The Missing Numerator: Towards a Value Measure for Smartphone Apps

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Mobility Is The Important Feature
MY IPHONE SPENDS THAT MUCH TIME ON CHARGE

IT MIGHT AS WELL BE A FRIGGIN LANDLINE
Energy Management Is A Well Researched Field

- **eDoctor: Automatically Diagnosing Abnormal Battery Drain Issues on Smartphones**  

- **Where is the Energy Spent Inside My App?: Fine Grained Energy Accounting on Smartphones with Eprof**  
  Pathak, A., Hu, Y. C., Zhang, M.

- **Energy management in mobile devices with the cinder operating system**  
  Roy, A., Rumble, S. M., Stutsman, R., Levis, P., Mazie and Zeldovich, N.

- **V-edge: Fast self-constructive power modeling of smartphones based on battery voltage dynamics**  
  Xu, F., Liu, Y., Li, Q., and Zhang, Y.

  Yoon, C., Kim, D., Jung, W., Kang, C., and Cha, H.

- **Currentcy: a unifying abstraction for expressing energy management policies**  
  Zeng, H., Ellis, C. S., Lebeck, A. R., and Vahdat, A.

- **Quanto: Tracking energy in networked embedded systems**  
  Fonseca, R., Dutta, P., Levis, P., and Stoica, I.

- **Carat: collaborative energy diagnosis for mobile devices**  
So we should be able to answer some simple energy consumption questions
Comparing Apps

App A consumes more energy than App B.
Comparing Apps

App A

App B
Comparing Apps

App A

App B
Comparisons Are Hard

- Different apps from different categories
- Different apps from same category
- Same app on different users/devices
- Same app on same user/device for different time instances
Disconnect between researchers and real world users
My dissatisfication is immeasurable.
Energy management != Energy Measurement

Energy Measurement

- Battery Lifetime
- Performance
Energy Efficiency = \frac{App Value}{Energy Consumption}
How will this **numerator** help?
Comparing Apps

- App A: 31%
- App B: 21%

1d 23h 58m 28s on battery
Does *value* exist?
Can you assign energy quota to apps you want to use?
How to measure **value**?
Hard Question !!!
Value = Content delivered by an app

We use screen refresh rate for measuring video content and audio bit rate for measuring audio content.
Implementation

Instrumented Android platform and distributed to PhoneLab testbed users at University at Buffalo
Comparing Four Simple Metric

<table>
<thead>
<tr>
<th>Usage Based Metric</th>
<th>Power Metric</th>
<th>Foreground Energy Efficiency Metric</th>
<th>Content Efficiency Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>No value.</td>
<td>Value = Total App Running Time</td>
<td>Value = Screen Foreground Running Time</td>
<td>Value = Weighted Screen Refresh Rate And Audio Bit Rate</td>
</tr>
</tbody>
</table>
# Comparison Of App Ranks

<table>
<thead>
<tr>
<th>Rank</th>
<th>Usage Metric</th>
<th>Power Metric</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Android Browser</td>
<td>Facebook Messenger</td>
<td>Bank Of America</td>
<td>Youtube</td>
</tr>
<tr>
<td>2</td>
<td>Facebook</td>
<td>Google+</td>
<td>The Weather Channel</td>
<td>Candy Crush Saga</td>
</tr>
<tr>
<td>3</td>
<td>Chrome Browser</td>
<td>Super-Bright LED Flashlight</td>
<td>Skype</td>
<td>Bank Of America</td>
</tr>
<tr>
<td>4</td>
<td>Android Phone</td>
<td>UB Parking</td>
<td>Youtube</td>
<td>DropBox</td>
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<td>Android Music</td>
<td>Android Messaging</td>
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</tr>
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<td>Android Messaging</td>
<td>Google Search</td>
<td>Android Gallery</td>
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</tr>
<tr>
<td>7</td>
<td>WhatsApp Messenger</td>
<td>NFL Mobile</td>
<td>Android Calculator</td>
<td>Twitter</td>
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<td>Google Search</td>
<td>Pandora</td>
<td>Twitter</td>
<td>Android Clock</td>
</tr>
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<td>9</td>
<td>Candy Crush Saga</td>
<td>Starbucks</td>
<td>Chrome Browser</td>
<td>Yahoo Mail</td>
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<td>Android News and Weather</td>
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Survey

Q: Which apps are you willing to uninstall to improve battery life?

- 3 apps: least efficient by content-metric
- 3 apps: consumed most energy
- 3 apps: randomly selected
Result

- **Usage-Based Measure**: 15 Wins
- **Efficiency-Based Measure**: 20 Wins

47 Responses
Lessons Learned

• No way to differentiate between frames which provide information from those which don’t.

• Asking to uninstall apps is too extreme.

• Users are still willing to remove apps if identified correctly.

• Need better parameters to measure content.

• Simple metrics may not work.
Other Value Approaches

1. Background App Component
2. Foreground Usage
3. User Interaction
**Evaluating Different Value Measures**

**Jouler** helps to experiment with different energy management approaches.
Summary

• Energy management is more than just energy measurement.

• Per app, per user, temporally variant value measure is needed for effective energy management.

• We do not know the right way to measure value, yet.