SmolPhone

a smartphone with energy limits

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SmartPhone evolution

Nokia 3310 (2000)

16 MB storage
100 MHz ARM7
13 kg eq.CO2

Iphone 3GS (2009)

32 GB storage
600 MHz ARM8 + GPU
55 kg eq.CO2

Iphone 14 Pro (2020)

Up to 1TB storage
6 cores + 5GPU + NN+Img
116 kg eq.CO2

- Battery life: only feature to steadily decrease, despite tripled capacity

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SmolPhone project

- A device offering some smartphone-like features but lasting days on a charge
- Aim of increased battery life, possibly at the cost of a reduced set of features

Energy trade-offs

Typical smartphone consumption (from literature)

- CPU: 3000 mW
- Screen: OLED 800 mW
- Cellular: 600 mW idle / 1200 mW TX (4G – LTE Cat4)
- Wifi: 80 mW idle / 120 mW TX

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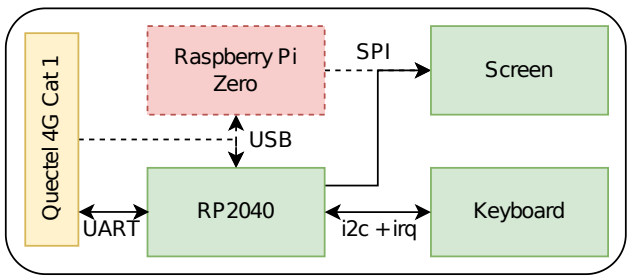
Smolphone envisioned hardware

- Energy-efficient computing: micro-controllers
  - RP2040 (Cortex M0): 100 mW / core @133MHz; Fast sleep mode at 0.4 mW
  - Speed comparable to Pentium II (1997 – $\approx$ 50W) but 264kB RAM, 2MB flash
- Energy-efficient screen
  - OLED: 3 mW/cm^2 (black) to 20 mW/cm^2 (bright white)
  - eInk is bi-stable, but inefficient updates (10 mW/cm^2 at 2 Hz)
  - Memory LCDs: no refresh $\rightsquigarrow$ 2 μW/cm^2 (monochrome, fast)
- Energy-efficient cellular network
  - LTE Cat M1: 200 mW (TX 10kbps) / 5G: 3000 mW (TX 100Mbps)

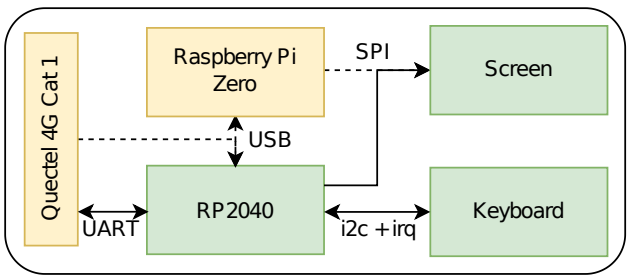
The SmolPhone vision: advanced low-techs

On-board computation offloading

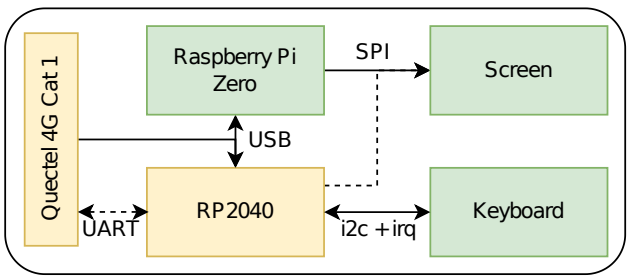
- Tiny-small design: most operations on a RP2040 microcontroler;
  - Offload heavy computations to a Raspberry Pi Zero on board
  - Pass full control to Pi Zero for legacy application



Main operating mode



Offloading computations



Capability / performance mode

- Multikernel: Harness compute power; offload TCP, filesystem to other chips
- Compile-time verif with Rust to alleviate lack of MMU & runtime safety

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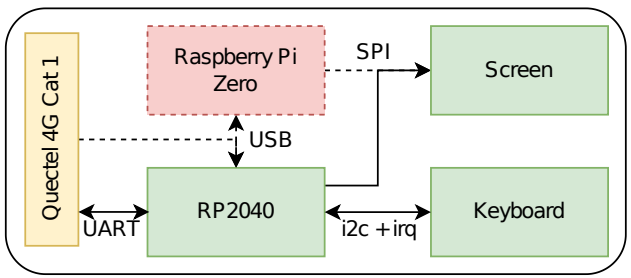

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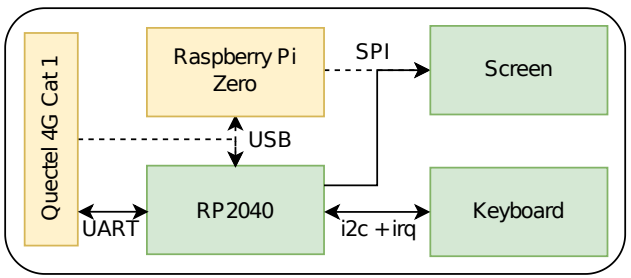

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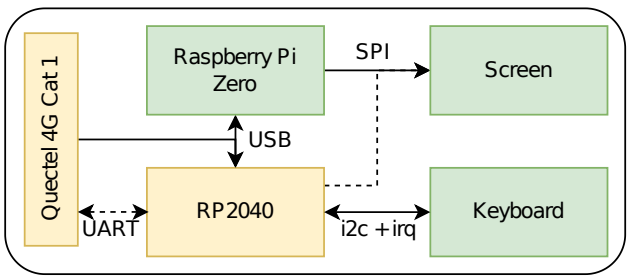

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Online proxying in cloud

- Remote renderer of HTML5, before download
  - Do not offload anything to the cloud (extra work hardly efficient)
- Online point of presence: turn off data plan aggressively
  - Online proxy sends text messages when a message arrives

Conclusion

Designing a smartphone with energy limits

- A device offering some smartphone-like features but lasting days on a charge
  - Tiny-small design on board + multi-kernel to spread OS functions on chips
  - Cloud-assisted: Rendering in smart proxy + online point of presence

Prospective applications

- Phone, Text messaging, DAV calendar, todo notes, podcasts: RP2040
- MyAndroidApp: Pi Zero with WayDroid; Passkey instead of banking app
- GPS navigation: Tile rendering on Pi Zero, navigation on RP2040
- Instant messaging: Matrix proxy server in cloud, interactions on RP2040
- HTML pages: Rendering in cloud, interactions on RP2040
- Redefining smartphones: features removed (video), but offline OSM / WP

Current state: prototyping / exploration