Mining Questions About Software Energy Consumption

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The Problem

- Energy efficiency is becoming a key design consideration.

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- A large body of work in hardware/architecture, operating systems, runtime systems.

- But…

  - what about the application level?

  - what do programmers *think* about this problem?

The Goal

1. Whether application programmers are interested in software energy consumption, and, if so
2. How they are dealing with energy issues?

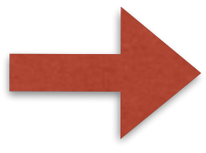
2M+ Users

5M+ Questions

10M+ Answers

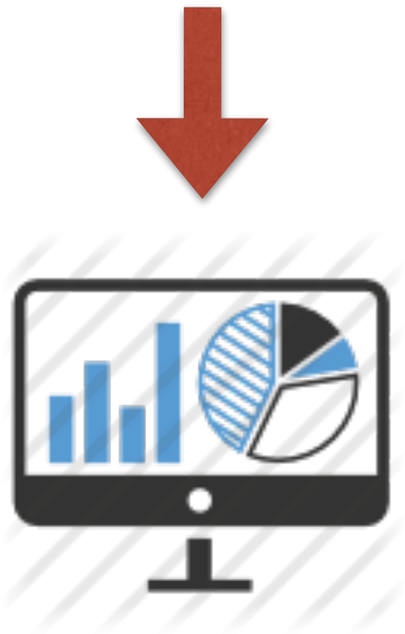
50GB+ of data

5M Questions



Automatic Filter

Manual Filter



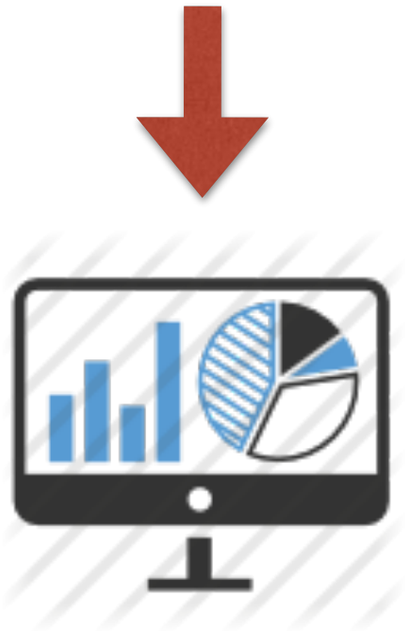
Final Data

5M Questions

Automatic Filter

615 Questions
1,197 Answers

Manual Filter



Final Data

5M Questions

Automatic Filter

Manual Filter

Final Data

325 Questions
558 Answers

Base Group

from 2008 to 2013

Research Questions

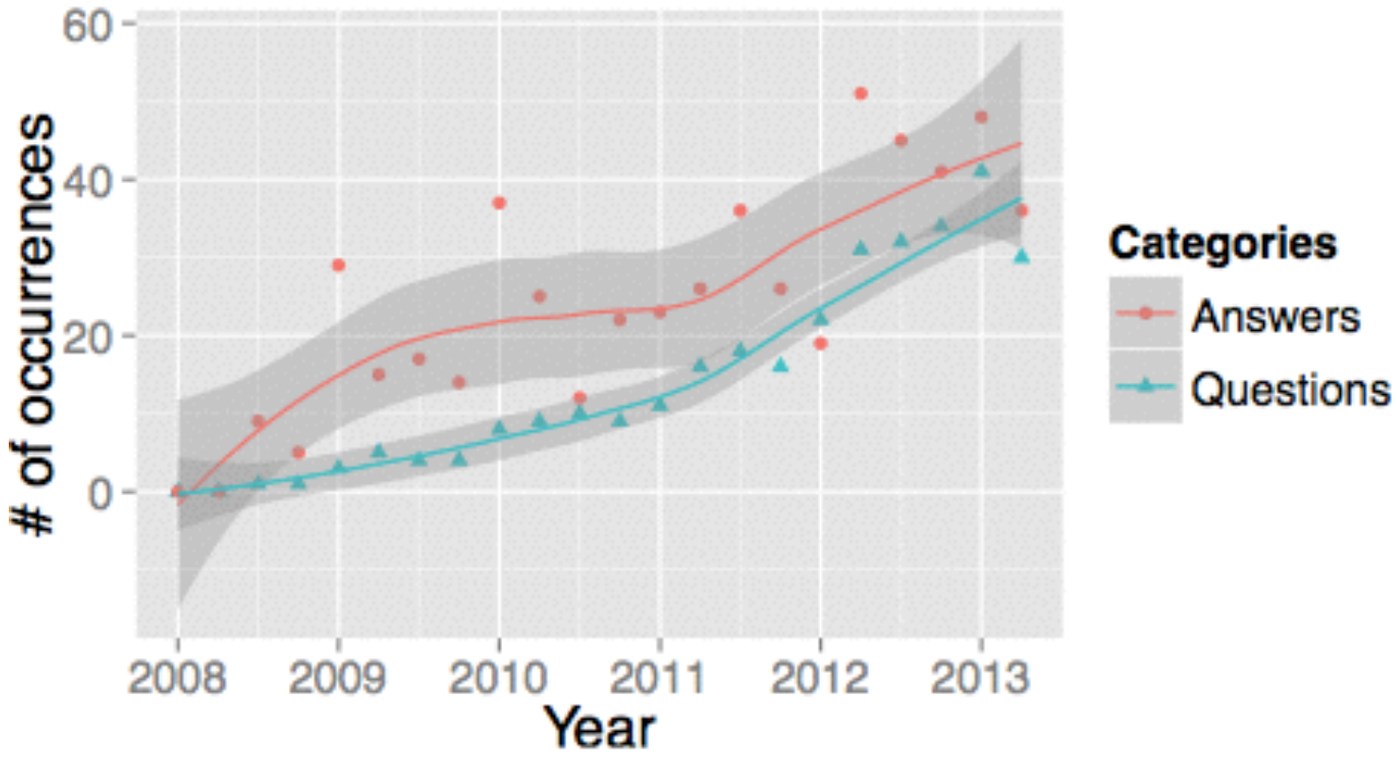
- **RQ1:** What are the distinctive **characteristics** of energy-related questions?

- **RQ2:** What are the most common energy-related **problems** faced by software developers?

- **RQ3:** What are the main **causes** for software energy consumption problems?

- **RQ4:** What **solutions** do developers employ or recommend to save energy?

RQ1: Characteristics



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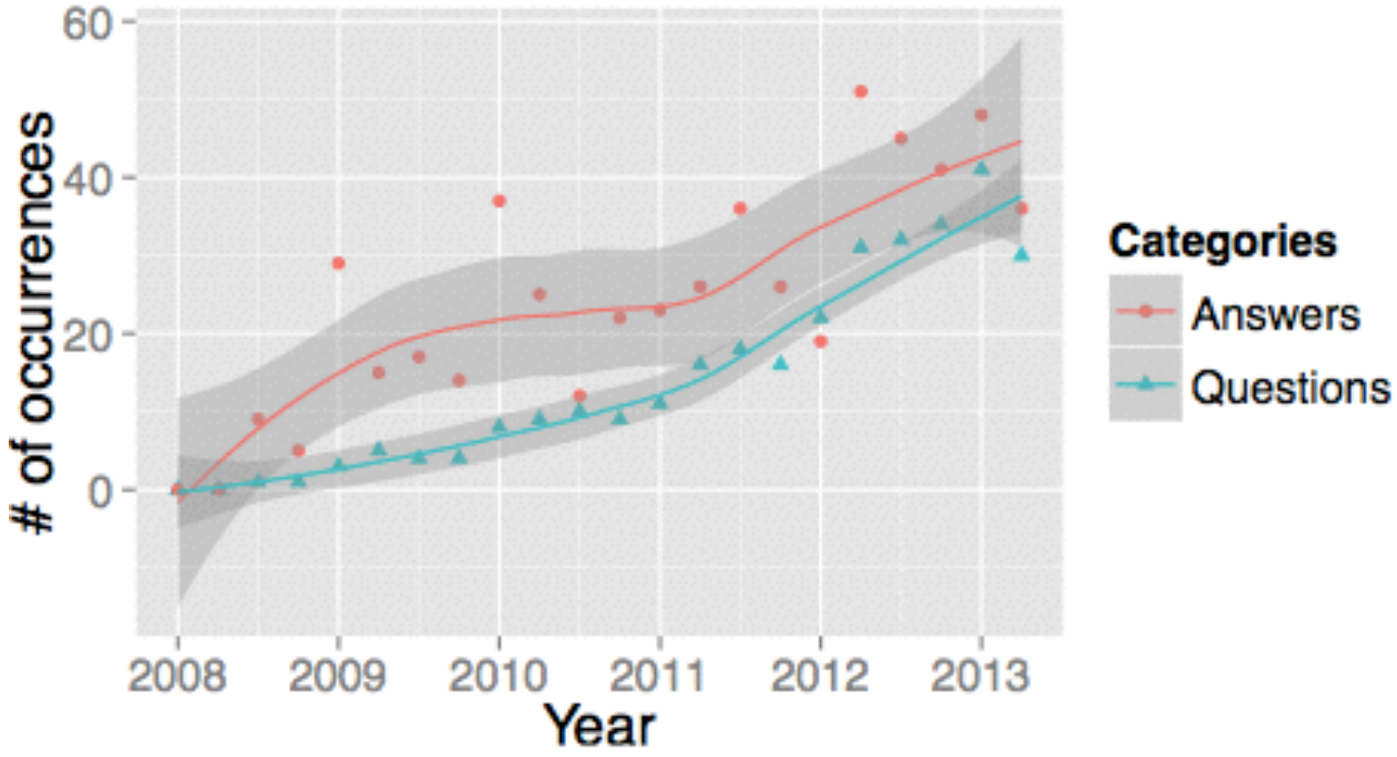

85% of Q. have A.
(45% are answered successfully)

No obvious “energy expert”

1/4 of questions are from mobile dev.

RQ1: Characteristics

$$\mathbb{P} = \mathbb{S} + \mathbb{A} + \mathbb{C} + \mathbb{F} + \mathbb{V}$$

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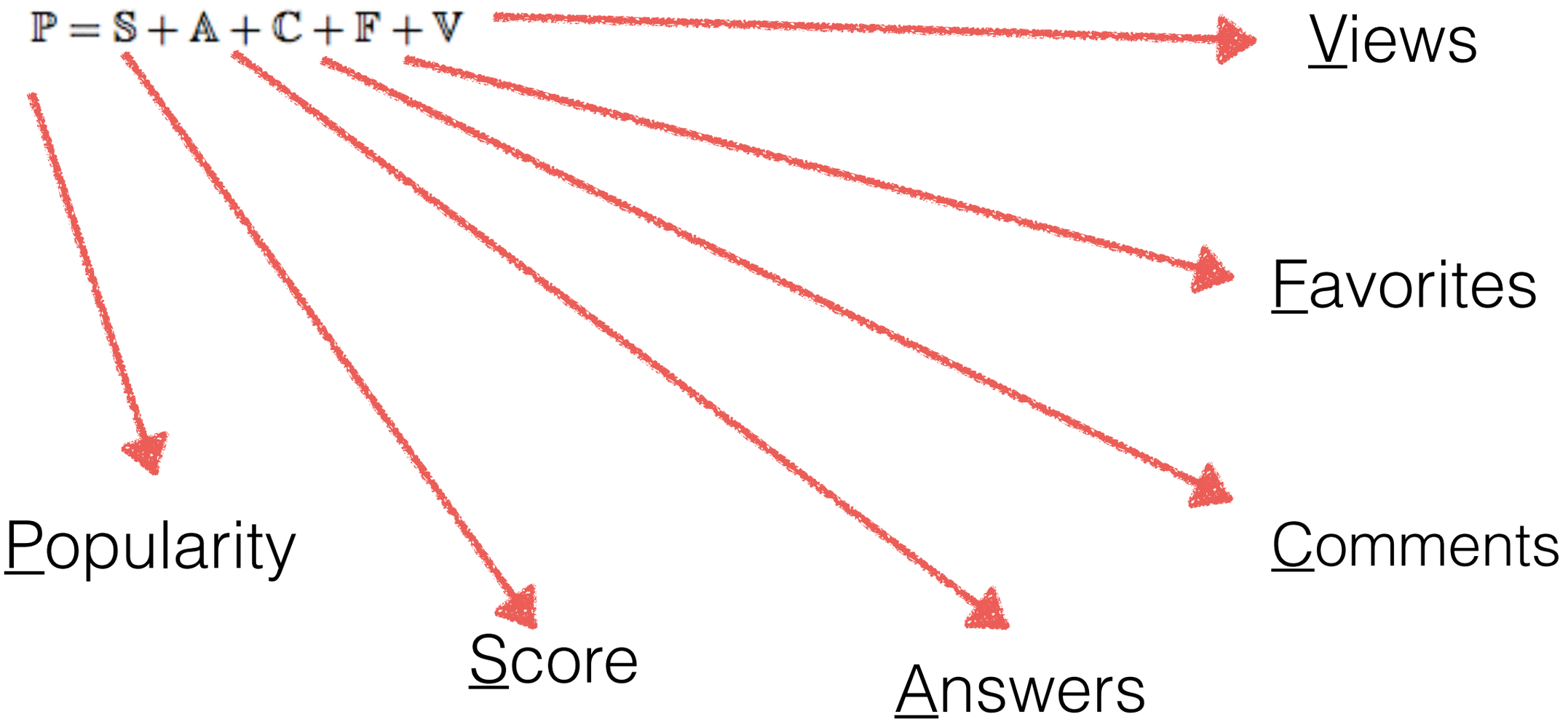

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Normalized as

$$\mathbb{V} = questionsViews \Big/ stackOverflowViews$$

StackOverflow $\mathbb{P}$ is 5

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	Studied Questions	Median
$\mathbb{S}$	1.10	1.00
$\mathbb{A}$	2.67	1.00
$\mathbb{C}$	1.11	1.00
$\mathbb{F}$	3.89	0.00
$\mathbb{V}$	1.68	1.00
$\mathbb{P}$	10.45	–

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More *interesting* than the average SO questions

StackOverflow $\mathbb{P}$ is 5

RQ2: Problems

- Measurements (59/97 — Q/A)
- General Knowledge (40/84 — Q/A)
- Code design (36/133 — Q/A)
- Context-specific (83/110 — Q/A)
- Noise (107/134 — Q/A)

“I want to measure the energy consumption of my own application (which I can modify) [...] on Windows CE 5.0 and Windows Mobile 5/6. Is there some kind of API for this?”

- Measurements (59/97 — Q/A)
- General Knowledge (40/84 — Q/A)
- Code design (36/133 — Q/A)
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“Can a code optimized for least MCPS be guaranteed to have least power consumption as well?”

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- General Knowledge (40/84 — Q/A)
- Code design (36/133 — Q/A)
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“Are there any s/w high level design considerations […] to make the code as power efficient as possible?”

- Measurements (59/97 — Q/A)
- General Knowledge (40/84 — Q/A)
- Code design (36/133 — Q/A)
- Context-specific (83/110 — Q/A)
- Noise (107/134 — Q/A)

“I want to prevent the monitor from going to sleep. […] What call do I make?”

- Measurements (59/97 — Q/A)
- General Knowledge (40/84 — Q/A)
- Code design (36/133 — Q/A)
- Context-specific (83/110 — Q/A)
- Noise (107/134 — Q/A)

“What are the good features of a processor should have which help in carrying out multimedia(Video/Image)?. [...] PS: It has to be low power as it is for portable applications.”

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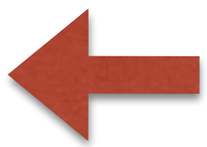

— Highest popularity
— Highest A per Q ratio
— Highest success rate

RQ3: Causes

- Unnecessary resource usage (49 occurrences)
- Fault GPS behavior (42 occurrences)
- Background activities (40 occurrences)
- Excessive synchronization (32 occurrences)
- Background wallpapers (17 occurrences)
- Advertisement (11 occurrences)

"to have a background application that monitors device usage, identifies unused/idle resources, and acts appropriately"

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"When there are bugs that keep the GPS turned on too long they go to the top of the list to get fixed"

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RQ4: Solutions

- Keep IO to a minimum (29 occurrences)
- Bulk operations (24 occurrences)
- Avoid polling (17 occurrences)
- Hardware Coordination (11 occurrences)
- Concurrent Programming (9 occurrences)
- Race to idle (7 occurrences)

“do not flood the output stream with null values”

- Keep IO to a minimum (29 occurrences)
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“Don’t transfer say 1 file, and then wait for a bit to do another transfer. Instead, transfer right after the other.”

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Do researchers agree?

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Recurring problems in the answers

- Misconceptions (37 users)
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- The perception of lack of tools (38 questions)

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- Power and Energy?
- Performance as an indicator to Energy?
- Shift to managed languages

Recurring problems in the answers

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- “Make your code small”
- “Run as slow as possible”

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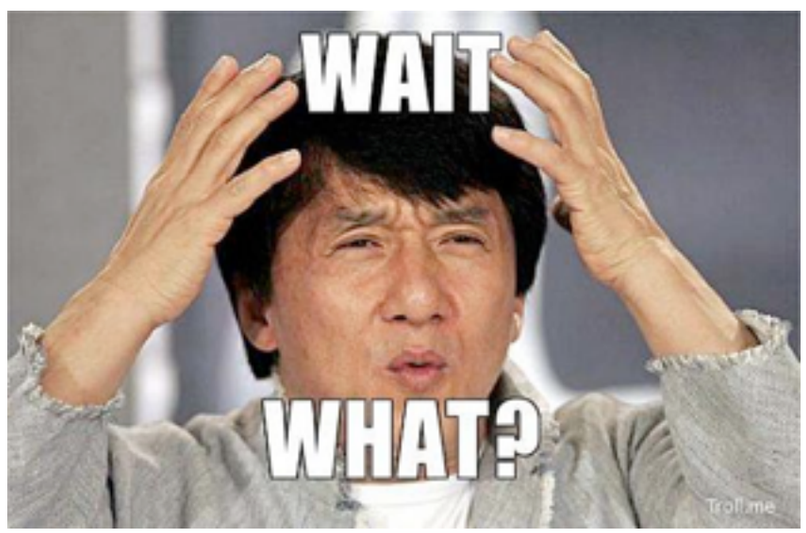

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- OS, Kernel, Virtual machine
- Process/Threads
- Application (line, method, whole program)

Conclusions

- A practical guide for future energy-aware and energy-efficient software development

- We described the needs and challenges that developers face

- 5 most common **problems**

- 7 most common **causes**

- 8 most common **solutions**

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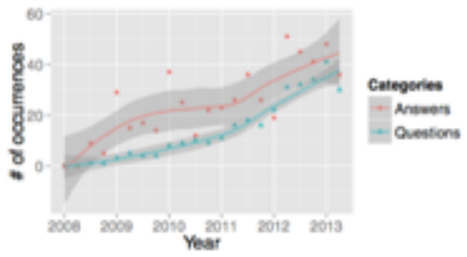

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Thanks!

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