Carat: Collaborative Detection of Energy Bugs

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Mobile is Hot

• ... sometimes, literally:

ASK LIFESHIELD

Why Is My Cellphone Burning a Hole in My Pocket?

Dear Lifeshield,

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 Logo]
A Day in the Life

![Image of a mobile device interface with "Loading..." message]
A Day in the Life
A Day in the Life

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?
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
First collaborative approach for diagnosing energy problems.
Carat

- Mobile app for iOS and Android
- Personalized energy debugging
  - What is misbehaving
  - Whether that is normal
  - What you can do about it
  - How much it will help
To improve battery life...

Kill Pandora
Expected improvement: 1h 27m 57s

Kill vampires
Expected improvement: 1h 15m 28s

Restart MobileCal
Expected improvement: 54m 38s

Restart Camera
Expected improvement: 44m 29s

Upgrade the Operating System
Expected improvement: 42m 15s

Help Spread the Word!
Expected improvement: +100 karma!

(Updated 1m 43s ago)

Your J-Score: 64
Active Battery Life: 9h 28m 37s
OS version: 5.1.1
Device model: iPhone 3GS
Running apps:
Memory used:
Memory active:

Carat
Today

• Collecting data
• Generating results
• Quantifying uncertainty
• Real-world deployment
Carat Sampling
Carat Sampling
Carat Sampling
Carat Sampling
Computing Rates
Computing Rates
Computing Rates

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

Computing Rates
Energy Hog

Energy Rate (% / s)

Probability

Energy Hog
Energy Hog

Energy Rate (% / s)

Probability

Energy Hog
Energy Hog

Energy Rate (% / s)

Probability

Energy Hog
Energy Hog

Probability vs. Energy Rate (% / s)

energy hog

Energy Hog
Energy Bug

Probability

Energy Rate (% / s)

Energy Bug
Without the crowd, there is no way to know whether this use is normal.
Energy Bug

(Given Facebook is not a Hog.)

Energy Rate (% / s)

Probability

Energy Bug
(Given Facebook is not a Hog.)

Energy Bug

Energy Rate (% / s)

Probability

Energy Bug
Original Distribution

![Graph showing probability distribution over energy rate]
Original Distribution

E[subject]

E[reference]

Energy Rate (% / s)

Probability
Original Distribution

Energy Rate (% / s)

Probability

E[subject]  E[reference]

D
Mean Distribution

\[ \text{Probability} \]

\[ \text{E[Energy Rate]} \text{ (\% / s)} \]

- \text{E[reference]}
- \text{E[subject]}
Error and Confidence

![Graph showing the relationship between E[Energy Rate] and Probability, with EV marked as the peak.]
Error and Confidence

\[ \pm e \text{ \%} / \text{s} \]

50% confidence

\[ \text{E[Energy Rate]} \text{ (\% / s)} \]

Probability
Error and Confidence

\[ \pm E \% / s \]

95% confidence

Probability

E[Energy Rate] (% / s)
Confidence Factors

![Graph showing probability distribution with energy rate on the x-axis and probability on the y-axis. The graph includes a dotted line indicating an energy value (EV).]
Confidence Factors

![Diagram showing probability and energy rate](image)

- Energy Rate (% / s)
- Probability
- EV

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Confidence Factors

![Diagram showing the relationship between probability and energy rate.]

- **Energy Rate (%) / s**
- **Probability**

**EV**
Classification

Energy Rate (% / s)

Probability

not-F

F

Energy Rate (% / s)

Probability
Classification

Energy Rate (% / s)

Probability

not-F

F

Energy Rate (% / s)

Probability

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Classification

Energy Rate (% / s)

<table>
<thead>
<tr>
<th>Energy Rate (% / s)</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>not-F</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

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Diagnosis
“Killing app \(a\) will give \(x \pm e\) of battery life (95\% confidence), as would upgrading the OS to version \(v\).”
Initial Deployment

- TestFlight over-the-air beta
- 100 sign-ups (Apple’s max)
- 75 installs
- Collected 10,000+ samples
Initial Results

• Found 35 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
Flipboard Bug

• Digital magazine app
• Bug on 6 clients
• Support thread: iOS 5.0.1
• Confirmed by our data
• OS upgrade
  → 44m 17s improvement
Kindle Bug

- E-book reader
- Bug on 5 clients
- Forum: WhisperSync
- Confirmed by our data
- Turn on WiFi → 1h 33m improvement
Carat: The Brilliant App That Increases Your Battery Life By Showing What Other Apps To Kill

JOSH CONSTINE

Thursday, June 14th, 2012

To improve battery life...

Kill Skype
Expected improvement: 1h 15m 42s

"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...
Suddenly...
Free Carat app finds 'energy hogs,' 'energy bugs' on iOS or Android devices

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

Carat: Extend Your Phone’s Battery Life

Your J-Score: 70
(Updated 15s ago)
Average Battery Life: 11h 7m 32s
OS version: 5.1
device model: Simulator
running apps: View Process List
Help Spread the Word!
Expected improvement:
Upgrade the Operating System
Expected improvement:
(Updated 1d 4h 27m 1s)

App of the day
GIZMODO

Carat
Carat: Extend Your Phone’s Battery Life

Suddenly...

iOS and Android app helps you get more from your battery

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

- 320,000+ devices
  - 190,000+ on iOS
  - 130,000+ on Android
- 20M+ samples
- 20,000+ hogs and 2M+ buggy instances
Some Lessons Learned

• Cloud ≠ free scaling
• “Research product” cuts both ways
• Contract with the crowd
Next Steps

• Quantifying and improving confidence
• API for developers
• 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.