Decomposing Power Measurements for Mobile Devices

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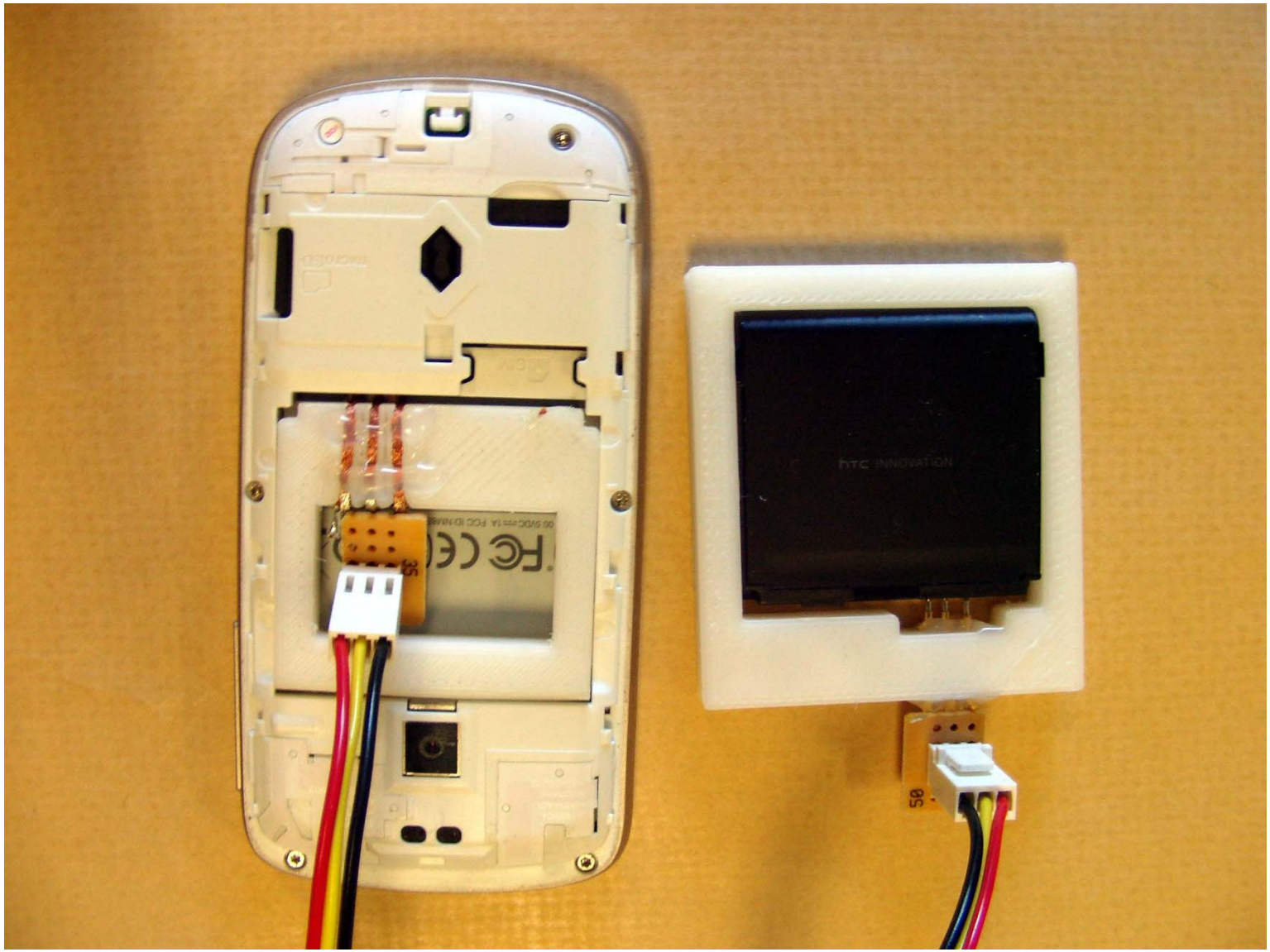
Introduction

- Lots of mobile phones! (over 2 billion)
- Power consumption an issue
  - Power hungry, short-lived
  - Constantly running, low power
  - Context-sensitive, participatory sensing
- What if we could analyze power consumption, and make better choices?

System Features

- Automated test execution (automatic testing)
- Batch operation (sequences of tests)
- Untethered operation (no physical connections)
- No hardware modification (except replacement battery)
- Power Server, phone client


htc INNOVATION

Measurement Hardware

- Power consumption measured using .02 ohm measurement resistor
  - Replacement batteries for G1 and Magic
- National Instruments PCI-MIO-16E-4 sampling board to measure voltage
  - Developed prototype microcontroller to use in future experiments
- Hardware did not effect power use

Test Client: Steps

- Download script
- Prepare
- Sync
- Test
- Prepare
- Sync
- Upload log

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Test Client: Stabilizing

- Break down power consumption
- Ideal: identify, characterize, shut off
- CPU – constantly waking up processes
  - Run background process
  - Stabilizes power trace
  - Can't distinguish between test and background loads (not a big deal)

Test Client: Synchronization

- Events very quick (<1sec)
  - Must match times on phone and measurement PC
- Embed a sync pulse in the energy trace!
  - Backlight off to on
  - Embeds two Gold codes on either end
  - Use these times w/ energy to create trace of the pulse

Test Client: Calibration

- Many tests involve initializing components
- Scripts allow marking steps as baseline
  - Calculate power for these steps, remove from subsequent steps
  - Transmitting over WiFi vs. keeping WiFi open

Traffic Monitoring

- Costs of different methods to send/receive
- PC connected to WAP, running DHCP
  - Libpcap on PC to record all traffic
- Combines sync info, timing log, and net traffic to produce graph of power consumption

Power Consumption Analysis

- Let's use it!
  - Studied sending data over wireless
- Results gathered using the Magic handset
  - G1 results almost identical

Analysis: Connecting

- Connect to WiFi, get IP using DHCP
  - Follows standards in RFCs

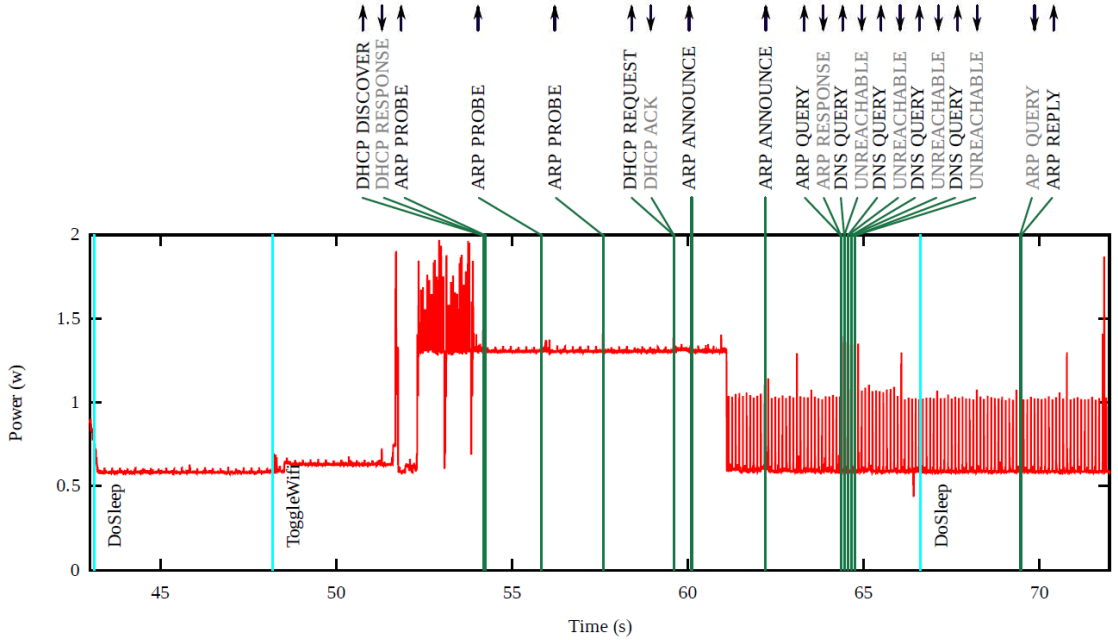

Figure 9. An extract from the energy trace of connecting to a WiFi network and obtaining an IP address, annotated with each IP packet sent and received.

Analysis: Idle Power

- WiFi lowest, then 3G, then 2G!
  - Not concrete, base station location and building matter
  - Shows cannot assume one will always be better!

Analysis: Idle Power

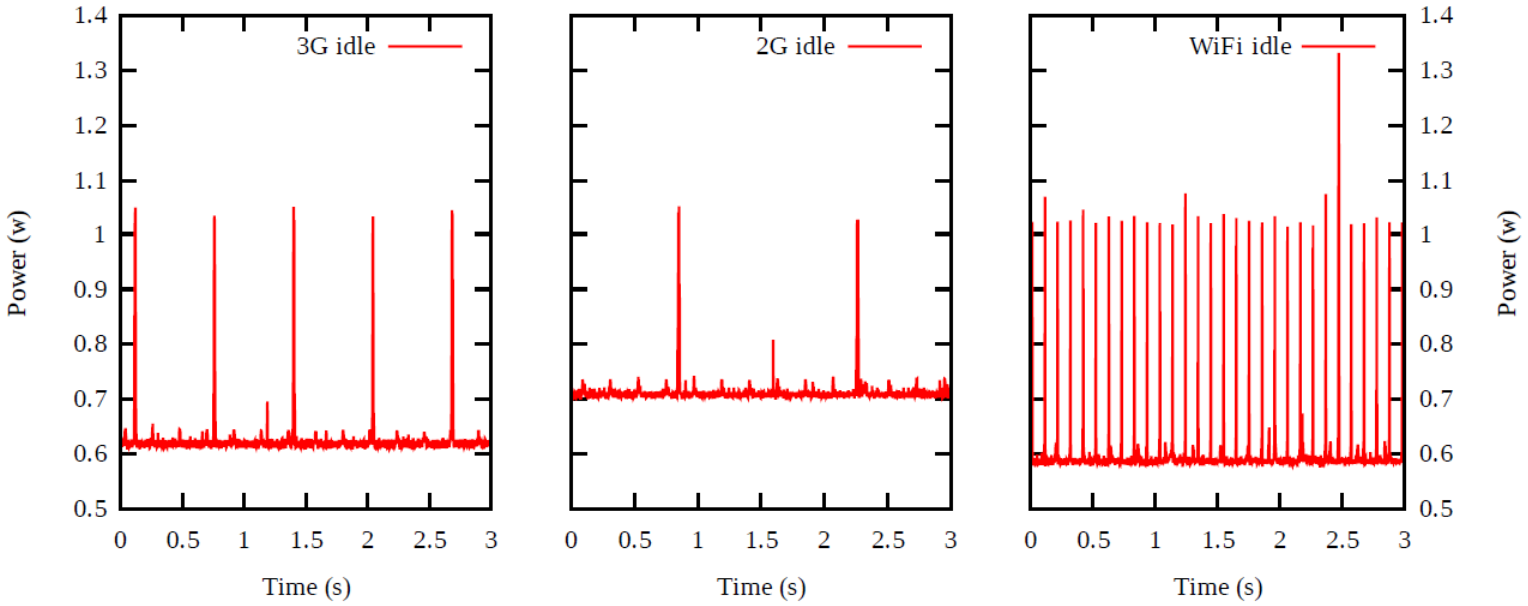

Figure 10. Idle power when connected to 3G, 2G and WiFi networks.

Analysis: Data Transmission

- Large jump from 7KB to 8KB message size (no explanation)

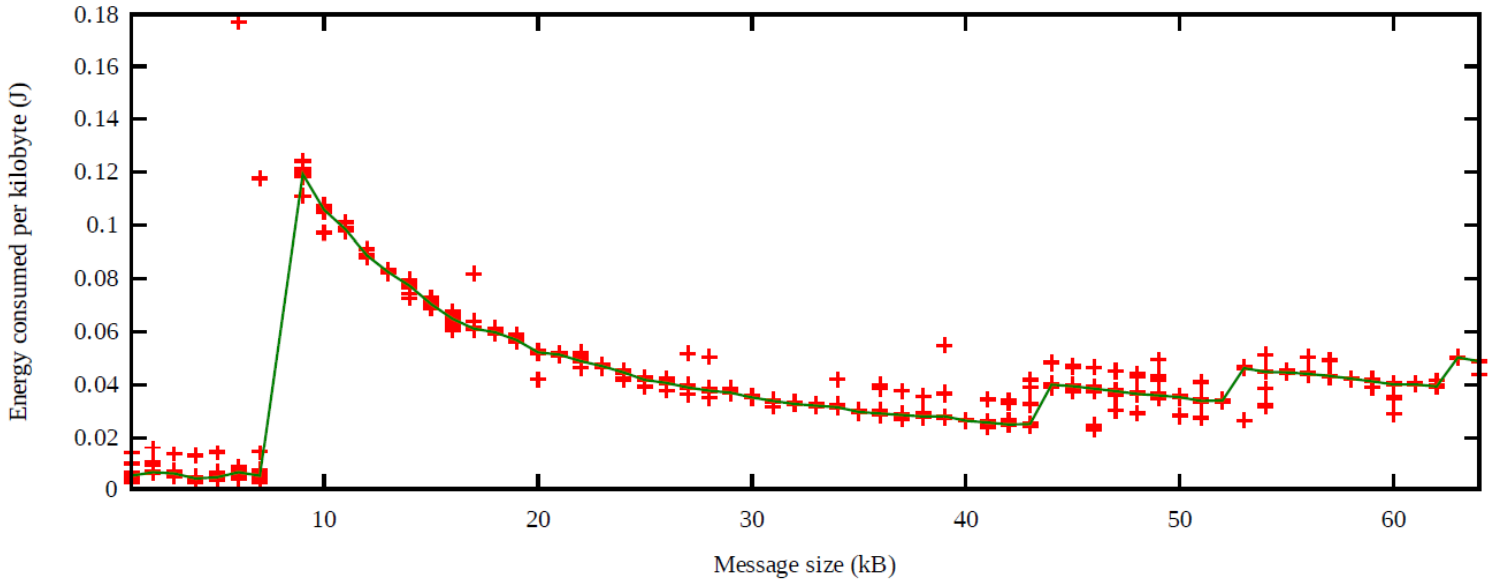

Figure 11. Variation in energy cost per unit data with total message size.

Analysis: Send Buffer Size

- Programs write buffers to socket
  - This size can greatly affect power usage
  - Up to 10X!!

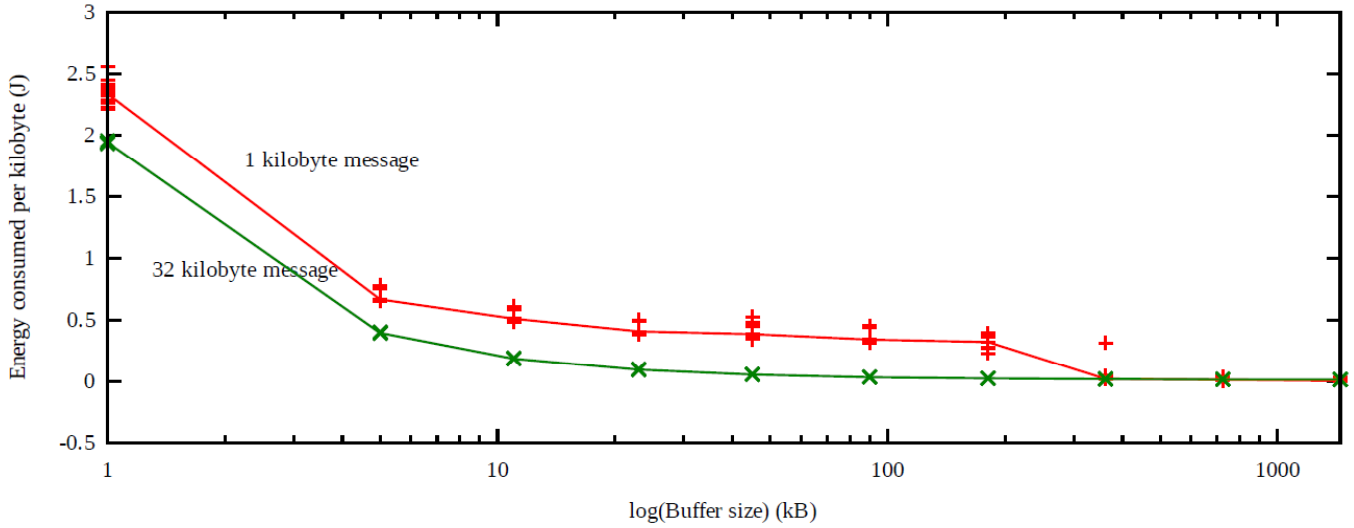

Figure 13. Variation in energy cost per unit data with buffer size.

Conclusions

- Created system for fine-grained understanding of energy consumption
- Showed large gains can be made with small changes
- Different scenarios lead to different results

Questions?