⌘ The Occult / the Apple GPU

Alyssa Rosenzweig

⌘ Introduction

⌘ The wizards

- Dougall Johnson
- Hector Martin
- Sven Peter
- Alyssa Rosenzweig

Designed by Asahi in Canada.

Assembled in… also Canada. 🇨🇦

⌘ DCP

⌘ Hardware

- **D**iabolical **C**luster**p**uck

...Er, wait.

⌘ Hardware

- **D**isplay **C**o**p**rocessor
- Manages the display controller
- Has its own cursed coprocessor
- 7 megabytes of firmware

⌘ DCP

⌘ RTKit

- **R**eal **T**ime **Kit**
- Secret real-time operating system
- Apple firmware (and AirPods)
- Shared memory and mailbox

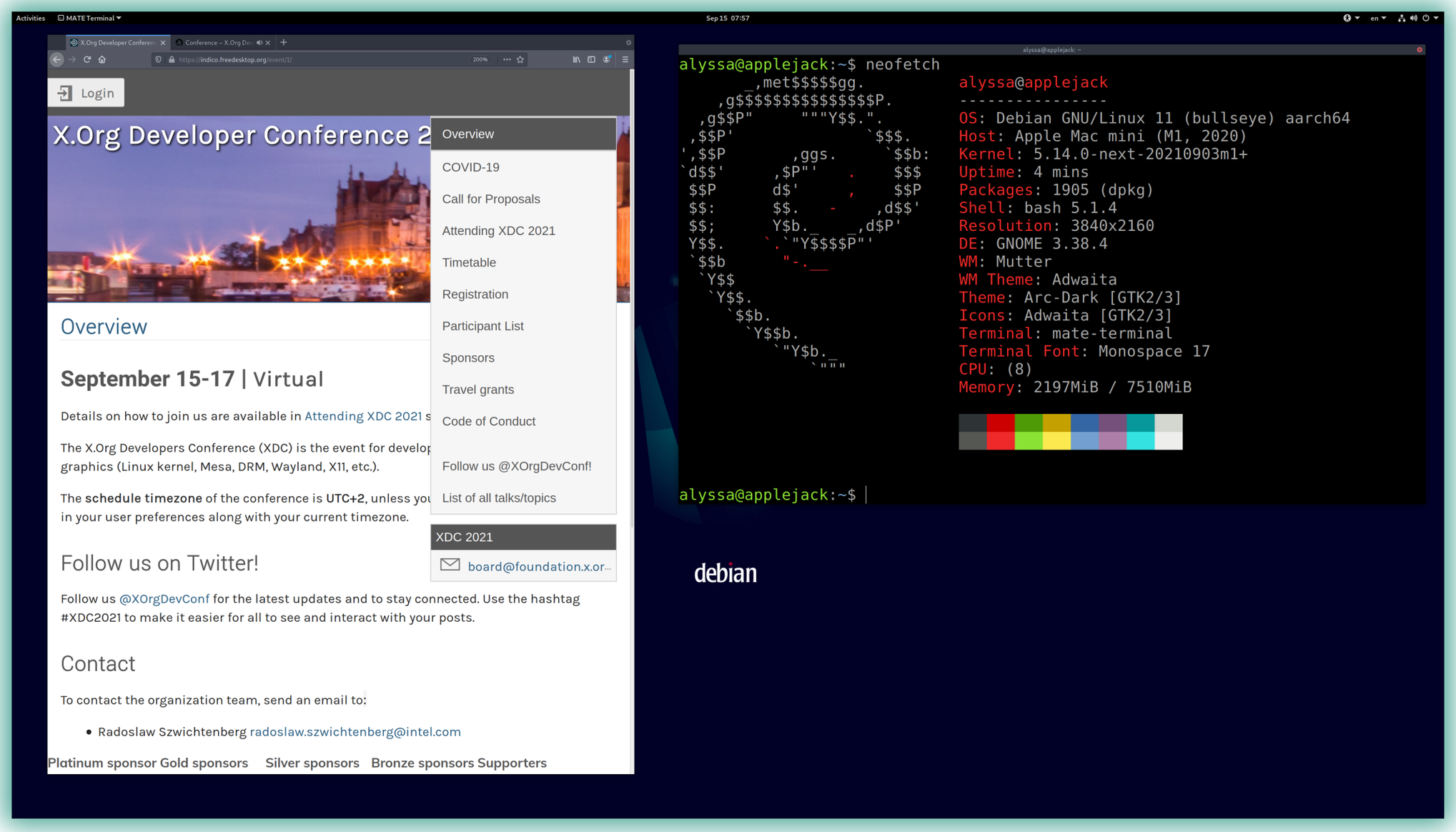
⌘ Firmware

- Object-oriented C++
- Remote procedure calls
- Unstable ABI ⇒ maintenance nightmare

⌘ Linux

- Goofy DRM/KMS driver
- Atomic KMS → DCP calls
- Haunted by IOSurface

⌘ Status


Activities
MATE Terminal
Sep 15 07:57
en
Login
X.Org Developer Conference 2
Overview
COVID-19
Call for Proposals
Attending XDC 2021
Timetable
Registration
Participant List
Sponsors
Travel grants
Code of Conduct
Follow us @XOrgDevConf!
List of all talks/topics
XDC 2021
board@foundation.x.or...
Overview
September 15-17 | Virtual
Details on how to join us are available in Attending XDC 2021 s
The X.Org Developers Conference (XDC) is the event for develop
graphics (Linux kernel, Mesa, DRM, Wayland, X11, etc.).
The schedule timezone of the conference is UTC+2, unless you
in your user preferences along with your current timezone.
Follow us on Twitter!
Follow us @XOrgDevConf for the latest updates and to stay connected. Use the hashtag
#XDC2021 to make it easier for all to see and interact with your posts.
Contact
To contact the organization team, send an email to:
Radoslaw Szwichtenberg radoslaw.szwichtenberg@intel.com
Platinum sponsor Gold sponsors Silver sponsors Bronze sponsors Supporters
alyssa@applejack: ~
alyssa@applejack:~$ neofetch
alyssa@applejack
OS: Debian GNU/Linux 11 (bullseye) aarch64
Host: Apple Mac mini (M1, 2020)
Kernel: 5.14.0-next-20210903m1+
Uptime: 4 mins
Packages: 1905 (dpkg)
Shell: bash 5.1.4
Resolution: 3840x2160
DE: GNOME 3.38.4
WM: Mutter
WM Theme: Adwaita
Theme: Arc-Dark [GTK2/3]
Icons: Adwaita [GTK2/3]
Terminal: mate-terminal
Terminal Font: Monospace 17
CPU: (8)
Memory: 2197MiB / 7510MiB
alyssa@applejack:~$
debian


⌘ AGX

⌘ Hardware

- **A**pple **G**raphi**cs**
- Tiler
- Dual-issue, scalar instruction set
- Made for Metal

⌘ Mesa

- Gallium3D driver
- NIR compiler

⌘ Metal lacks OpenGL features

⌘ “Fun” with AGX

⌘ Divergence styles

- Mali: Branches with hardware reconvergence
- AMD: Compiler manages execution masks
- Apple: Count control flow nesting

⌘ AGX divergence

⌘ AGX control flow

- 32 threads in a warp
- Implicit execution 32-bit mask
- Nesting counter in `r0l` (0 if active)
- Warp-static jumps
- Structured if, else, do…while
- Control flow sets `r0l` and mask

⌘ NIR control flow

- If-else
- Infinite loop
- Break, continue

⌘ Implementing if

```
if_icmp cond != 0 (n = 1)
    ...
pop_exec (n = 1)
```

⌘ Implementing if...else

```
if_icmp cond != 0 (n = 1)
    ...
else_icmp cond == 0 (n = 1)
    ...
pop_exec (n = 1)
```

⌘ What about loops?

⌘ Implementing loops, take 0

No way to break!

```
start:
    ...
    jmp_exec_any start
```

⌘ Implementing loops, take 1

```
start:
    ...
    do_while true (n = 1)
    jmp_exec_any start
```

Break:

```
mov r0l, #1
pop_exec (n = 0)
```

⌘ Implementing loops, take 2

Don’t clobber the execution mask.

```
push_exec (n = 1)

start:
    ...
    do_while true (n = 1)
    jmp_exec_any start

pop_exec (n = 1)
```

⌘ Implementing loops, take 2

- Implements `loop { ... }`
- Can break out of multiple loops at once
- What about continue?

⌘ Implementing loops, take 3

Quoth the Dougall:

“Continue is a break.”

```
do {
    do {
        ...
    } while(0);
} while (cond);
```

⌘ Implementing loops, take 3

Model two nested loops in general.

```
push_exec (n = 2)

start:
    ....
    do_while true (n = 2)
    jmp_exec_any start

pop_exec (n = 2)
```

⌘ Implementing loops, take 3

Break:

```
mov r0l, #2
pop_exec (n = 0)
```

Continue:

```
mov r0l, #1
pop_exec (n = 0)
```

⌘ Implementing loops, take 4

Break:

```
mov r0l, #(nested_if_count + 2)
pop_exec (n = 0)
```

Continue:

```
mov r0l, #(nested_if_count + 1)
pop_exec (n = 0)
```

⌘ Conclusion

⌘ Status

- DCP driver downstream
- AGX upstream in Mesa
  - Passing 95% of dEQP-GLES2
- AGX kernel driver pending

⌘ Thank you

Alyssa Rosenzweig
alyssa@rosenzweig.io