SOFTWARE ENERGY CONSUMPTION OF MOBILE DEVICES

Gabriele Kotsis, Andreas Hannes Schuler
Reflecting the Energy Demand of ICT

- Digitalization and energy consumption. Does ICT reduce energy demand?
- Evolution of IT Energy Demand
- Power Consumption of Mobile Devices

Characterizing Software Energy Consumption in Mobile Application Development to Support Third-Party-Library Selection

- A systematic review on mobile software energy profiling
- A generic approach to profiling software energy consumption at a fine-granularity
- API utilization profiles (uapi) as proxy for the energy characteristics of Third Party Library (TPL) dependencies
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Digitalization and energy consumption – Does ICT reduce energy demand?

Digitalization affects energy consumption via

- Energy efficiency
- Sectoral change
- Direct effects
- Economic growth

Reduction Increase

Lange et.al. 2020 (Ecological Economics)

Johannes Kepler University Linz
Evolution of IT Energy Demand (TWh)

Schneider Electric estimates that IT sector electricity demand will grow by 50 percent by 2030, reaching 3,200TWh, equivalent to 5 percent Compound Annual Growth Rate (CAGR) over the next decade – evolution of IT energy demand in TWh.

https://www.i-scoop.eu/sustainability-sustainable-development/it-sector-electricity-demand/
Power Consumption of Mobile Devices based on Usage Scenarios

Ardito et al. 2015
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Characterizing Software Energy Consumption in Mobile Application Development to Support Third-Party-Library Selection

➢ A systematic review on mobile software energy profiling [1]
➢ A generic approach to profiling software energy consumption at a fine-granularity [2,3]
➢ API utilization profiles (u_{api}) as proxy for the energy characteristics of Third Party Library (TPL) dependencies [4,5]

Systematic Literature Review

“What types of contributions are provided by the selected research?”

Key Insights

- Since 2014 increase in availability of replication packages
- Only 5 of the tools are actively maintained and publicly available
- Potential for future research regarding energy efficiency guidelines, patterns and metrics

Systematic mapping of contribution types over power modelling approaches.

Availability of replication packages in relation to selected studies per year.
Systematic Literature Review – Replication Package

- Search-and-Queryable graph database containing the studies covered by the review [1]

![Explore the articles, authors and their relations in mobile software energy research.](image)


Open Source Data https://zenodo.org/record/7140240
public void testFileReader() throws IOException {
    try (FileReader fileReader = new FileReader(FILE)) {
        int data = fileReader.read();
        StringBuilder builder = new StringBuilder((char) data);
        while (data != -1) {
            data = fileReader.read();
            builder.append((char) data);
        }
    }
}
Profiling software energy consumption at a fine-granularity

- A generic approach
- Series of steps for the definition, execution and synthesis of energy profiling experiments
- Comprises a testbed for the execution of energy tests
- Algorithm to isolate and attribute a power profile to program structures (i.e. methods in source code)

![Diagram of profiling software energy consumption at a fine-granularity](image)

Figure: Example of a recorded power signal.
Case Study: Sorting Algorithms

- Empirical study on the energy characteristics of sorting algorithms on Android [2]
- Compared 12 sorting algorithms for datatypes (int, double, Comparable) for problem sizes 50k, 75k and 100k
- Sampled each test 20 times, averaged results
- Choice of datatype has significant impact on energy characteristics
  - Kruskal-Wallis, $df = 2, p < .001$, Dunn’s Post-Hoc Test

u_api profiles

- u_api profile follows trend in energy consumption
- Accuracy of using u_api as proxy
  - energy consumption - 94.8%
  - average power - 56.9%
- Selected candidates show non-uniform energy behavior
  - GSON worse energy performance in serializing scenario
  - Implementations should favor a TPL candidate performs equally well in all scenarios
$u_{api}$ profiles as proxy for the energy characteristics of Third Party Library (TPL) dependencies
Take Home Messages and Future Work

- Developing software under **sustainable design goals** plays crucial role in shaping our future

  *Knowledge on „How to develop energy-efficient software solutions“ is limited*

- Tools and approaches required to support building awareness

- Facilitate access to software energy profiling for a broad audience (e.g. cs students, researchers and practitioners)
  - Provide tools and approaches seamlessly integrated in usual workflows
  - Increase the awareness how energy is dissipated in software