Visit websites once and save credentials in the browser

A password-less OpenBSD laptop?



└ Managing keydisks

Managing keydisks



1. Tie one keydisk to physical keyring (house keys)
2. Hide secondary backup keydisk at a safe location
3. Store a digital keydisk image in case both disks are lost

Managing keydisks



└ 1997: Maurice joins “Rambazamba” Theatre



1. Fresh out of hospital, Maurice arrives at Rambazamba Theatre in a wheelchair
2. At the time, Maurice could not speak
3. Maurice was convinced he could not act
4. The director put Maurice on the floor and said “act!”.
5. Maurice screamed
6. Maurice got the part

1997: Maurice joins “Rambazamba” Theatre

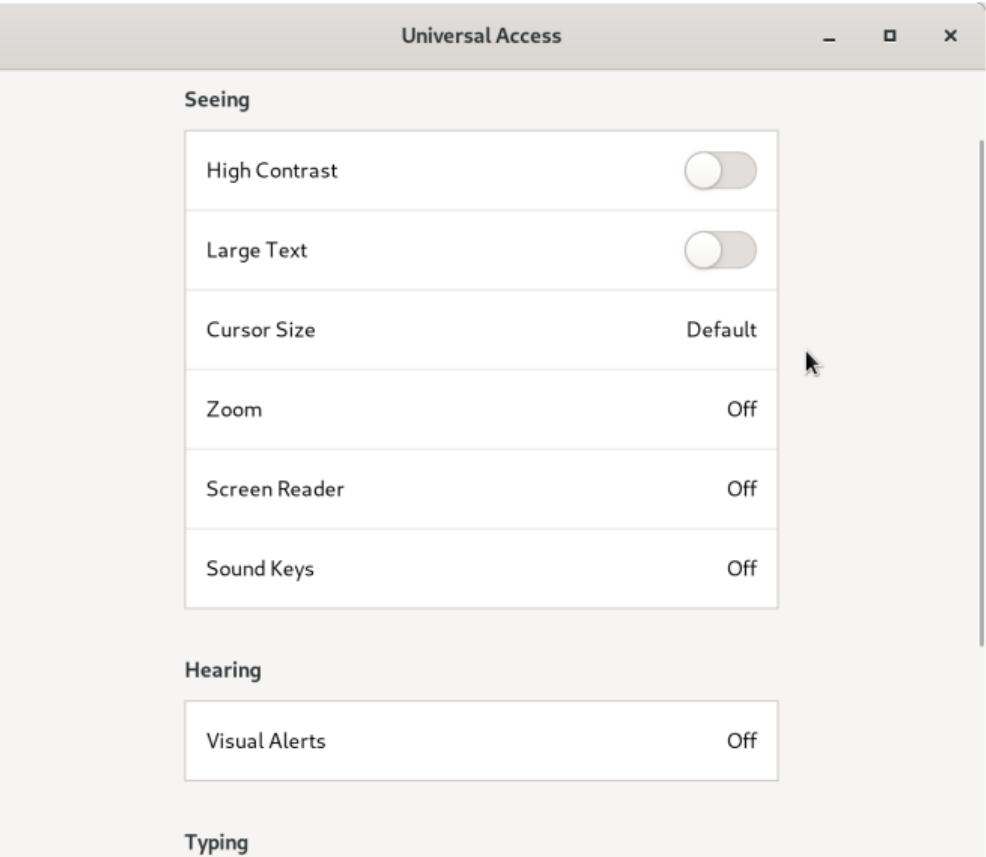


└ Accessibility software

1. Gnome's built-in accessibility features don't address Maurice's specific problems
2. Maurice's problems are related to bad short-term memory and short attention span
3. Maurice can read text and use a keyboard (with one hand) just fine



Accessibility software

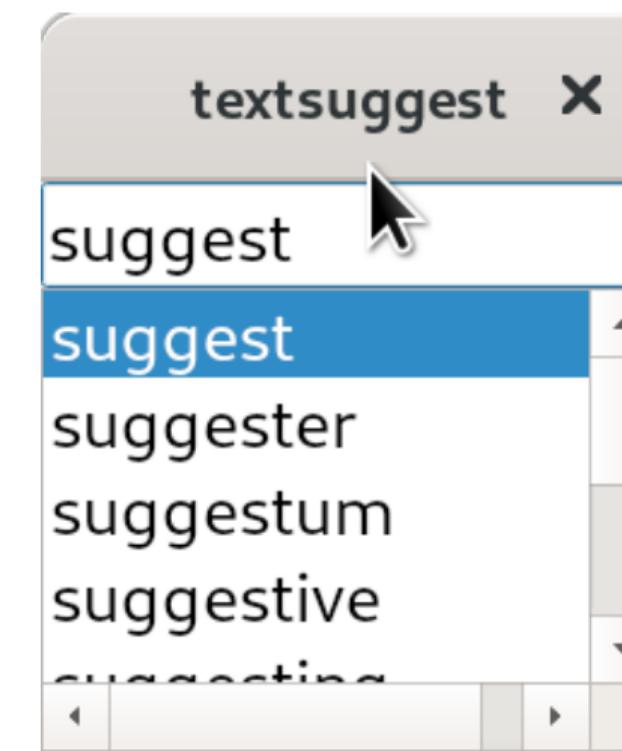


TextSuggest: spelling and typing aid for X11



1. zoomed image of TextSuggest

TextSuggest: spelling and typing aid for X11



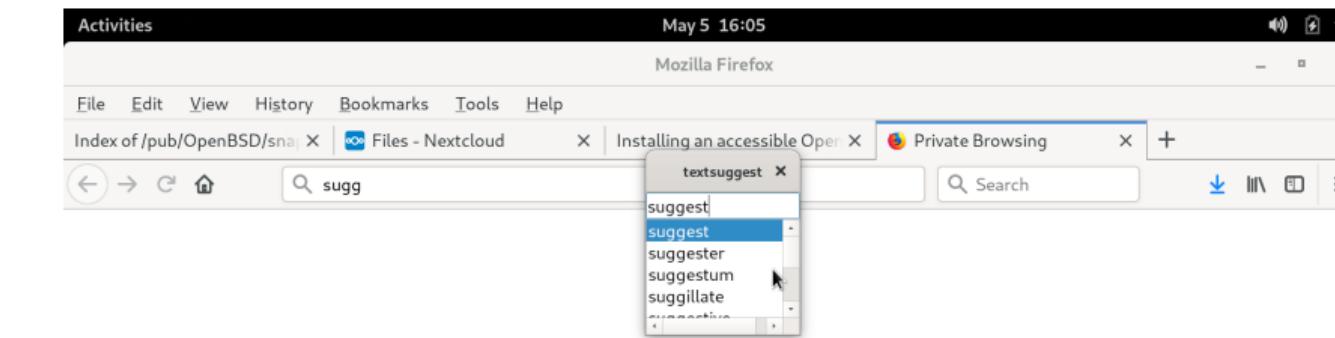
└ TextSuggest: spelling and typing aid for X11

1. Written in C++
2. Uses 'xdotool' to type shortcuts which select, copy, and insert text
3. Uses X11 clipboard API from C++
4. Server and client components (dbus)
5. Suggestion window is bound to a keyboard shortcut
6. Fuzzy matching copes with small mistakes anywhere in typed word
7. Prototype quality, but already quite useful



TextSuggest: spelling and typing aid for X11

- Developed by Bharadwaj Raju (<https://bharadwaj-raju.itch.io/textsuggest>)
- Manipulates the X clipboard
- Suggestion menu is bound to a hotkey





1. TextSuggest's embeds small copies of C++ header libraries
2. these libraries had several problems
3. cpp-subprocess contained unportable code (`stdio_filebuf.h`)

Porting TextSuggest: cpp-subprocess

TextSuggest includes a copy of cpp-subprocess
<https://github.com/tsaarni/cpp-subprocess>

- requires GNU C++ extension "ext/stdio_filebuf.h"
- cannot be built with clang
- had to rewrite cpp-subprocess using a portable API



- 1. clip library contained mutex handling bugs (double unlock)
- 2. exposed by OpenBSD librthread
- 3. porting software to OpenBSD tends to reveal bugs not exposed elsewhere

Porting TextSuggest: clip

TextSuggest includes a copy of clip <https://github.com/dacap/clip/>

- Threading bug: mutex unlocked twice
 - once at the end of a class method scope
 - and again in the destructor of the class
- Tripped over mutex consistency checks in librthread
 - textsuggest-server dumps core
- Had to debug C++ locking code; not exactly fun

Fixed: <https://github.com/dacap/clip/pull/26>

└ Is TextSuggest the right tool for the job?



1. Goal was to have Maurice type short messages himself
2. Maurice has not yet been using it a lot
3. Could not remember which hotkey to use; key is now marked
4. Perhaps he will start getting used to it; time will tell
5. Asking people for assistance is still easier

Is TextSuggest the right tool for the job?

Maurice's favourite kitchen tool: a one-handed knife

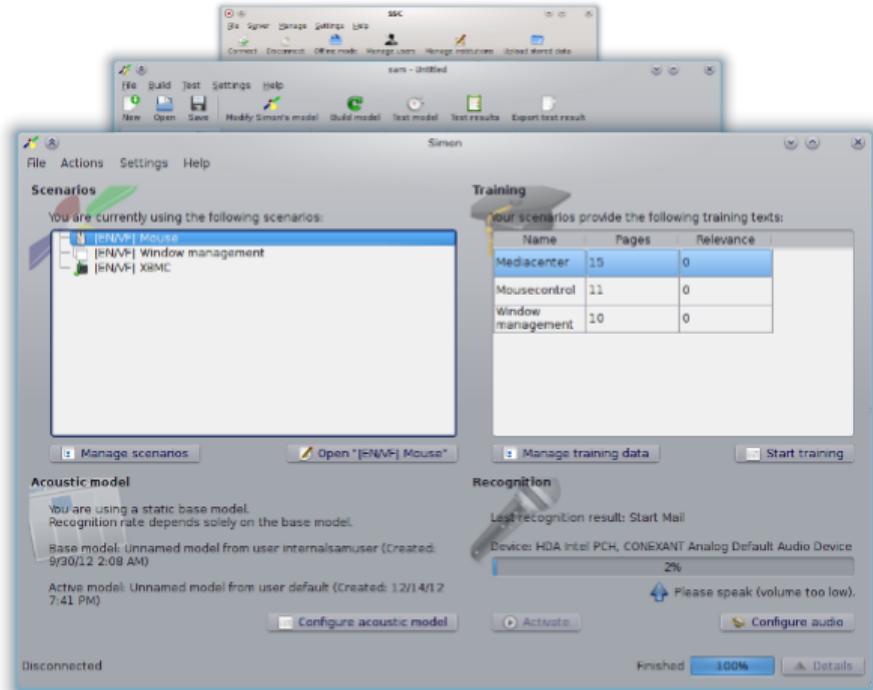


└ Simon Speech Recognition (<http://simon.kde.org>)

1. Simon is a speech-to-command software package
2. Can be trained to understand words in any language
3. Can control the mouse and specific applications (e.g. Firefox) by voice
4. Sounds fun! Maurice would like to try Simon...



Simon Speech Recognition (<http://simon.kde.org>)



Porting Simon

1. Most dependencies are already in the ports tree
2. I got Simon up and running in April 2019

```
Porting Simon

Work required:
  • Update and port more components of CMU Sphinx
  • Write an sndio backend

$ cd /usr/ports/x11/kde4/simon; head Makefile
# $OpenBSD$

COMMENT = speech recognition replacement for mouse and keyboard
VERSION = 0.4.90
DISTNAME = simon-$VERSION
CATEGORIES = audio inputmethods x11

MODULES = x11/kde4
MAINTAINER = Stefan Sperling <stsp@openbsd.org>
```

Porting Simon

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```



1. KDE add-ons repository has no working add-ons
2. Attempts to create own training data ran into bugs
3. Might try again if Simon project becomes active again

Problems with Simon

- Simon requires application-specific add-ons to work:
 - speech models
 - language dictionaries
 - application scenarios
- The Simon project has been unmaintained since 2015 :-(
- Adds-on can no longer be downloaded
- Work-in-progress port saved at <https://stsp.name/simon-port>

└ 2000s: Maurice keeps working as an actor

2000s: Maurice keeps working as an actor

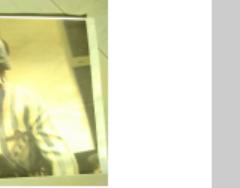


1. Gradually, Maurice relearned how to speak
2. At first, lines were given via earpiece
3. The lines of each play took him years to remember
4. Maurice learned to play the Accordeon and the Chello one-handed
5. Toured Denmark, Poland, Switzerland, Germany
6. Became a founding member of Kalibani Theatre

2000s: Maurice keeps working as an actor



└ System Administration



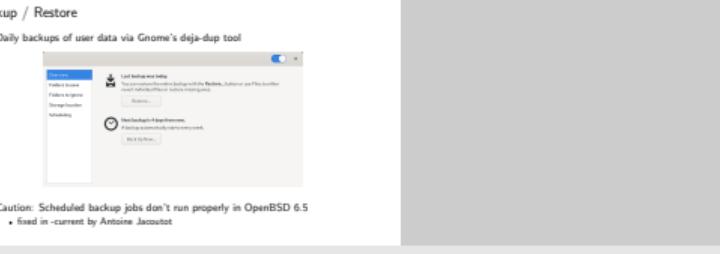
1. Let's look into system administration topics

System Administration



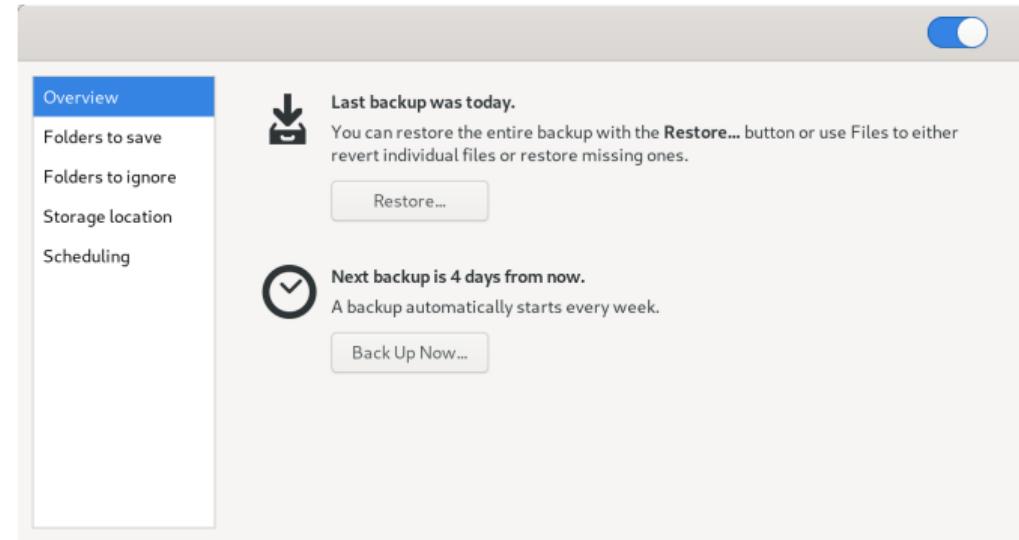
└ Backup / Restore

1. Data stored encrypted on a Nextcloud server
2. Nextcloud password stored in gnome-keyring
3. Data can be restored with same application



Backup / Restore

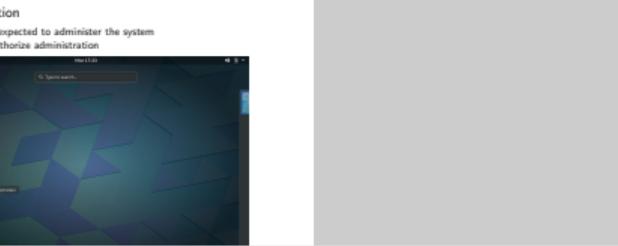
- Daily backups of user data via Gnome's deja-dup tool



- Caution: Scheduled backup jobs don't run properly in OpenBSD 6.5
 - fixed in -current by Antoine Jacoutot

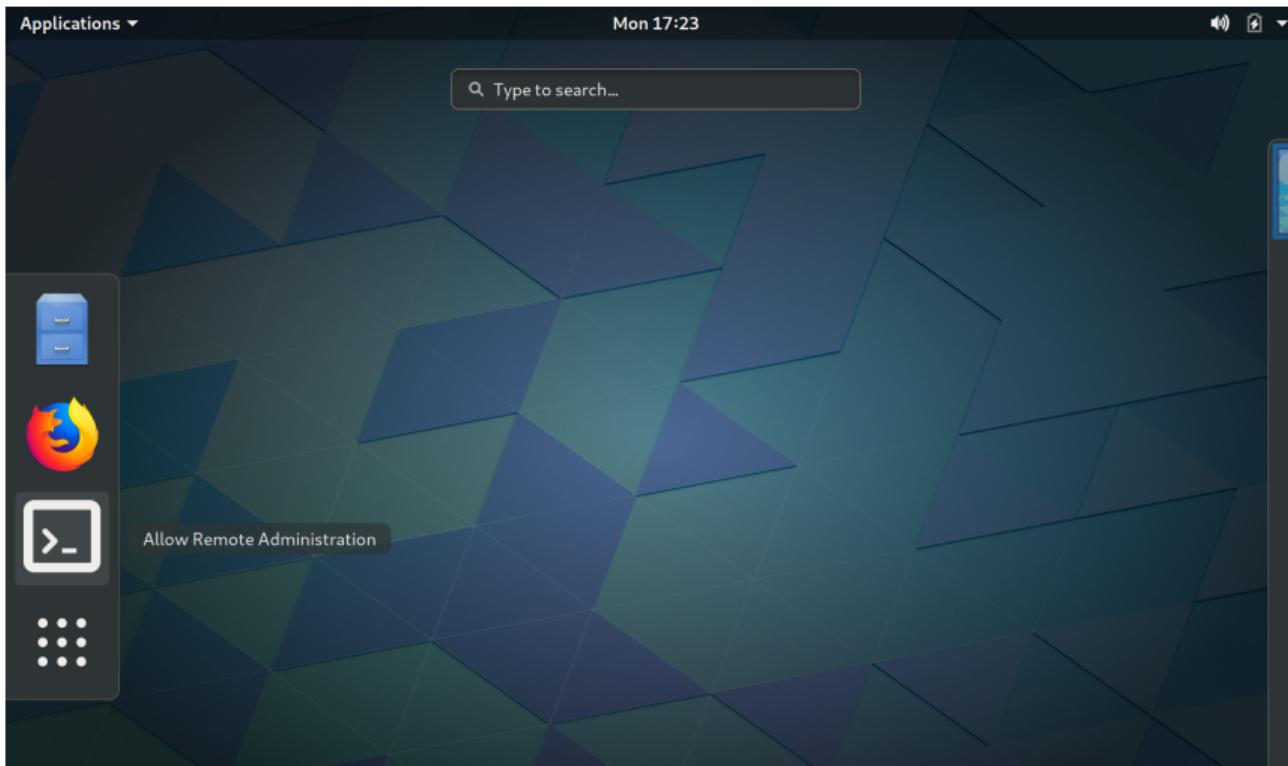
└ Remote administration

1. Administration may have to happen remotely
2. Laptop won't usually have a public IP
3. Desktop menu entry enables remote administration



Remote administration

- Maurice cannot be expected to administer the system
- But he is able to authorize administration



└ Remote administration

1. Maurice logs into jump host and sets up reverse tunnel to port 22
2. Admin logs into the same jump host
3. Admin logs into laptop and becomes root
4. Admin remains connected while both remain connected to jump host

```
Remote administration

Host jumphost
Hostname ssh.example.com
RemoteForward 2222 127.0.0.1:22

maurice-laptop$ ssh jumphost # <- desktop menu entry
adminhost$ ssh jumphost
jumphost$ ssh -p 2222 127.0.0.1
maurice-laptop$ su
Password:
maurice-laptop#
```

Remote administration

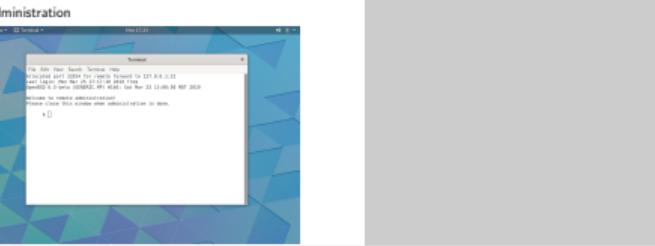
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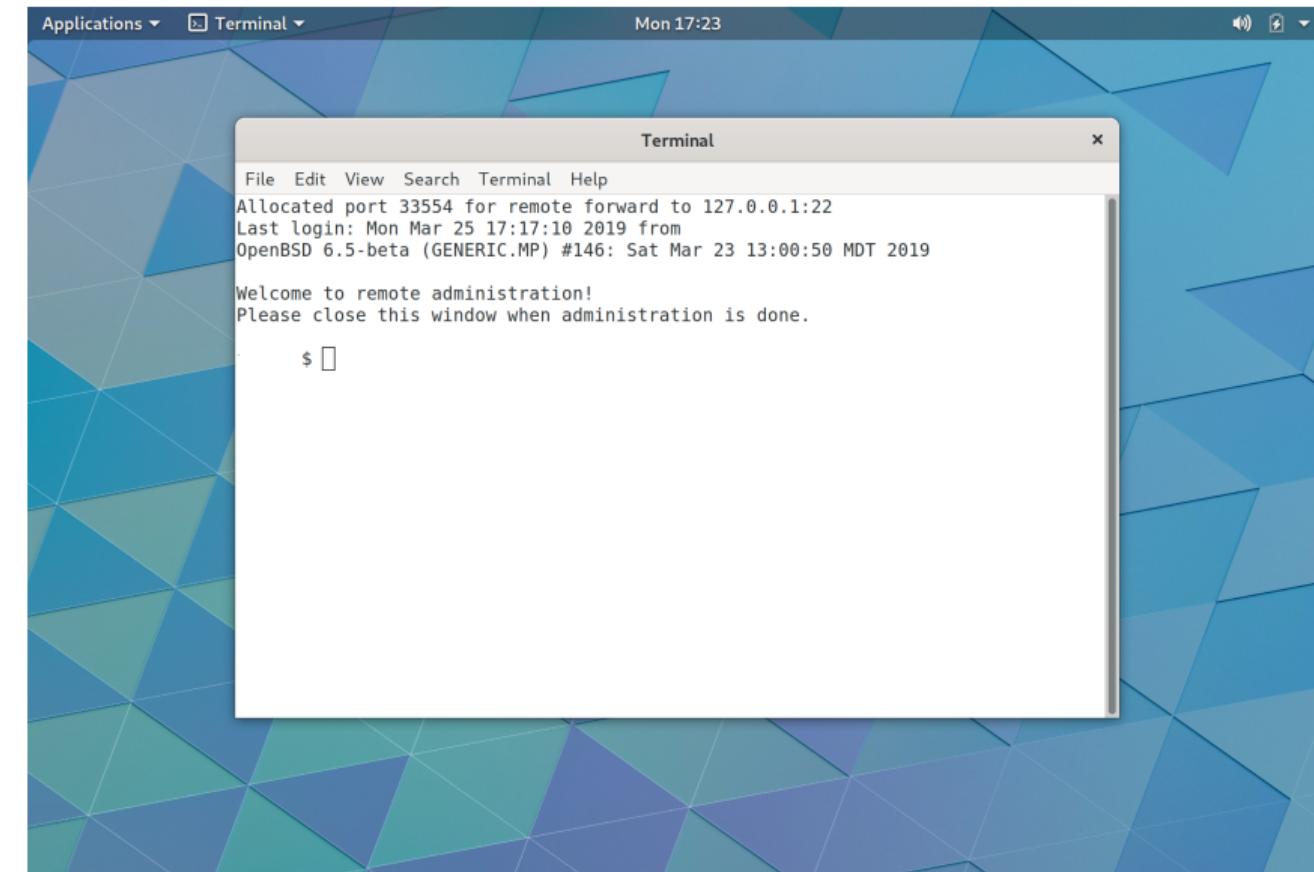
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jumphost$ ssh -p 2222 127.0.0.1
maurice-laptop$ su
Password:
maurice-laptop#
```

└ Remote administration



1. Maurice controls admin's SSH access to his machine
2. SSH reverse-tunnel is terminated when Terminal window is closed

Remote administration



└ 2019: "I am a lucky person"



1. Maurice is generally in a good mood
2. Old woman observing Maurice climbing the stairs with huge effort:
"Life is hard, isn't it"
3. Maurice: "Positively speaking, I can do this!"
4. Maurice is granted German citizenship (now a dual UK/DE citizen)

2019: "I am a lucky person"



└ Thank you for listening!



Thank you for listening!



└ And what about video conferencing?



And what about video conferencing?

Nextcloud Talk works with WebRTC in Firefox
Let's try a live demo...

Useful links:

- Laptop setup guide: <https://stsp.name/maurice-laptop.html>
- Donate to OpenBSD: <https://openbsdfoundation.org>
- Donate to Maurice: <https://liberapay.com/mauricejones/>