Linaro Connect
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An Arm laptop project conclusion

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Introduction

- Windows on Arm (WoA)
- Laptops built on (Qualcomm) 64-bit Arm SoCs
- Quiet and power efficient
- Non-standard boot chain
- Customised OS
- What would it take to run Linux on them?

Project overview

- Linaro project
- Funded by Arm and Qualcomm
- Hardware from Qualcomm and Lenovo
- Proof-of-concept: Mainline Linux on Arm laptop (built for Windows)
- How far could we get?

People

- Johan Hovold
- Björn Andersson
- Linaro’s Qualcomm landing team
- Building on work done by Qualcomm, Linaro and many others

Lenovo ThinkPad X13s

- Snapdragon 8xc Gen3 Compute (sc8280xp)
- 13.3” FHD (1920x1200) display
- 32 GB LPDDR4 (up to)
- 1 TB NVMe SSD (up to)
- Adreno 690 GPU
- 2 speakers, 2 microphones, headphone jack
- 5 MP camera
- Wi-Fi 6E (802.11ax)
- Bluetooth 5.1
- 5G modem (optional)
- 2 x USB-C 3.2 Gen 2
- 49.5 Wh battery

Boot firmware

- Qualcomm and Windows on Arm
- UEFI
  - Runtime services not available after boot (e.g. EFI variables)
- ACPI vs DT
  - Supporting Qualcomm’s non-standard ACPI not feasible
- DtbLoader.efi
  - Ship devicetree blob with UEFI firmware
  - Allows for generic distro installers
- Hypervisor
  - UEFI and Linux starts in EL1
  - No virtualisation

WIP branches

- Important fixes and features under development
- Reference kernel configuration (johan_defconfig)
- Rebased on RC kernels
- Several regressions found and fixed early
- 70 branches so far, latest:
  - https://github.com/jhovold/linux/tree/wip/sc8280xp-6.9-rc7
- Announced on #aarch64-laptops

Mainline feature support

- 6.0
  - Backlight
  - CPUfreq
  - Keyboard
  - Remoteproc
  - Touchpad
  - USB
  - Watchdog
- 6.1
  - System suspend
- 6.2
  - Modem
  - NVMe SSD
  - PCIe (x4)
  - Thermal sensors
- 6.3
  - Battery
  - External display (USB-C DP)
  - Internal display (eDP)
- 6.4
  - Bluetooth
  - IOMMU (*)
  - RTC
  - Touchpad (alternate)
  - Wi-Fi
- 6.5
  - Audio
  - GPU
- 6.7
  - EFI variables

Device firmware

- Use Windows firmware files for bringup
- Work with Lenovo and Qualcomm to get firmware released
- Wi-Fi board file not compatible with ath11k firmware
  - Took one year to get calibration data released
- Everything in linux-firmware (2023-09-19) except:
  - Bluetooth calibration data
  - Video acceleration (venus)

User-space dependencies

- alsa-ucm-conf 1.2.11
- linux-firmware-20230919
- Mesa 23.1.4
- ModemManager 1.20
- Qualcomm protection-domain mapper daemon (pd-mapper)

Work in progress

- Camera (soft ISP)
- DisplayPort audio
- eDP Panel Self Refresh (PSR)
- Fingerprint reader (merged for 6.10)
- USB Power Delivery (USB-PD) (merged for 6.10)
- Video acceleration (in wip branch)

- Bugs and usability issues
- Performance optimisation
- Power consumption

Power consumption

- Idle: 3.2 W (15 h)
  - Backlight at 66% (high)
  - Panel Self Refresh (PSR): +2 h

- Suspend: 1.7 W (29 h)
  - Not yet hitting deepest low-power state

Future work

- Active speaker protection
- Bluetooth BD_ADDR and Wi-Fi MAC address
- ~~Camera ISP~~
- Hibernation
- Keyboard special keys (e.g. mic mute)
- Thermal throttling, non-CPU and non-GPU (e.g. DSP, charger, radio)
- Trusted Platform Module (TPM)
- ~~Virtualisation~~

Pain points

- One full-time developer
  - Regressions, bugs, features, firmware, support
- Regressions
  - Example: 6.9 display regressions
- Hypervisor resets
- Lack of documentation
  - Reverse engineering (e.g. efivars)
  - Bluetooth and Wi-Fi MAC address
- Firmware access
  - Wi-Fi calibration data (took one year)
  - Bluetooth calibration data (still missing)
  - Video acceleration (still missing)
  - Firmware updates (e.g. adsp)

Community

- #aarch64-laptop IRC channel (OFTC)
- Testing
  - Wide range of distros, peripherals and use cases
  - Everyday users
- Support for new users
- Direct contributions
  - EFI variables support (Maximilian Lutz)
  - Freedreno A690 GPU support (Rob Clark)
  - Bluetooth bringup (Steev Klimaszewski)
- Experimental EL2 and virtualisation (Nikita Travkin)

Distro support

- Everything is upstream so any distro should work
  - Recent enough firmware
  - Kernel configuration
- Distros can provide
  - Installer
  - Installation guide
- Examples
  - https://fedoraproject.org/wiki/Thinkpad_X13s
  - https://wiki.debian.org/InstallingDebianOn/Thinkpad/X13s

Wiki

- For updated status, known issues and other resources, see:
  - https://github.com/jhovold/linux/wiki/X13s

Summary

- Lenovo ThinkPad X13s well supported by mainline Linux
  - Primary laptop of several developers
  - Achieved with very limited resources
- Work done benefits future platforms directly
- Remaining issues are generic (Qualcomm) issues
  - Need to be addressed also for future laptops
- The X13s should remain a priority platform
  - Largish user base
  - Regression testing


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Thank you
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