SmolPhone

a smartphone with energy limits

Joseph Paturel, Martin Quinson, Simon Rokicki
Univ. Rennes, IRISA, Inria, France.

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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
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Iphone 14 Pro (2022)

Up to 1TB storage
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Exponential growth vs. Finite resources and finite needs

- How could we do otherwise? Do we really need all this?
- Can we go for low-tech mobile computing? What would it mean?

What are the low-techs?

Definition by ADEME

- Maximize social utility; Reduce complexity; Maintenance over replacement
- Reduce environmental impact to not overpass local and planetary limits
- Aim at essential needs
- Accessible solutions: empowers broader audience w/ understanding and usage

Definition by the Low-tech Lab

- Accessible: buildable and repairable with no advanced tooling/knowledge
- Useful: not futile. Addressing fundamental needs.
- Durable: ecological (efficient, reuse), reparable.

Definition by Stéphane Crozat

- environnemental sustainability, social responsibility and technical conviviality

Some initiatives toward practical applications

- Some fablabs, Low-tech lab, L'atelier paysan, etc (but none in ICT).

Low-tech computing?

Previous definitions are not adapted to computing

- Are computers doomed as a large technosystem? cf. "Héritage et Fermeture"
- Resilient systems (efficient, durable, reusable, easy-to-use, fault tolerant)?
- Can we avoid rebound effects and expert's dictatorship?

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ESOS project (lead by Insa Rennes)

- Sustainable, Open and Sovereign Electronic
- Bottom-up approach to the problems induced by the computing technosystem

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The SmolPhone project (this work)

- Attempt toward a useful, durable and accessible mobile computing
- Top-down: Simplify hardware to the point where capabilities must be reduced

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- Attempt toward a useful, durable and accessible mobile computing
- Top-down: Simplify hardware to the point where capabilities must be reduced
- Smartphone with increased battery life at the cost of a reduced set of features
  - Reconsider classical design choices

The SmolPhone project

Research-action in post-growth computing

- Practical goal: low-tech smartphone with a one-week battery life
  - Not optimizing but reconsidering design choices
- Long term (unrealistic) goals: lasting 10 years; hackable by non-specialists
- Non-goals:
  - Cheaper device
  - Business plan on selling devices or services
  - Nostalgia or retrocomputing: need GPS, WhatsApp/Signal, web access, etc.
- Inspirations:
  - UXN: tiny but convivial VM (64kb of working memory but lovely assembly)
  - gemini: debloated HTML (web of hypertexts without inline links or images)
  - oulipo: writing movement using formal constraints to boost the creativity

Going under 100mW on average: hardware side

- Battery on FairPhone5 or iPhone 15: $\approx$ 4200mAh = 16.25Wh = **97mW·week**

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Typical smartphone consumption (Galaxy S3 – 2017)

- CPU: 80mW idle / 3000 mW full
- Screen: OLED 800 mW — 3 mW/cm² (black) to 20 mW/cm² (bright white)
- Cellular 4G: 600 mW idle / 1200 mW TX
- Wifi: 80 mW idle / 120 mW TX

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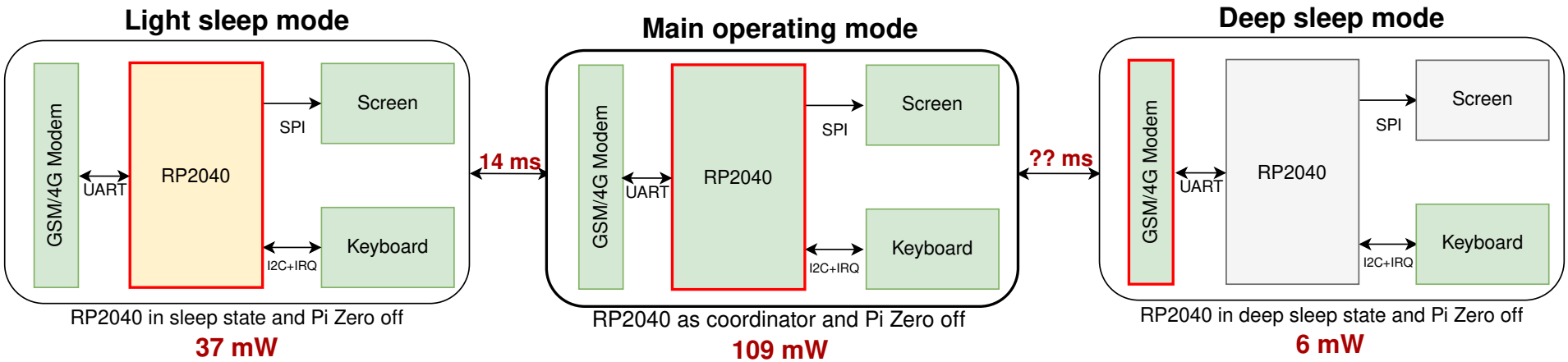
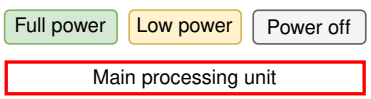
Smolphone envisioned hardware

- Energy-efficient computing: micro-controllers (RP2040: 100mW peak)
  - Speed comparable to Pentium II (1997 – $\approx$ 50W) but 264kB RAM, 2MB flash
- Energy-efficient screen
  - eInk is bi-stable, but inefficient updates (10 mW/cm² at 2 Hz)
  - Memory LCDs: no refresh $\rightsquigarrow$ 2 μW/cm² (monochrome, fast)
- Energy-efficient cellular network
  - 4G LTE Cat 1: 1µW idle, 250 mW TX (10kbps)
  - 5G: <1µW idle, 3000 mW TX (100Mbps)

Building a smartphone on that hardware

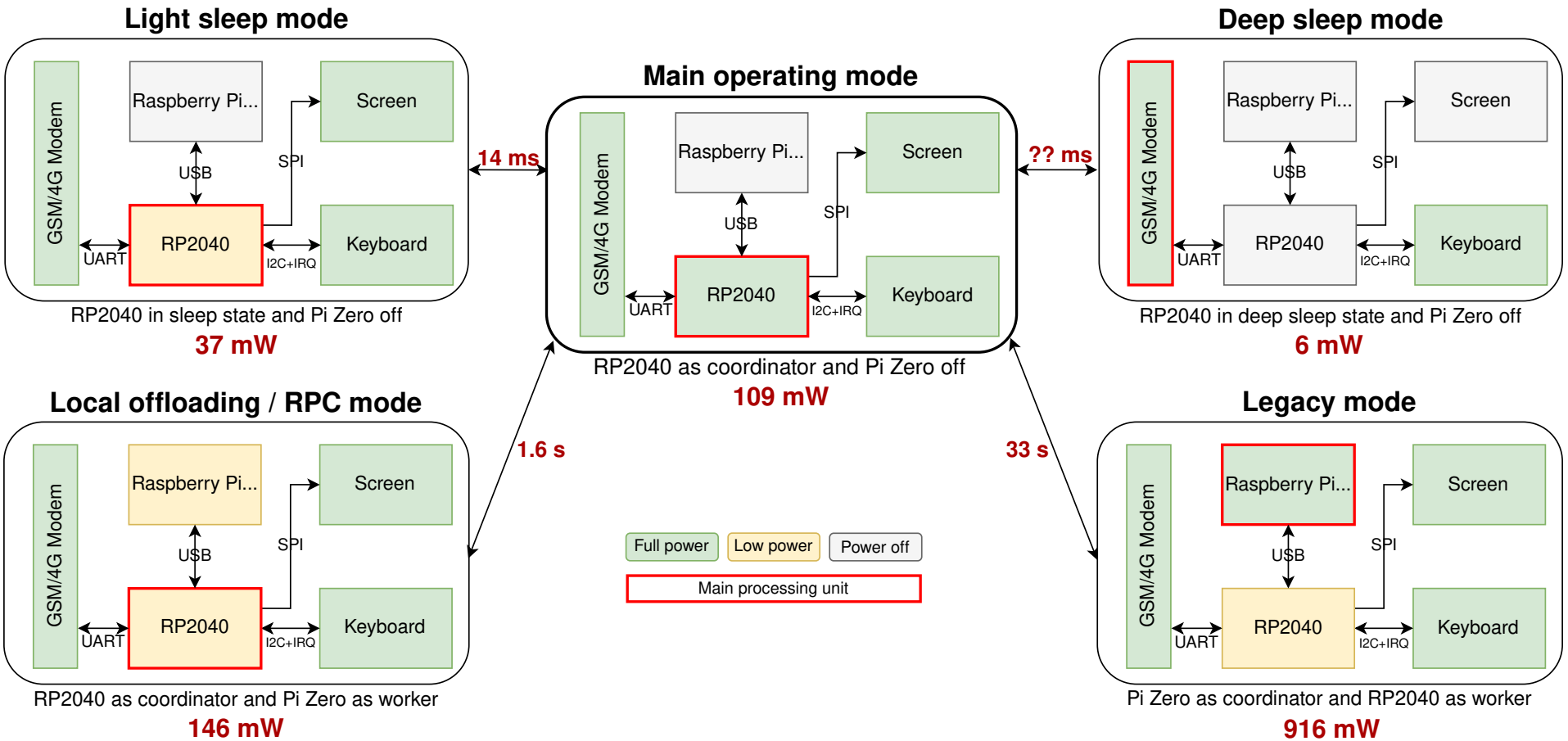
- Run on a RP2040 microcontroler
- Light sleep mode dozen times a second; deep sleep whenever possible





Building a smartphone on that hardware

- Run most operations on a RP2040 microcontroler
- Light sleep mode dozen times a second; deep sleep whenever possible



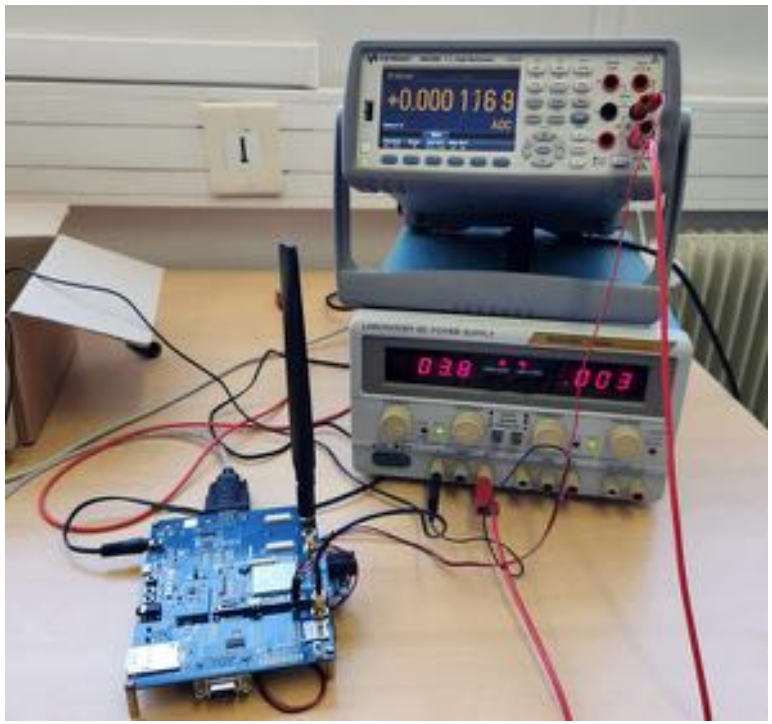
- Tiny-small design: add a Pi Zero for heavy computations
- Offload simple computations to PiZ bare metal (GPS tile)
- Pass full control to Linux on Pi Zero for legacy application

Quectel E912U-GL

- LTE Cat 1 are low-power modems intended for IoT
- Power Saving Mode: power off; back on RX or interrupt. $\approx$ 1µW
- Discontinuous reception (eDRX): off for 60s when no data is expected. $\approx$ 1µW

Preliminary measurements

- Data TX or RX: 250mW
- Voice call: 500mW
- Idle: 100mW
- Sleep: 40mW
- PSM: 1µW ?
- Text message: 0.1mWh



- More work needed to characterize this device, and explore others

Online infrastructure

Remote rendering

- HTML5 cannot be rendered on 2040
- Render in the cloud before download, to not start the PiZ
- 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 Signal message arrives
- Maybe useless with LTE M1 hardware?

Junkyard computing

- Reuse existing hardware (e.g. your old phone)
- Reduce carbon impact
- Data self-hosting improves privacy

Software stack

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

Smol is beautiful

- Applications should be scripted for conviviality (UXN targets 64kb of RAM)
- Aggressively prioritize simplicity over features (inspired by DuskOS)

Redefining smartphones

- Some features are removed: video, IA and neural networks
- Some features are added: offline OSM and wikipedia, easy extensions
- What can I remove from your smartphone before you stop using it?
- What crazy application you'd want?

Designing a smartphone with energy limits

Low-power mobile device

- Memory LCD + keyboard: 0.5mW monochrome (from 800mW OLED)
- LTE M1 cellular: 250mW @10kbps (from 1200mW 4G or 3000mW 5G)
- Processing: RP2040 100mW per busy core + 900mW Pi Zero (from 3000mW)

Device with smartphone-like features but lasting days on a charge

- Tiny-small design on board
- Cloud-assisted: Rendering in smart proxy + online point of presence

Other crazy ideas

- Multikernel: Harness compute power; offload TCP, filesystem to other chips
- Noisy algorithms: long-lasting device through soft robust to transient faults
- Data-over-Voice-over-GSM, intermitent computing, energy harvesting

Why would I want such phone?

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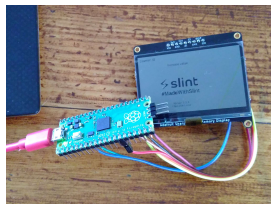
Why would I want such phone?

- Trade power (let the world obey) for might (do things by yourself) [Damasio]
- Really yours to fiddle with: opening it won't void the warranty

SmolPhone current state

Prototyping and exploration since maybe one year



Past internships

- Aloïs Rautureau: On-board offloading (metering the modes' consumption)
- Israel Kafando: Metering the 4G modem, and modem workbench

Ongoing internship: SmolNet

- Aurel Hamon: Cloud rendering, deported asynch GUI and simplified HTML

Future work: Inria Action Exploratoire

- HW engineer for 2 years: Puzzle prototype + A5 devboard + better form factor
- Victorien Elvinger: software engineer for 2 years
  - Scriptable convivial framework (between uxn and DuskOS)
  - Base software (phone, text messaging, DAV calendar, todo notes, podcasts)
  - Online infrastructure toward self-hosting and junkyard computing

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2025-. . . : Post-growth distributed infrastructures

- We need less bloat, in a fluctuating world.
  - Simplicity over modularity; Robustness over performance and control
- Not forking off my research agenda, just another perspective on same objects
- Since tech is not neutral, what is it that you want to foster?

Conclusion

Low-techs as an appealing future

- Resource efficient, accessible by novices, participative, non-superfluous needs
- Social utility, low complexity, long maintenance, essential needs, accessible
- Accessible, useful and durable.

Special challenges to low-tech computing

- Rebound effect, expert dictatorship, technosystem as a ruinous ruin

The SmolPhone project

- Low power hardware limiting the applications by design
- Constrains unleash creativity, toward many original research projects

We are scientists

- We are not going to change the world, but we can at least work towards it