RISC-V Developer Images
Bay Area RISC-V Group

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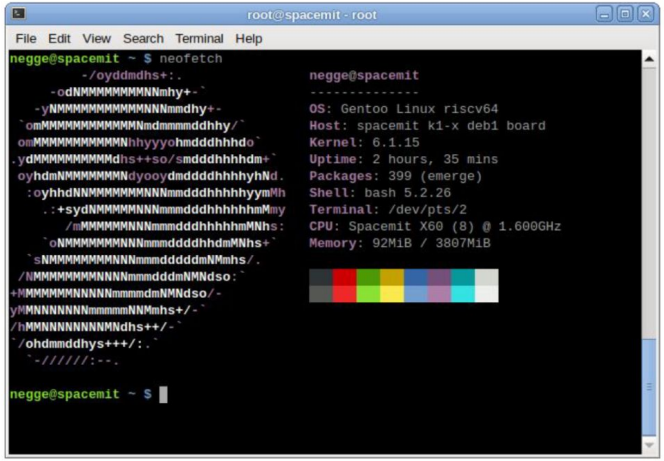
RISC-V Summit EU - June 2024

- Presented single slide on *manually* prebuilt developer images
- Since then work has focused on build automation

Prebuilt Developer Images

- Facilitate development by providing up-to-date toolchains for building and testing
  - Latest toolchain package versions
    - clang-18.1.5
    - gcc-13.2.1_p20240503
    - rust-1.77.1
    - binutils-2.42
    - cmake-3.29.3
    - python-3.12.3
    - perl-5.38.2
    - git-2.45.1
    - subversion-1.14.3
  - Kendryte K230 and Banana Pi BPI-F3



[1] https://people.videolan.org/~negge/canaan-3G-2024-04-08.img.xz
[2] https://people.videolan.org/~negge/spacemit-4G-2024-05-15.img.xz

ROMA II image coming soon!!

RISE

Project Goals

- Fastest way to create bootable images with **up-to-date** toolchains!
- RISC-V toolchains under active development and move very quickly
  - Bugs are found and fixed continuously, point releases matter!
- Primarily driven by need for tools to enable RVV 1.0 optimizations
  - Finally have widely available hardware e.g. K230, BPI-F3, ROMA II
  - As per Gentoo tradition, would like to build ***all*** packages with full support for available hardware: auto-vectorizer, bitmanip, crypto, etc.
  - Added benefit of assessing compiler readiness, and report gaps [1]

[1] GCC Bug 116242 - [meta-bug] Tracker for zvl issues in RISC-V

Build scripts

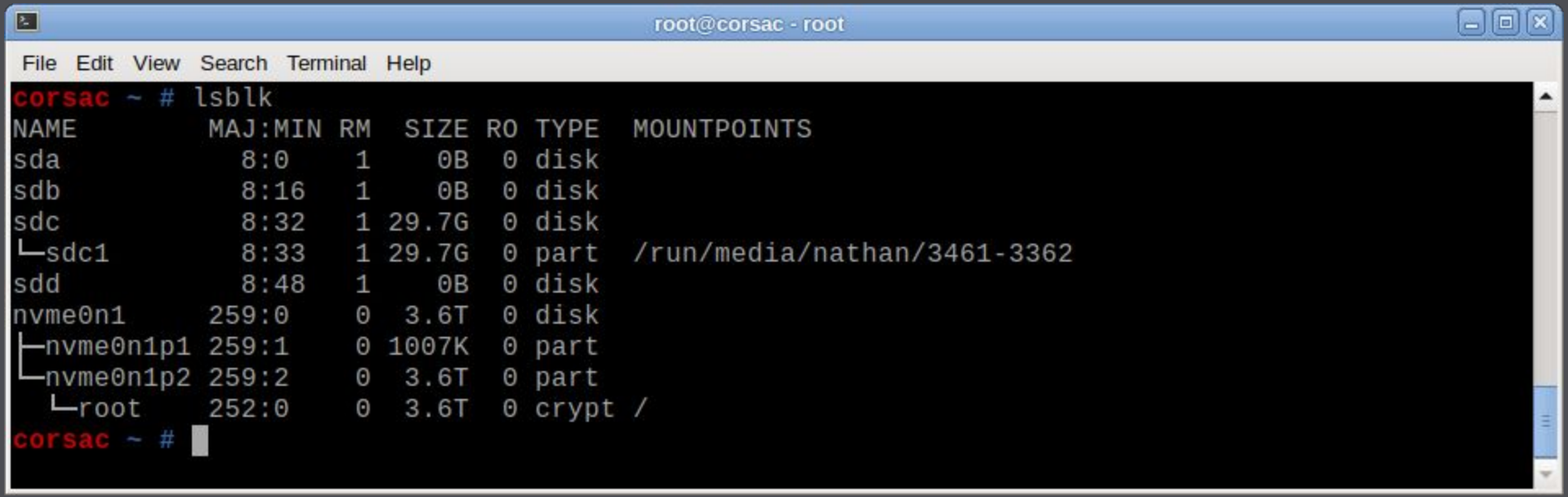
- Traditionally Gentoo builds new images through Catalyst
  - Images built through stages: `stage1` -> `stage2` -> `stage3`
  - Every stage is built either on native host or via qemu-user
    - Emulation via qemu-user adds *large* amount of overhead

- crossdev-stages [1] is an experiment on cross compiling
  - It leverages crossdev to avoid relying on qemu-user for RISC-V
  - Much, much faster (6x to 10x) and can be made even faster
    - First attempt building a full stage3 (300+ packages) took ~343m
    - Building stage3 + clang + additional tools now takes ~305m

[1] https://github.com/lu-zero/crossdev-stages

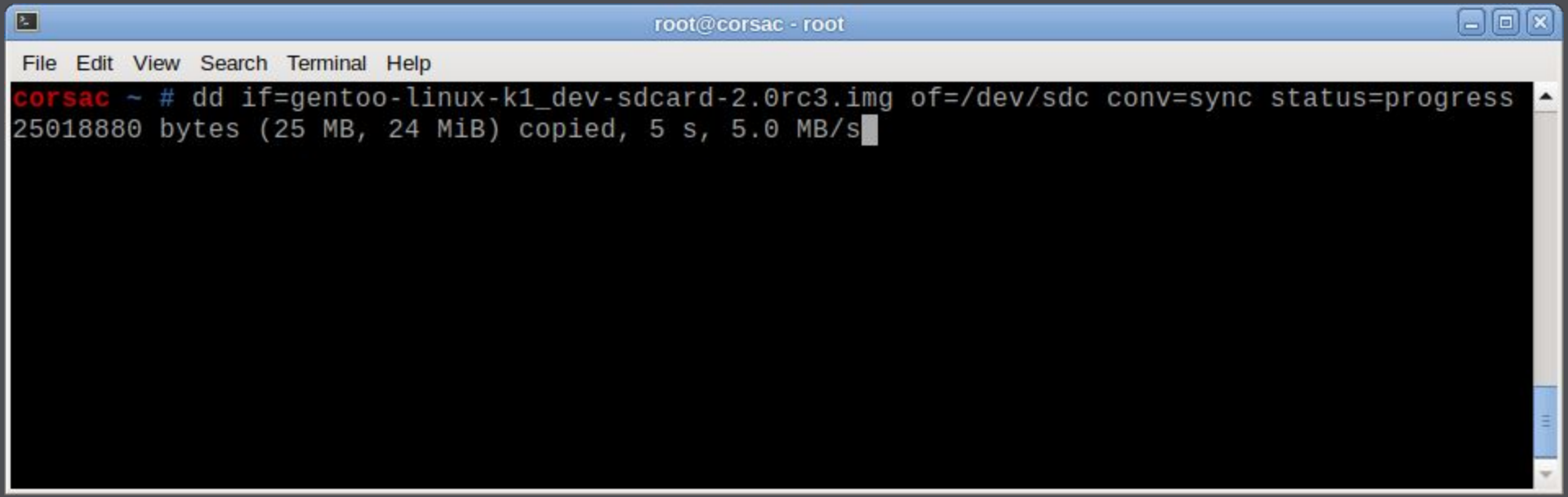
Preparing the Disk

```
$ lsblk
```



Installing the image [1]

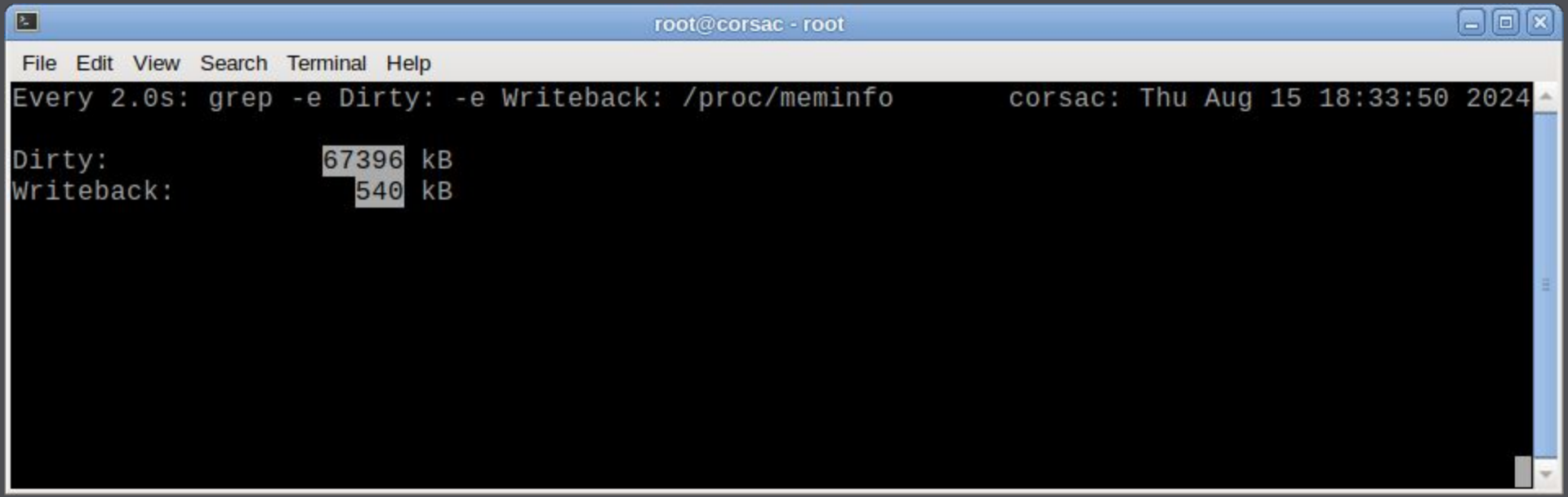
```
$ dd if=gentoo-linux-k1_dev-sdcard-2.0rc3.img of=/dev/sdc conv=sync status=progress
```



[1] https://dev.gentoo.org/~lu_zero/gentoo-linux-k1_dev-sdcard-2.0rc3.img.xz

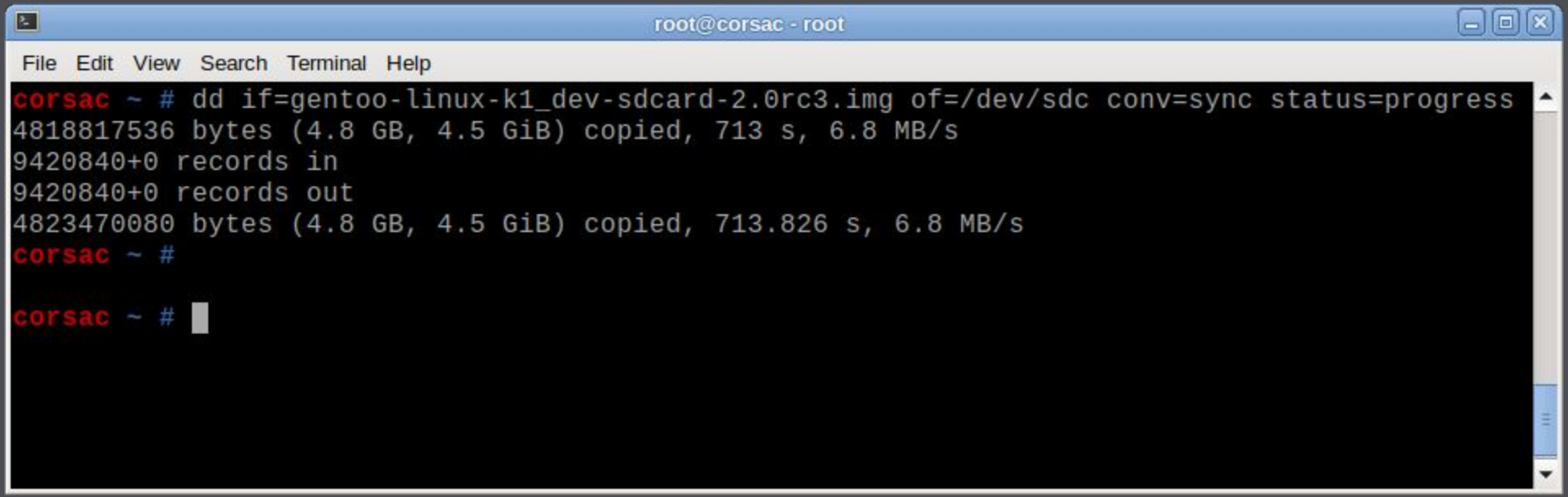
Check the dirty page cache

```
$ watch -d grep -e Dirty: -e Writeback: /proc/meminfo
```



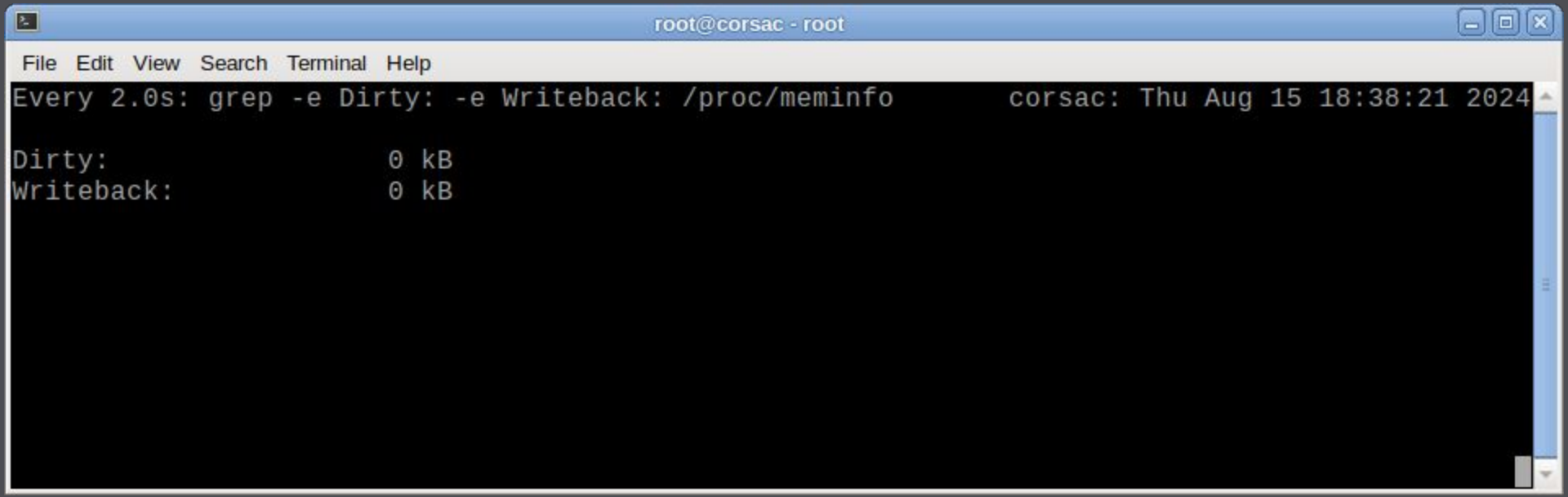
Looks like it is done …

```
$ dd if=gentoo-linux-k1_dev-sdcard-2.0rc3.img of=/dev/sdc conv=sync status=progress
```



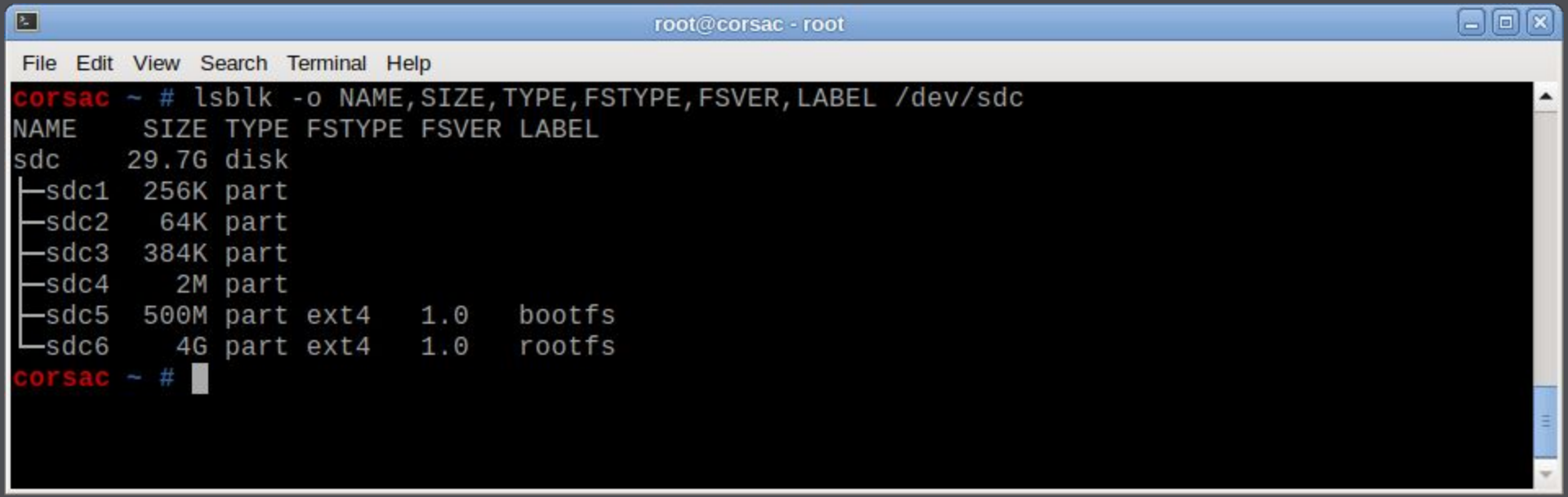
… but now you can unplug

```
$ watch -d grep -e Dirty: -e Writeback: /proc/meminfo
```



Check that image was written

```
$ lsblk -o NAME,SIZE,TYPE,FSTYPE,FSVER,LABEL /dev/sdc
```



Check that image was written

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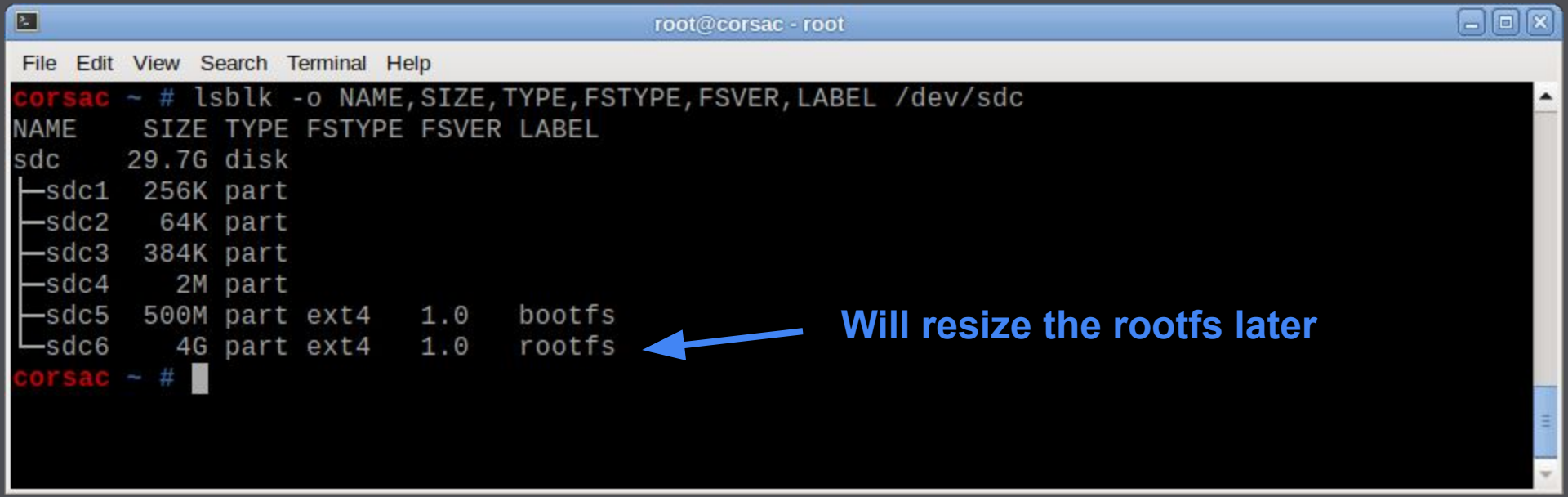
$ lsblk -o NAME,SIZE,TYPE,FSTYPE,FSVER,LABEL /dev/sdc
```



Boot process

```
U-Boot SPL 2022.10spacemit (Aug 14 2024 - 20:15:22 -0000)
DDR type LPDDR4X
lpddr4_silicon_init consume 11ms
Change DDR data rate to 2400MT/s
Boot from fit configuration k1-x_deb1
## Checking hash(es) for config conf_2 ... OK
## Checking hash(es) for Image uboot ... crc32+ OK
## Checking hash(es) for Image fdt_2 ... crc32+ OK
## Checking hash(es) for config config_1 ... OK
## Checking hash(es) for Image opensbi ... crc32+ OK


U-Boot 2022.10spacemit (Aug 14 2024 - 20:15:22 -0000)

CPU:   rv64imafdcv
Model: spacemit k1-x deb1 board
DRAM:  DDR size = 4096 MB
DDR size = 4096 MB
DDR size = 4096 MB
```

```
## Loading kernel from FIT Image at 11000000 ...
   Using 'conf-default' configuration
   Verifying Hash Integrity ... OK
   Trying 'kernel' kernel subimage
     Description:  Linux 6.6.36+
     Type:         Kernel Image
     Compression:  gzip compressed
     Data Start:   0x110000bc
     Data Size:    14255955 Bytes = 13.6 MiB
     Architecture: RISC-V
     OS:           Linux
     Load Address: 0x00200000
     Entry Point:  0x00200000
     Hash algo:    crc32
     Hash value:   7c3065e0
   Verifying Hash Integrity ... crc32+ OK
## Flattened Device Tree blob at 31000000
   Booting using the fdt blob at 0x31000000
   Uncompressing Kernel Image
```

Boot process (con’t)

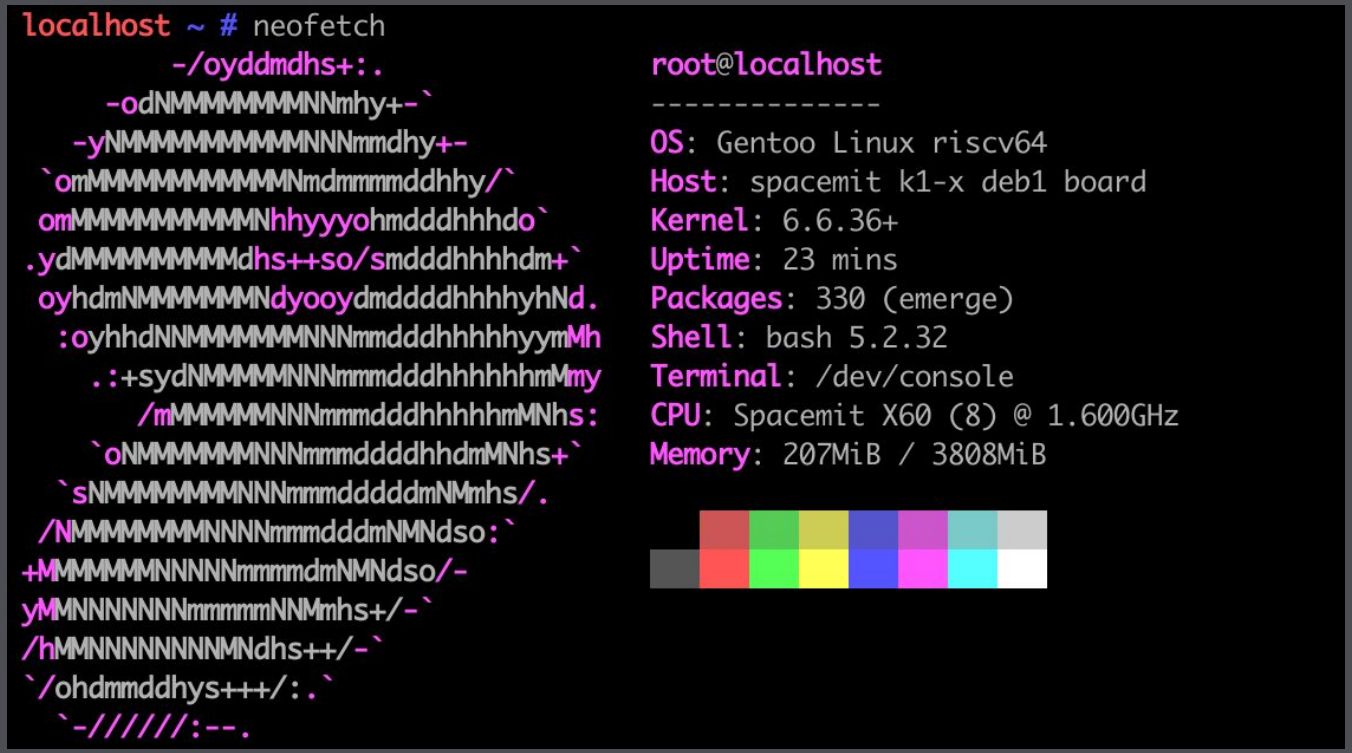
```
   OpenRC 0.54.2 is starting up Gentoo Linux (riscv64)

 * Mounting /proc ...
 [ ok ]
 * Mounting /run ...
 [ ok ]
 * /run/openrc: creating direct
 * /run/lock: creating director
 * /run/lock: correcting owner
 * Caching service dependencies
[    5.445256] usb 2-1.5: new h
 [ ok ]
 * Mounting /sys ...
 [ ok ]
 * Mounting debug filesystem ..
 [ ok ]
 * Mounting config filesystem .
 [ ok ]
 * Mounting fuse control filesy
 * Create Volatile Files and Directories ...
 [ ok ]
INIT: Entering runlevel: 3
 * Starting metalog ...
 [ ok ]
 * Starting DHCP Client Daemon ...
dhcp_vendor: No such process
 [ ok ]
 * Mounting network filesystems ...
 [ ok ]
 * Starting sshd ...
 [ ok ]
 * Starting local ...
 [ ok ]


This is localhost (Linux riscv64 6.6.36+) 21:56:52

localhost login:
```

Full Gentoo Linux System \o/



Up-to-date Toolchains!

```
localhost ~ # clang --version
clang version 18.1.8
Target: riscv64-unknown-linux-gnu
Thread model: posix
InstalledDir: /usr/lib/llvm/18/bin
Configuration file: /etc/clang/riscv64-unknown-linux-gnu-clang.cfg
localhost ~ # gcc --version
gcc (Gentoo 14.2.0 p4) 14.2.0
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This is free software; see the source for copying conditions.  There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

localhost ~ # /usr/lib/ld-linux-riscv64-lp64d.so.1 --version
ld.so (Gentoo 2.40 (patchset 1)) stable release version 2.40.
Copyright (C) 2024 Free Software Foundation, Inc.
This is free software; see the source for copying conditions.
There is NO warranty; not even for MERCHANTABILITY or FITNESS FOR A
PARTICULAR PURPOSE.
localhost ~ #
```

Wifi and ethernet just work out of the box

```
localhost ~ # modprobe 8852bs
localhost ~ # /etc/init.d/wpa_supplicant start
 * Starting WPA Supplicant Daemon ...
Successfully initialized wpa_supplicant                          [ ok ]
localhost ~ # ifconfig wlan0
wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
        inet 192.168.9.202  netmask 255.255.255.0  broadcast 192.168.9.255
        inet6 fd1a:637d:f215:0:d7e5:b531:88fc:b12e  prefixlen 64  scopeid 0x0<gl
obal>
        inet6 fd95:b4c7:7c8b:0:300c:64b3:c757:b96f  prefixlen 64  scopeid 0x0<gl
obal>
        inet6 fd8d:88cb:94f4:0:b5d0:53e4:4cf:2073  prefixlen 64  scopeid 0x0<glo
bal>
        inet6 fe80::b7a2:5296:db95:fe64  prefixlen 64  scopeid 0x20<link>
        inet6 fd1a:637d:f215::93c  prefixlen 128  scopeid 0x0<global>
        ether c0:4b:24:36:6b:af  txqueuelen 1000  (Ethernet)
        RX packets 12326  bytes 51588926 (49.1 MiB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 12397  bytes 696222 (679.9 KiB)
```

Emerge packages

```
localhost ~ # ldconfig
localhost ~ # emerge-webrsync -q
 * Latest snapshot date: 20240814
 *
 * Approximate snapshot timestamp: 1723682700
 *        Current local timestamp: 1723682400
 *
 * The current local timestamp is possibly identical to the
 * timestamp of the latest snapshot. In order to force sync, use
 * the --revert option or remove the timestamp file located at
 * '/var/db/repos/gentoo/metadata/timestamp.x'.
localhost ~ # getuto && emerge -g neofetch

 * IMPORTANT: 18 news items need reading for repository 'gentoo'.
 * Use eselect news read to view new items.


Local copy of remote index is up-to-date and will be used.
Calculating dependencies... done!
```

Resize the partition

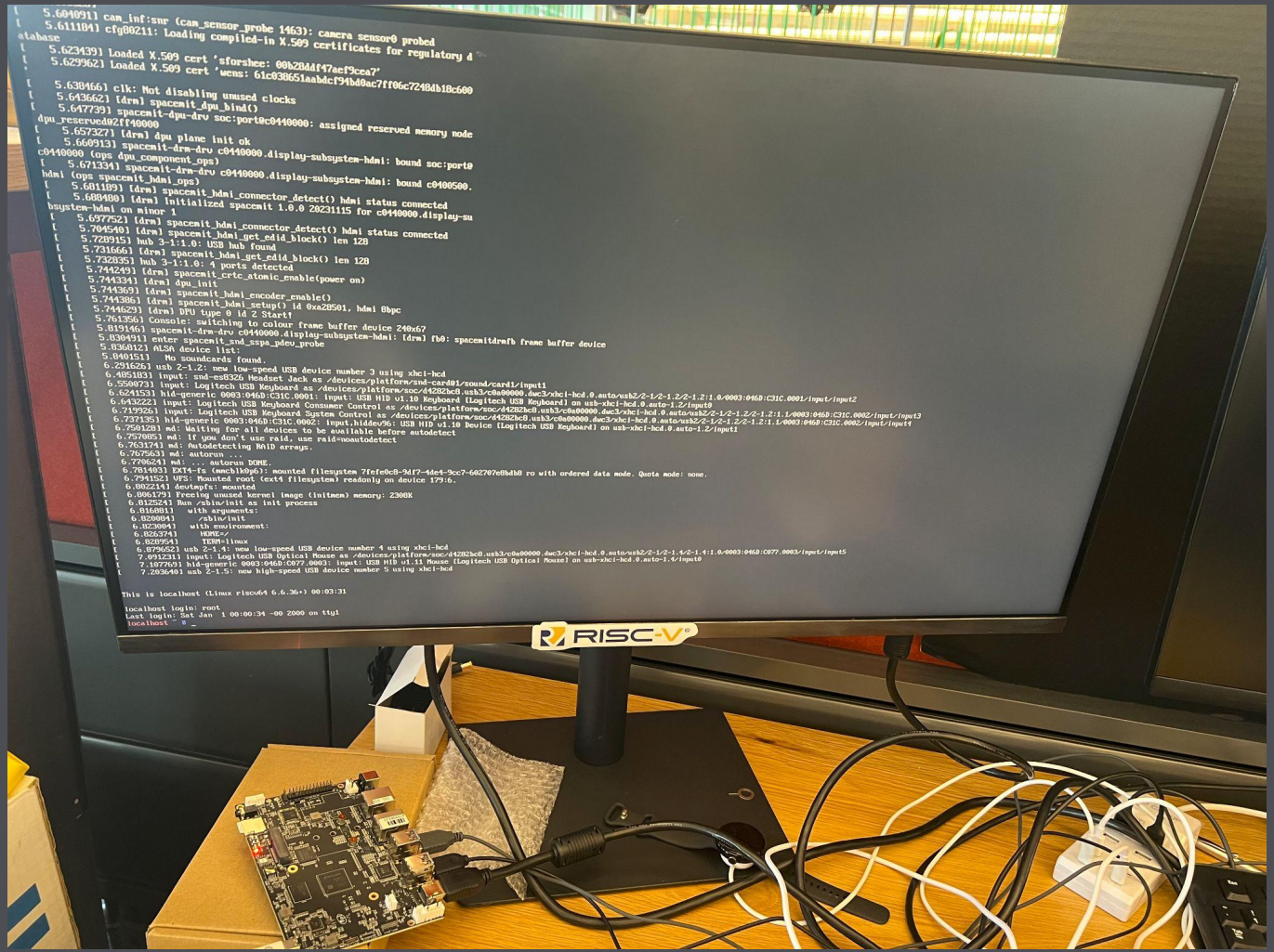
```
localhost ~ # parted /dev/mmcblk0
GNU Parted 3.6
Using /dev/mmcblk0
Welcome to GNU Parted! Type 'help' to view a list of commands.
(parted) p
Warning: Not all of the space available
can fix the GPT to use all of the space
with the current setting?
Fix/Ignore? Fix
Model: SD GC1S5 (sd/mmc)
Disk /dev/mmcblk0: 64.1GB
Sector size (logical/physical): 512B/5
Partition Table: gpt
Disk Flags:

Number  Start   End     Size    File sy
 1      131kB   393kB   262kB
 2      393kB   459kB   65.5kB
 3      459kB   852kB   393kB
Model: SD GC1S5 (sd/mmc)
Disk /dev/mmcblk0: 64.1GB
Sector size (logical/physical): 512B/512B
Partition Table: gpt
Disk Flags:

Number  Start   End     Size    File system  Name     Flags
 1      131kB   393kB   262kB                fsbl
 2      393kB   459kB   65.5kB               env
 3      459kB   852kB   393kB                opensbi
 4      852kB   2949kB  2097kB               uboot
 5      4194kB  528MB   524MB   ext4         bootfs
 6      528MB   4823MB  4295MB  ext4         rootfs

(parted) resizepart 6
Warning: Partition /dev/mmcblk0p6 is being used. Are you sure you want to
continue?
Yes/No? Yes
End?  [4823MB]? 20G
```

Demo



Future Work

- Experiment with alternate whole system build configs
  - Crossdev already supports **riscv64-unknown-linux-musl** as target
  - Paves the way to build the whole system using **clang**

- Build everything with **-O3 -march=rv64gcv_zvl256b**
  - Blocked on gcc bugs, but may work with clang

- Improve the overall cross-building experience
  - This project already found many bugs
    - Few packages (e.g. perl) already got some fixes
    - Crossdev has a pending patch to make it profile-aware
  - Possible to reduce the overall build time further
    - Using specific portage features already improved the overall build time by around 10%
    - Some packages do not take advantage of all available cores
      - Portage can build different packages in parallel as long they are independent

Questions?