Genode meets the Pinephone

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Outline

1. Background
2. Development Story
3. Preview of Sculpt OS on the Pinephone
4. What's next?

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Motivation

Power struggle

Dominating Corporations

Civil Society

Corporate Motives

1. Profits, growth
2. Recurring and growing revenue
   - Increase the customer base
   - Keep existing customers paying
   - Raise margins whenever possible
3. Fostering customer retention
   - Leverage platform effects
   - Create dependencies
   - Introduce complexity, give aid

   $\rightarrow$ Addicts are the best customers
4. Seeking holistic knowledge

Corporate Motives

People are addicted to smartphones.

Smartphones need constant medication.
Curation of Apps, Security updates, Follow fashion

Two corporations dominate.

My motives as a member of Civil Society

1. Participation in (digital) society
2. Enjoying the utility value of smartphones
3. **Digital Autonomy**
   - Dependability → *no changes without my consent*
   - Dignity → *my attention is mine, no Ads, no tracking*
   - Privacy of communications
   - Protection of personal data
4. Sustainability → *environmental footprint, learned skills*

Risks for Conflicts of Interest

- Subscription-business models $\rightarrow$ *taxation of digital life*
- Data silos
- Mass surveillance
- Growing extortive power of dominant corporations
- Artificial aging of digital products $\rightarrow$ *Electronic waste*

Risks for Conflicts of Interest

These are political problems...
...outside the scope of the Microkernel Devroom.

But as technologists,
we can draft alternative paths!

Sentiments shared by a few others...

Precursor by Sutajio Kosagi

- Custom FPGA-based SoC
- Open-Source Hardware
  (board, schematics)
- Custom Open-Source firmware / OS
- Crowdfunded at
  `https://www.crowdsupply.com`
- Deliberate deviation from smartphones

Precursor

Mobile, Open Hardware, RISC-V System-on-Chip (SoC) Development Kit

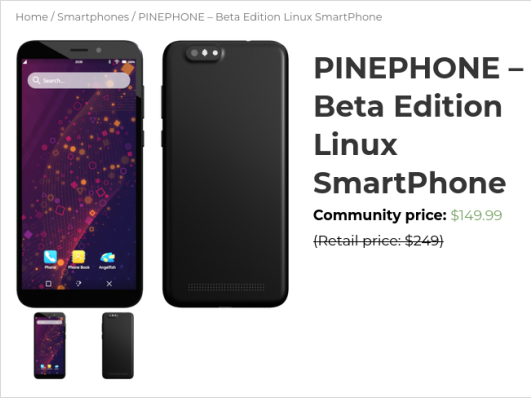
Part of **Silicon Labs IoT Accelerator**

170% Funded!		Order Now
$375,157 raised	23 updates	570 backers

What about Smartphones?

Pinephone by Pine64

- Open-Source-friendly
  (public documentation, schematics)
- Targeting the Linux community
  (mainline kernel, diverse distributions)
- Well-understood 64-bit ARM SoC
- Readily available
  `https://www.pine64.org`



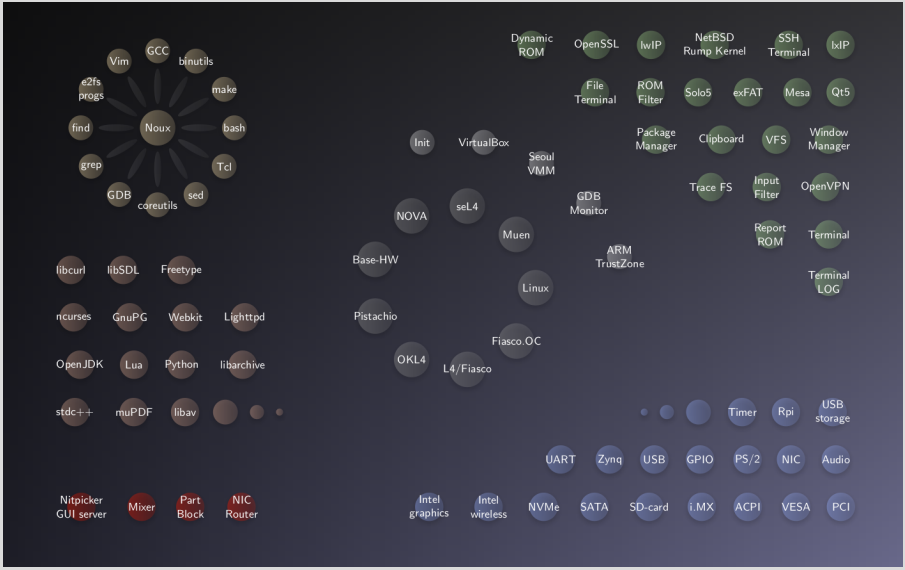
Open Source is not enough

Complexity defeats autonomy.

Linux distributions are impossible to assess.
We need to be faithful in an incomprehensible software stack.

No cure for security-update treadmill in sight.

Genode OS Framework



Mission: Combine Genode OS with the Pinephone

Aspired features

- Telephony
- Messaging
- Web browsing
- Encrypted communication
- Encrypted storage
- Good battery life

Out of scope

- Entertainment
- Comfort functions *(digital camera, turn-by-turn navigation, ...)*

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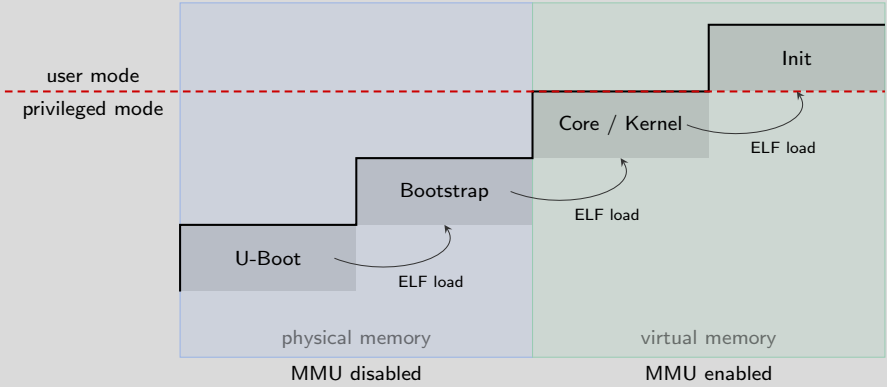
Development Story

Development Story - Genode boot steps



Development Story - Bare-metal serial output

A few lines of C...

```
static char const *text = "Aye aye.\n\r";
static char const *s;

for (;;)
  for (s = text; *s; s++)
    *(unsigned int volatile *)0x1c28000 = *s;
```

...plus a little Makefile...

```
serial_test: main.c
   $(CROSS_DEV_PREFIX)gcc -Wl,-Ttext=0x42000000 -nostdlib $< -o $@
   $(CROSS_DEV_PREFIX)objdump -ld $@

serial_test.img: serial_test
   $(CROSS_DEV_PREFIX)objcopy -Obinary $< $@
```

... can be a way to happiness!

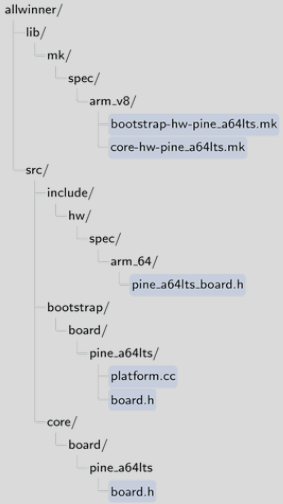
Development Story - Porting the Kernel

Allwinner A64 SoC

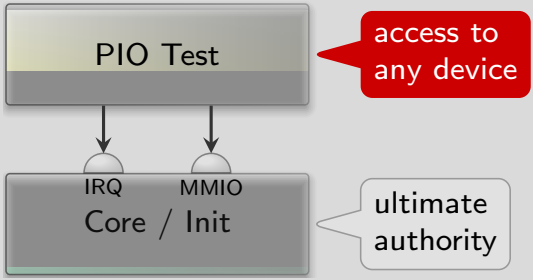
- Cortex-A53, 4-core ARM v8a
- GICv2 interrupt controller
- Generic timer
- NS16550 UART
- RAM layout

→ Merely selecting existing parts of the base-hw kernel

Development Story - Porting the Kernel



Development Story - Device access



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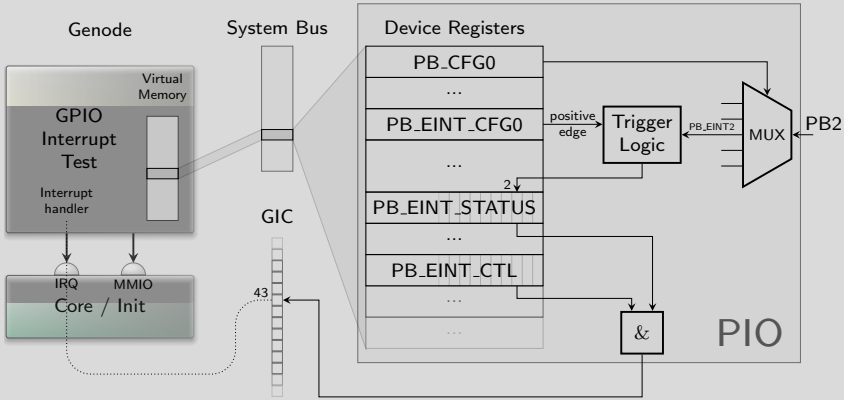
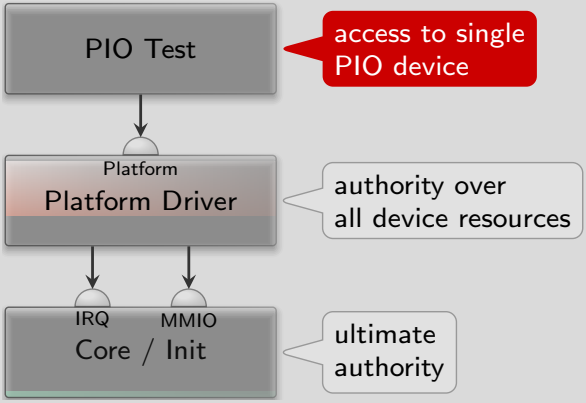
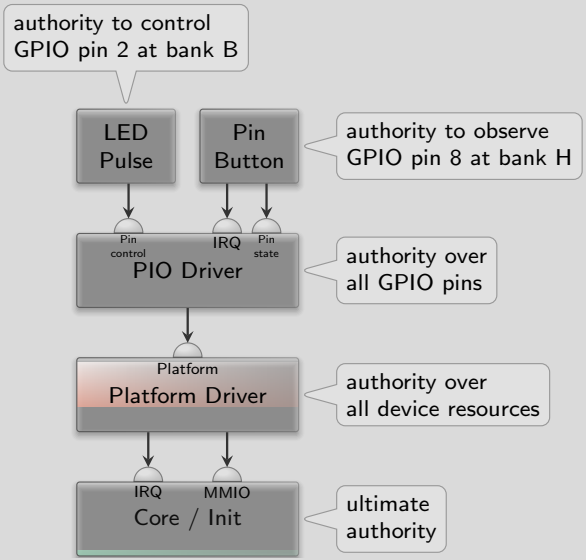


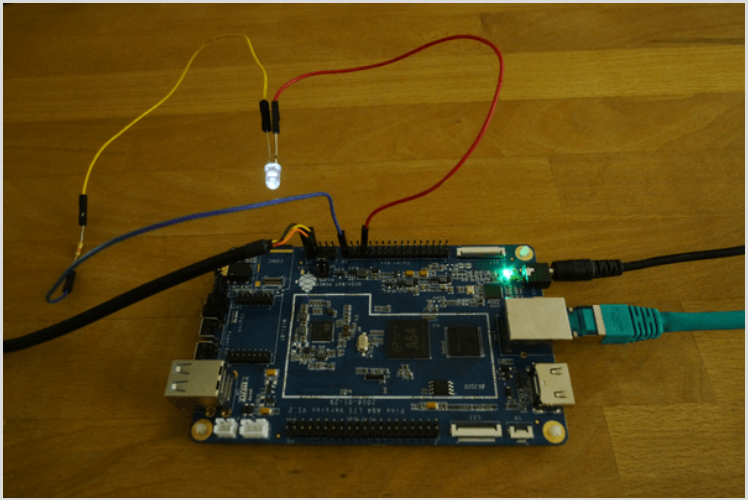
Development Story - Platform driver



Development Story - Cascaded authorities



Development Story - Experimental setup



Development Story - “Real drivers”

ARM SoCs are less regular than PC hardware

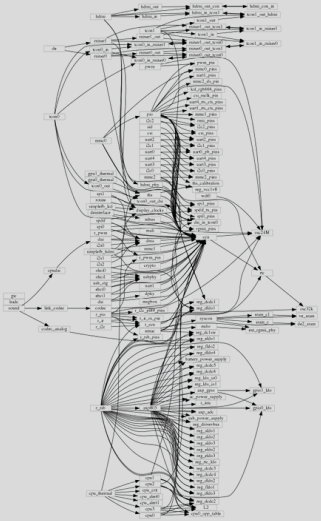
- Complex interplay of device units
  - Power regulators
  - Clocks, Resets
  - Variety of buses, quirky details
- Board-dependent pin functions (IOMUX)
- Lacking documentation

The only reliable reference is the Linux kernel

- Device trees = hardware documentation
- Porting beats developing
- Start with reasonable complex example → *Ethernet*

Development Story - Surviving in the Forest of Device Trees

Getting an overview of the Pine-A64-LTS hardware...

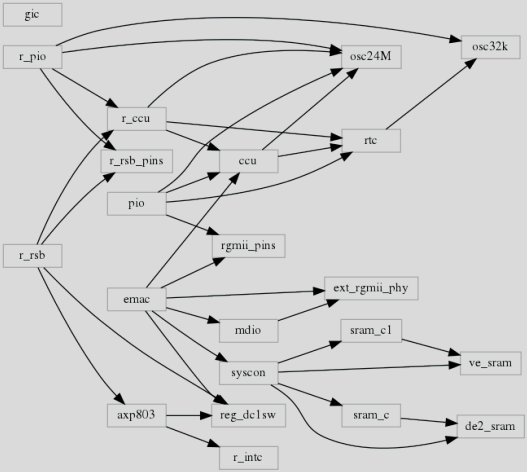


Development Story - Surviving in the Forest of Device Trees

Custom tooling for pruning device trees

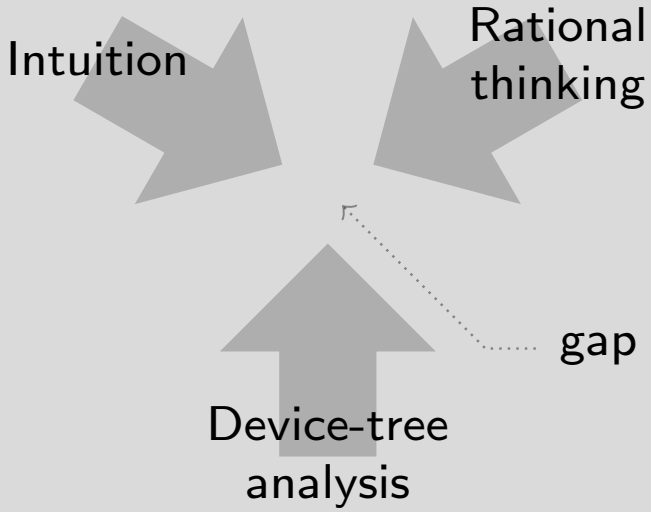
```
tool/dts$ ./extract -select emac flat_pine64lts.dts > emac.dts
```

Development Story - Surviving in the Forest of Device Trees



SoC parts relevant for the EMAC network device

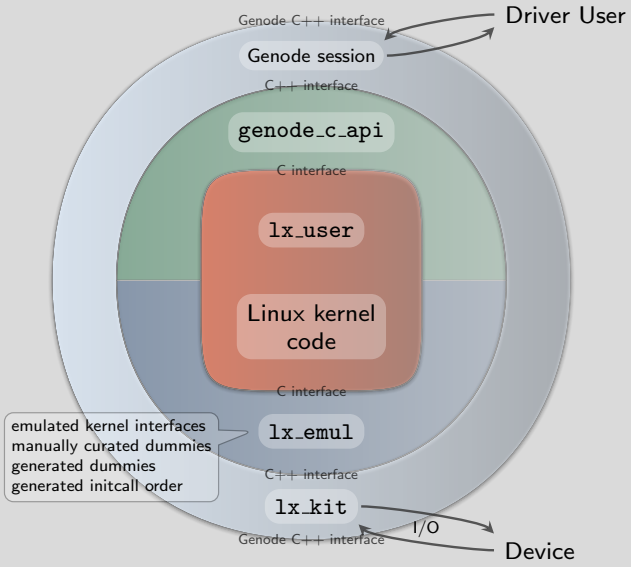
Development Story - Configuring a bare-bones Linux kernel



Configuration bisecting as last resort

```
# kernel fundamentals
LX_ENABLE += TTY SERIAL_EARLYCON SERIAL_OF_PLATFORM PRINTK HAS_IOMEM

# initrd support
LX_ENABLE += BINFMT_ELF BLK_DEV_INITRD

# SoC
LX_ENABLE += ARCH_SUNXI

# UART device
LX_ENABLE += SERIAL_8250 $(addprefix SERIAL_8250_,16550A_VARIANTS DW CONSOLE)

# network infrastructure
LX_ENABLE += NET NETDEVICES ETHERNET

# network driver
LX_ENABLE += NET_VENDOR_STMICRO STMMAC_ETH STMMAC_PLATFORM DWMAC_SUN8I

# ethernet PHY
LX_ENABLE += OF_MDIO MDIO_DEVICE PHYLIB
LX_ENABLE += MOTORCOMM_PHY                # needed for Pine-A64-LTS-V2

# network protocols
LX_ENABLE += INET IP_PNP IP_PNP_DHCP
```

Development Story - Linux Device-Driver Environment



Development Story - Pinephone as development platform

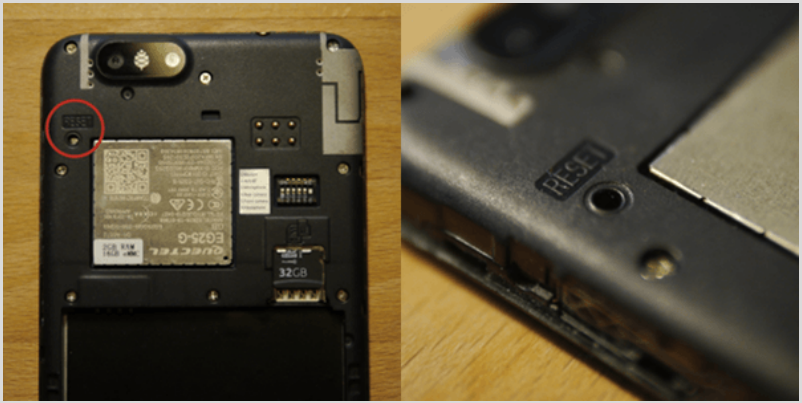
Nice Pinephone features

- Can boot directly from SD card!
- Audio jack can be turned into serial line!
- Accessible reset button!

Development workflow considerations

- SD-card juggling not viable
- Boot-loader customization
  - No Ethernet $\rightarrow$ no TFTP boot
  - Exploration of U-Boot's fastboot support
- Genode workflow automation (custom run-tool plugins)

Development Story - Pinephone as development platform



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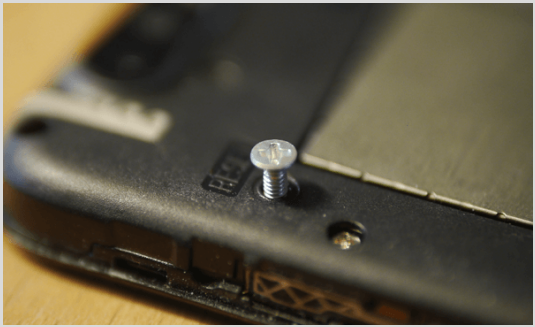
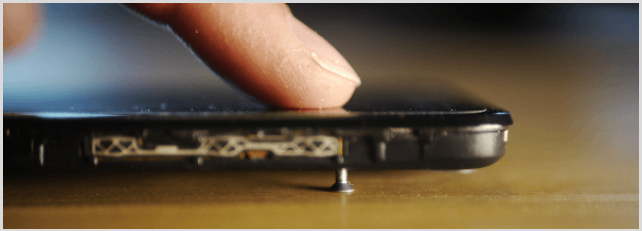
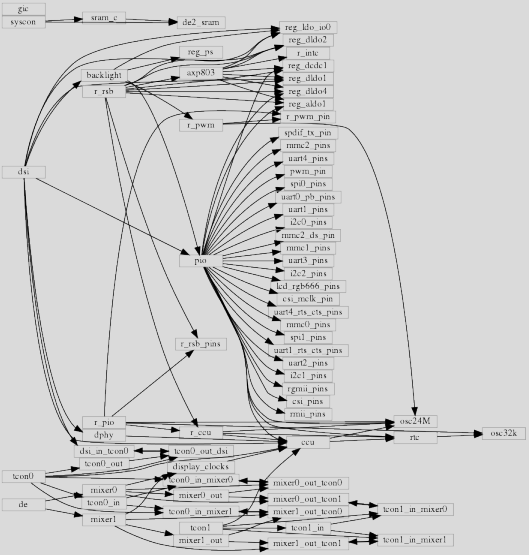




Development Story - Display



Development Story - Cutting down Linux

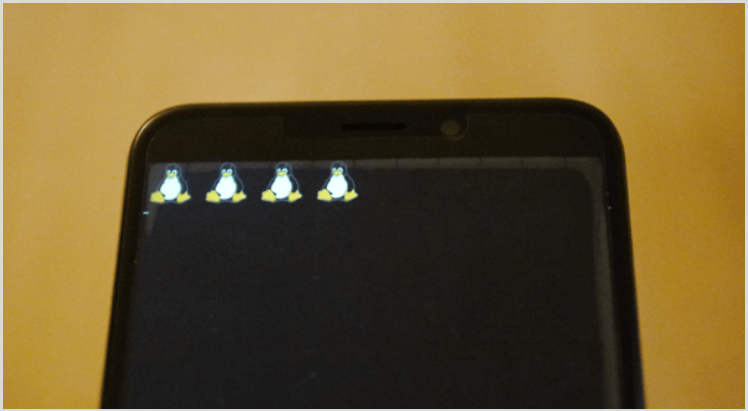
```
# framebuffer driver
LX_ENABLE += DRM DRM_SUN4I DRM_SUN8I_MIXER DRM_SUN8I_DW_HDMI

# determined by bisecting kernel configuration options (needed by fb driver)
LX_ENABLE += CMA DMA_CMA MFD_AXP20X_RSB REGULATOR REGULATOR_AXP20X
LX_ENABLE += PROC_FS SYSFS

# to automatically set up screen mode at boot time
LX_ENABLE += FRAMEBUFFER_CONSOLE

# show Tux
LX_ENABLE += LOGO
```

Development Story - Cutting down Linux



Development Story - Transplanting Linux code to Genode

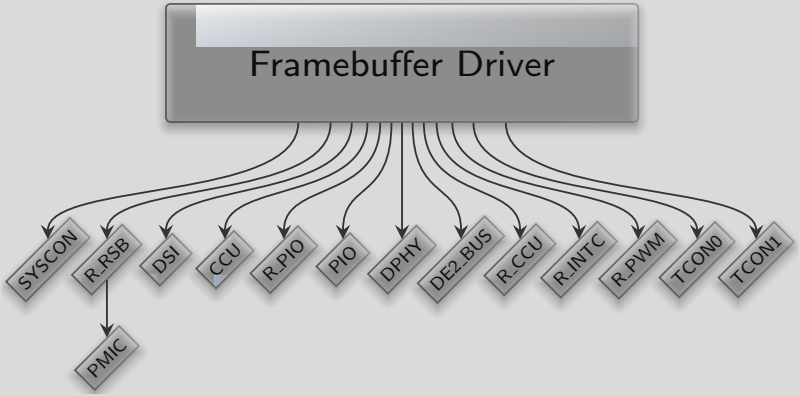
1. Selecting the relevant driver sources
2. Compiling and linking
3. Generating dummy implementations of unresolved symbols

```
$ tool/dde_linux/create_dummies generate \
                                LINUX_KERNEL_DIR=a64_linux \
                                TARGET=drivers/framebuffer/de
```

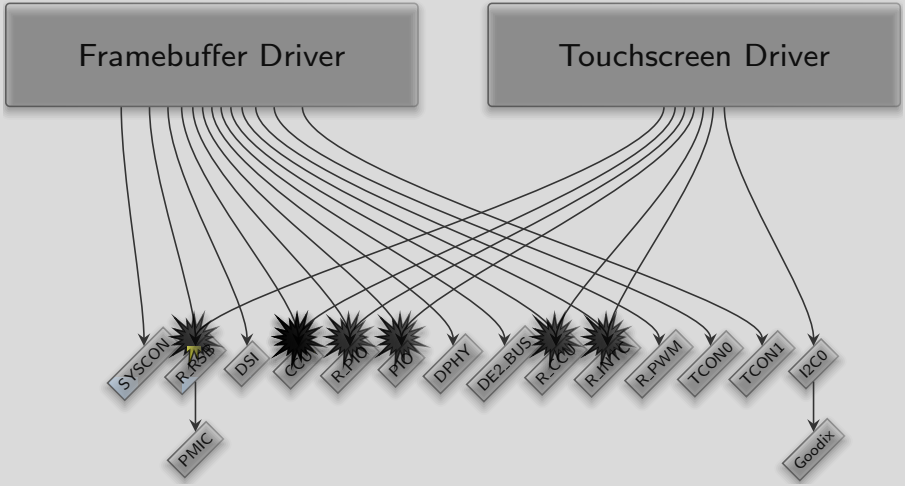
4. Supplementing custom Linux emulation code, looking sideways
5. Using a custom run script test bed for the driver
6. Resolving the access to device resources at the platform driver

Development Story - Display

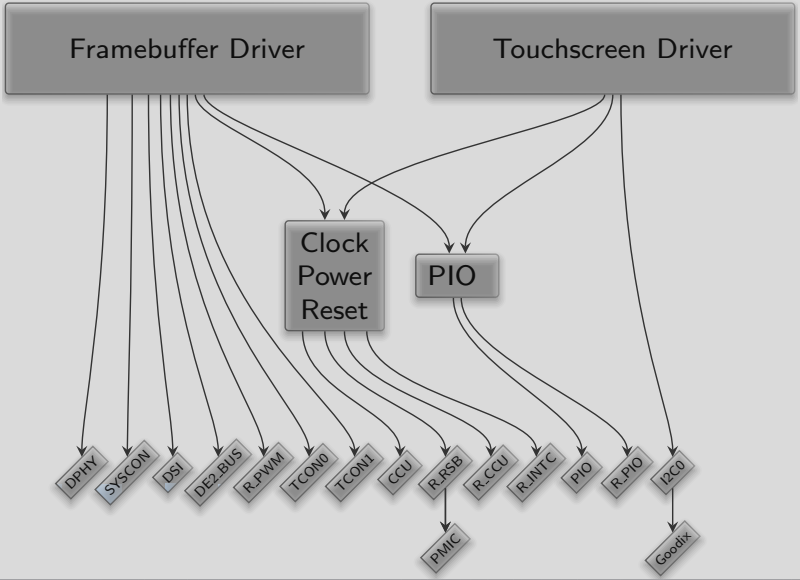
Development Story - Display



Development Story - Display and Touch



Development Story - Reconciliation



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What's next?

Goal for 2022: Video chat via Genode/Sculpt on the Pinephone

- Voice telephony
- Persistent storage (SDcard, eMMC)
- Mobile-data connectivity
- Power management
- Performance
- Chromium browser
- Camera
- Real-time media streaming
- Wireless networking
- Simple mobile UI

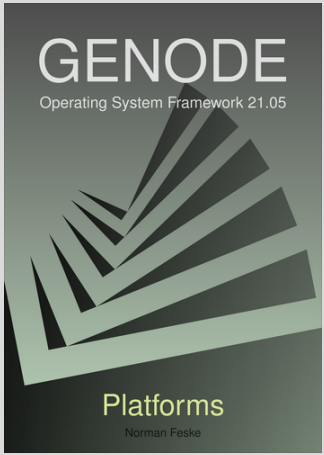
Following the progress...

"Pine fun" article series

https://genodians.org

Following the progress...

Evolving “Genode Porting Guide” document



`https://genode.org`

Thank you

Genode OS Framework

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