Collaborative Energy Debugging for Mobile Devices

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Mobile is Hot

• ... sometimes, literally:

ASK LIFEHACKER

Why Is My Cellphone Burning a Hole in My Pocket?

Dear Lifehacker,
I'm loving my new smartphone, but sometimes it gets really hot in my pocket—like surface-of-the-sun hot. Is there something wrong with it? Why does it get so hot, and how can I make it stop?

Sincerely,
Fearing Firey Phones

Photo remixed from an original by Shutterstock.
A Day in the Life
A Day in the Life
A Day in the Life

![Facebook Screen](image)
A Day in the Life
A Day in the Life
A Day in the Life

[Image of a screen with the word "asana"]
A Day in the Life
A Day in the Life
A Day in the Life
Users’ Questions

• Why is my battery draining?
• Is that normal?
• What can I do about it?
Today

1. Carat
2. Sampling to Diagnosis
3. Dealing with Uncertainty
4. Deployment
Prior Approaches

- Ad hoc
  - e.g., no-sleep bug
- Intrusive
- Generic
  - “Kill all background apps”
  - “Dim the screen”
Prior Approaches

- Ad hoc
  - e.g., no-sleep bug
- Intrusive
- Generic
  - “Kill all background apps”
  - “Dim the screen”
Our Approach

*the crowd*

instrumentation data → Spark on EC2 → raw and derived data → DynamoDB and S3

*the cloud*

actions and reports → Spark on EC2 → statistical analysis

*big data*

raw and derived data
First collaborative approach for diagnosing energy problems.
Carat

• Mobile app for iOS and Android
• Personalized energy debugging
• Design point
  • Deployable on app stores
  • Maximally invasive
Carat Sampling
Carat Sampling

t_1

WiFi? iOS 5.1?

t_2

WiFi? iOS 5.1?
Carat Sampling
Carat Sampling
Computing Rates
Computing Rates
Computing Rates

\[ \frac{\Delta\%}{\Delta t} = \text{discharge rate (\%/s)} \]
Computing Rates

\[ \frac{\Delta \%}{\Delta t} = \text{discharge rate (\%/s) } | F \]
Energy Anomalies

Probability

Energy Rate (% / s)

Energy Anomalies
Energy Anomalies

Energy Rate (% / s)

Probability

Energy Anomalies
Energy Anomalies

Energy Rate (% / s)

Probability

Energy Anomalies
Energy Anomalies

Energy Rate (% / s)

Probability

energy hog

Energy Anomalies
Energy Anomalies

Energy Rate (% / s)

Probability

Energy Anomalies
Without the crowd, there is no way to know whether this use is normal.
(Given Facebook is not a Hog.)

Energy Anomalies
Energy Anomalies

(Given Facebook is not a Hog.)

energy bug

Energy Rate (% / s)

Probability

Energy Anomalies
Distance

Probability

Energy Rate (% / s)
Distance

$E[\text{reference}]$

$E[\text{subject}]$

Probability

Energy Rate (% / s)
Distance

Probability

Energy Rate (% / s)

E[reference]

E[subject]

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<thead>
<tr>
<th>Trigger</th>
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<th>Actual %</th>
</tr>
</thead>
<tbody>
<tr>
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<td>x</td>
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</tr>
<tr>
<td>else</td>
<td>x</td>
<td>(x-5, x]</td>
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### Measurement Uncertainty

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85% $\rightarrow$ 85%
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- ![Battery icon] 85% $\rightarrow$ 85%
- ![Battery icon] 85% $\rightarrow$ (80%, 85%]

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- Measurement Uncertainty

Prior:

- 85% → 85%
- 85% → (80%, 85%]
Measurement Uncertainty

Battery %

Time

Energy Rate (% / s)

Probability

Prior

Measurement Uncertainty
Measurement Uncertainty

Battery %

Time

Energy Rate (% / s)

Probability

Prior

actual

samples

Measurement Uncertainty
Measurement Uncertainty

Energy Rate (% / s)

Probability

Battery %

Time

actual
samples

Prior

Energy Rate (% / s)

Measurement Uncertainty
Measurement Uncertainty

Battery %

Time

Energy Rate (% / s)

實際值

樣本

前導

Probability

Energy Rate (% / s)

Measurement Uncertainty
Measurement Uncertainty

Battery % vs. Time

Energy Rate (% / s)

Probability

Prior

Measurement Uncertainty
Ground Truth

• Sampling cost and accuracy
• iPhone 4S + Monsoon Power Monitor
• Good accuracy with low overhead
Ground Truth

• Discharge rate estimation
  • 0.00088 %/sec error
  • Samples: 9 vs. 28,800,000

• Overhead
  • Less than Weather app
  • ~3.5% of the battery less
Initial Deployment

- TestFlight and Zubhium
- App Store and Play Store
- 883 devices
- 180k samples
Initial Results

- Found 644 apps exhibiting energy bugs
  - e.g., Facebook, Kindle, Flipboard
- Corroborated with forum posts, news articles, and data correlations
- Injected three bugs in Wikipedia
- Detected all of them
Kindle Bug (iOS)

- E-book reader
- Bug on 3.9% of clients
- Forum: WhisperSync
- Confirmed by our data
- Turn on WiFi
  → 36m improvement
Twitter Bug (Android)

- Microblogging app
- Bug on 14.9% of clients
- Data implicates OS
- WiFi also helps
- Upgrade to ICS 4.0.4 → 94m improvement
Carat: The Brilliant App That Increases Your Battery Life By Showing What Other Apps To Kill

JOSH CONSTINE

Thursday, June 14th, 2012

"Kill Pandora – Expected Battery Life Improvement: 1 hour 50 minutes" This is what you'll learn from Carat, an incredibly useful free new iOS and Android app that's the first to give you personalized mobile battery life-saving recommendations.

Carat quietly takes measurements from your device, does some math, combines it with other people's anonymized data, and sends back tips on if you should update your OS, kill or restart apps, and how many more minutes of tablet or phone fiddling you'll gain.

As battery tech is expected to improve slowly, some say increasing life just 5% a year, and as we get faster processors, more powerful apps, and brighter screens, everyone could use a Carat in their pocket.
Suddenly...
Free Carat app finds 'energy hogs,' 'energy bugs' on iOS or Android devices

ANDROID | JUNE 14, 2012 | BY: MICHAEL SANTO
Suddenly...

Carat

Gizmodo

App of the day

Your J-Score: 70

Carat: Extend Your Phone's Battery Life
Carat: Extend Your Phone’s Battery Life

Summary: Carat has been developed by a team of scientists from the UC Berkeley electrical engineering and computer science department’s Algorithms, Machines, and People Laboratory (AMP Lab).

By Adrian Kingsley-Hughes for Hardware 2.0 | June 15, 2012 -- Updated 10:21 GMT (03:21 PDT)

Follow @the_pc_doc
Carat went viral. In 24 hours, there were dozens of articles and we had more than 100,000 users.
Carat Today

• 360,000 devices
• 20M samples
• Deploy to the crowd; debug in the cloud
  • Platform for collaborative debugging
  • Statistics as a service

carat.cs.berkeley.edu
Fin

You have reached the end of the presentation. Please turn back.