WHY APPLICATIONS ARE STILL DRAINING OUR BATTERIES

and how we can help.

Aaron Schulman & Sachin Katti
We cannot rely on improvements in battery technology.

In past 30 years: only 4x improvement in energy density.

Source: Panasonic.
We can no longer rely on shrinking transistors

End of Dennard Scaling

2005

Source: Horowitz et al.
We now rely on heterogeneous design and power management logic. However, this makes it difficult for developers to reason about energy.
Application energy regressions often appear in the wild

**2015**

- Chrome is still a threat to your MacBook's battery
- Apple Music Will Kill Your iPhone Battery; Here's What To Do About It
- Fitbit Charge Users Report Worse Battery Life After Firmware Upgrade

**2016**

- Google Nest's battery-drain: Chilly users turn up heat over thermostat software glitch
  
  A software update may be the source of Google-owned Nest's smart thermostats becoming unresponsive or incapable of operating efficiently.

- Uninstalling Facebook app saves up to 20% of Android battery life

  Facebook's Android app negatively impacts performance and battery life, even when it's only running in the background, users find.
Empower application developers with tools that enable them to write efficient software.

Accurately measure system-level power and attribute to apps.
BattOr: Power measurement for application developers

Insight: The designs of battery powered computing devices are amenable to power measurement

1. Power monitor circuit

2. Power supply interceptors

3. Clock synchronization
Application developer requirements for power measurement

- **Accurate**: Power measurements must be actionable
- **Attributed**: Power must be associated with application actions
- **Practical**: Doesn’t require hardware mods, portable, automatable
Today’s power monitors trade off ease-of-use for accuracy and attribution.

**Monsoon** - Requires AC power and battery wires must be soldered onto device.

**NEAT** - Requires modification of an external battery and soldering a trigger wire.

Accurate

Attributed

Also, neither can monitor laptops.
A portable power monitor for smartphones & laptops

Insight: Power measurement is an ideal application for embedded systems
Intercepting a smartphone’s battery connection without soldering

Practical

Insight: Many smartphones have the same battery connectors
Camera flash-based clock sync

Attributed

Insight: Clock sync markers can be modulated into power measurements
Demo: BattOr is built into Google Chrome
Can BattOr find energy bugs in real world applications?
Diagnosing an energy bug in Chrome-for-Mac’s graphics stack

Chrome is still a threat to your MacBook's battery

133% → 125% → 114%
Teaching Stanford EE students about embedded systems by building BattOrs

- Analog circuits
  - Instrumentation Amplifier
- Synchronous serial
- Asynchronous serial
- GPIO
  - LEDs
- Clocks
- Timing
- Microcontroller arch.
- Firmware development
- Atmel 8-bit microcontroller (integrated ADC)
- 1 Mbit/s UART
- PCB Design
- SMD soldering
- 2”x3” PCB
- Digitally controlled potentiometers
Stanford’s EE107 students used their BattOrs to compare similar Android apps.

A student’s BattOr connected to a Nexus 5 smartphone.
Why is their energy consumption different?

Player FM decodes and add effects to the audio in software
Datacenters need energy debugging too

Efficiency gains from improving cooling and power distribution are diminishing

**PUE** - ratio of total data center energy to computing energy

Source: Google
Future work: BattOr in the data center

Vision: Use BattOrs to develop efficient cluster computing applications

• Likely many energy bugs in cluster computing applications
• Can we produce a global trace of the energy consumed across all servers?
• How do we design cluster applications that are optimized for energy?