**Android Energy Manager [or better title]**

A user friendly energy tool for Android Phones

Vikram Shanker

Carnegie Mellon University

Pittsburgh, PA, USA

vshanker@andrew.cmu.edu

Shilpa Murthy

Carnegie Mellon University

Pittsburgh, PA

shilpam@andrew.cmu.edu

*Abstract*—This electronic document is a “live” template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document. DO NOT USE SPECIAL CHARACTERS, SYMBOLS, OR MATH IN YOUR TITLE OR ABSTRACT. *(Abstract)*

*Index Terms*—Component, formatting, style, styling, insert. *(key words)*

# Introduction *(Heading 1)*

The use of mobile devices has now permeated our everyday lives. Cellular phones and other devices are merely an extension of the self. They are used and relied upon for everyday tasks such as phone calls, emails, text message, social media, web browsing and more. As the usage of smartphones increases, the battery life of phones has began to decrease. In the days of flip phones, devices could be used for multiple days without charging. However, now, most devices don’t last more than 6-8 hours.

The source of the loss in battery life is two-fold. First, the increased usage of the cell phone will naturally cause some loss in battery life. It is unrealistic to expect that we use a device much more and still have it maintain the same battery life. Second is the rise of power-hungry mobile applications. Mobile applications are consuming increasingly more of the phone’s energy.

There are two general classes of applications that consume disproportionally large amounts of energy. The nature of some applications is such that they must use large amounts of energy. Applications such as maps that rely heavily on real-time sensor data will naturally and inevitably use more battery. Other applications, such as Facebook, run continuously in the background polling for updates or user information, unbeknownst to the user, draining battery significantly. The second class is particular instances of applications that happen to consume more energy. This can sometimes be due to a faulty launch in the application and a simple restart is enough to cure the issue. Other times, the software itself has a bug.

Distinguishing between these two cases is difficult for a computer to do given that it has no information about the baseline of how much energy the app is expected to consume. However, this information is often intuitive to the user. It is simple for the user to determine whether the app is a naturally energy intensive application or it is consuming unexpected amounts of energy. Therefore, Android Energy Manager delegates the task of determining these thresholds to the user. The choice of this approach will be discussed in future work.

# Related Work

Many research projects have taken various approaches to monitoring application energy usage. Carat, by Oliner et al. takes a black-box approach at diagnosing energy-usage. Pathak et al. took a fine-grained approach to diagnosing energy usage, and Balasubramanium et al use native instrumenting tools to measure mobile device energy consumption.

In Energy Consumption in Mobile Phones, the native Nokia Energy Profiler was used to sample the energy consumed every 250 milliseconds. The application reported consumption at 95% confidence. Obvious drawbacks to the method are that this only works on Nokia phones. Furthermore, even though the data is fine-grained and accurate, users have reported that interpreting the data presented by the application is difficult to interpret and act upon. This is because the energy profiler only estimates energy consumption device level. It does not profile at the application level.

Pathak et al take the opposite approach in Fine Grained Energy Accounting on Smartphones with Eprof. They instrument the code in order to fully understand how energy is consumed at the sub-application level. However, this method is not portable for our application since it requires the source of applications. Furthermore, to measure the energy of a new app requires work for each additional app, which does not allow for universal use.

In Carat, Oliner et all take a blackbox approach to measuring app energy consumption at the application level. The blackbox approach, which does not require knowledge about the application, allows for the app to be used universally. To diagnose energy hogs and energy bugs, the application measures system wide energy usage as well as all processes running and constructs a graph representing the data. It compares many such graphs from various devices to detect apps as energy hogs (which consume disproportionately high energy across devices) and energy bugs (a particular instance of the application is consuming more energy than others) and reports it to the user. However, Carat’s implementation fails to distinguish between applications that should use more energy and those that do not. For example, Carat detects a map application as a hog, even though, it should naturally use more power.

[Insert Application Name Here] uses various aspects of the above implementations in order to allow the user to manage the energy consumption at the application level in order to extend the device lifetime.

# Design

The App Energy monitor aims to provide users with a tool to accurately understand and control how their phones consumes energy. As such the design had to meet a few specifications.

1. The application must be work for all applications and processes on that run on an android phone.
2. The application should provide the user with the ability to easily view and understand application level energy consumption.
3. The information provided by [Insert title here] should be easily actionable by the user.
4. The application should not incur large overhead as to increase battery drain of the phone.

**A - Universal Use**

In order for the application to be effective, it must work for any application and process that runs on the mobile device. This means we must adopt a blackbox like approach as used in Carat. Approaches similar to Pathak which allows for the lowest level of measurement will not port across applications easily. Furthermore, this level of detail is not necessarily useful since most user will not understand or be able to act upon it. The blackbox is sufficient since users cannot alter the mechanisms of the application, but can only choose to run it or not run it.

**B – User Actionability**

A major drawback of many systems is that the information given by application is not understood by the user or not actionable by the user. Data that presents uncontextualized information about energy consumed in millijoules use of little use to users since most users don’t have enough knowledge to understand what the number is saying. Other times, graphs displayed provide really detailed information but again no information that provides usable information to the user. Providing the user with well-chosen information about the application that allows the user to make informed decisions is key. [Insert application name here] provides users with a simple statistic about the energy consumption and memory consumption of each application/process. Users then have the option to set thresholds based on the information presented. This will be discussed in detail in \_\_\_\_\_\_insert section\_\_\_\_\_. change

Explain the choices of this paper

User defined thresholds

Simple selection

Hourly detection and user notification (android does not give access killing apps immediately + more user defined control so apps aren’t killed when they are undergoing some desired behavior)

# Measuring Energy

Cpu usage is highly proportional to energy usage.

V. Evaluation

Before you begin to format your paper, first write and save the content as a separate text file. Keep your text and graphic files separate until after the text has been formatted and styled. Do not use hard tabs, and limit use of hard returns to only one return at the end of a paragraph. Do not add any kind of pagination anywhere in the paper. Do not number text heads—the template will do that for you.

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar.

## Abbreviations and Acronyms (Heading 2)

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE and SI do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

## Units

Use either SI or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.

Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.

Do not mix complete spellings and abbreviations of units: “Wb/m2” or “webers per square meter”, not “webers/m2”. Spell out units when they appear in text: “. . . a few henries”, not “. . . a few H”.

Use a zero before decimal points: “0.25”, not “.25”. Use “cm3”, not “cc”. (*bullet list*)

## Equations

The equations are an exception to the prescribed specifications of this template. You will need to determine whether or not your equation should be typed using either the Times New Roman or the Symbol font (please no other font). To create multileveled equations, it may be necessary to treat the equation as a graphic and insert it into the text after your paper is styled.

Number equations consecutively. Equation numbers, within parentheses, are to position flush right, as in Eq. 1, using a right tab stop. To make your equations more compact, you may use the solidus ( / ), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in

 

Note that the equation is centered using a center tab stop. Be sure that the symbols in your equation have been defined before or immediately following the equation. Use “Eq. 1” or “Equation 1”, not “(1)”, especially at the beginning of a sentence: “Equation 1 is . . .”

## Some Common Mistakes

The word “data” is plural, not singular.

The subscript for the permeability of vacuum **0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.

In American English, commas, semi-/colons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)

A graph within a graph is an “inset”, not an “insert”. The word alternatively is preferred to the word “alternately” (unless you really mean something that alternates).

Do not use the word “essentially” to mean “approximately” or “effectively”.

In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.

Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”, “principal” and “principle”.

Do not confuse “imply” and “infer”.

The prefix “non” is not a word; it should be joined to the word it modifies, usually without a hyphen.

There is no period after the “et” in the Latin abbreviation “et al.”.

The abbreviation “i.e.” means “that is”, and the abbreviation “e.g.” means “for example”.

An excellent style manual for science writers is given by Young [7].

# Using the Template

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

## Authors and Affiliations

The template is designed so that author affiliations are not repeated each time for multiple authors of the same affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization). This template was designed for two affiliations.

### For Author/s of Only One Affiliation (Heading 3): To change the default, adjust the template as follows.

#### Selection (Heading 4): Highlight all author and affiliation lines.

#### Change Number of Columns: Select Format > Columns >Presets > One Column.

#### Deletion: Delete the author and affiliation lines for the second affiliation.

### For Authors of More than Two Affiliations: To change the default, adjust the template as follows.

#### Selection: Highlight all author and affiliation lines.

#### Change Number of Columns: Select Format > Columns > Presets > One Column.

#### Highlight Author and Affiliation Lines of Affiliation 1 and Copy this Selection.

#### Formatting: Insert one hard return immediately after the last character of the last affiliation line. Then paste down the copy of affiliation 1. Repeat as necessary for each additional affiliation.

#### Reassign Number of Columns: Place your cursor to the right of the last character of the last affiliation line of an even numbered affiliation (e.g., if there are five affiliations, place your cursor at end of fourth affiliation). Drag the cursor up to highlight all of the above author and affiliation lines. Go to Format > Columns and select “2 Columns”. If you have an odd number of affiliations, the final affiliation will be centered on the page; all previous will be in two columns.

## Identify the Headings

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is *“Heading 5”*. Use *“figure caption”* for your Figure captions, and *“table head”* for your table title. Run-in heads, such as “Abstract”, will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced. Styles named *“Heading 1”*, “*Heading 2”*, *“Heading 3”*, and *“Heading 4”* are prescribed.

## Figures and Tables

Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table captions should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation “Fig. 1” in the text, and “Figure 1” at the beginning of a sentence.

Use 8 point Times New Roman for figure labels. Use words rather than symbols or abbreviations when writing figure-axis labels to avoid confusing the reader. As an example, write the quantity “Magnetization”, or “Magnetization, M”, not just “M”.

If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

## Footnotes

Use footnotes sparingly (or not at all) and place them at the bottom of the column on the page on which they are referenced. Use Times 8-point type, single-spaced.

To help your readers, avoid using footnotes altogether and include necessary peripheral observations in the text (within parentheses, if you prefer, as in this sentence).

Number footnotes separately from reference numbers, and in superscripts. Do not put footnotes in the reference list. Use letters for table footnotes.

Table Type Styles

| Table Head | Table Column Head | | |
| --- | --- | --- | --- |
|  | Table column subhead | Subhead | Subhead |
| copy | More table copya |  |  |

a. Sample of a table footnote. *(table footnote)*

Example of a figure caption. *(figure caption)*

We suggest that you use a text box to insert a graphic (ideally 300 dpi, with all fonts embedded) because, in an MSW document, this method is somewhat more stable than directly inserting a picture.

To have non-visible rules on Example of a figure caption. *(figure caption)* your frame, use the MSWord pull-down menu, select Format > Borders and Shading > Select ”None”.

# Copyright Forms

You must submit the IEEE Electronic Copyright Form (ECF) as described in your author-kit message. THIS FORM MUST BE SUBMITTED IN ORDER TO PUBLISH YOUR PAPER.

# Acknowledgment

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression, “One of us (R. B. G.) thanks . . .” Instead, try   
“R. B. G. thanks”. Put applicable sponsor acknowledgments here; DO NOT place them on the first page of your paper or as a footnote.

# References

List and number all bibliographical references in 9-point Times, single-spaced, at the end of your paper. When referenced in the text, enclose the citation number in square brackets, for example: [1]. Where appropriate, include the name(s) of editors of referenced books. The template will number citations consecutively within brackets [1]. The sentence punctuation follows the bracket [2]. Refer simply to the reference number, as in “[3]”—do not use “Ref. [3]” or “reference [3]”. Do not use reference citations as nouns of a sentence (e.g., not: “as the writer explains in [1]”).

Unless there are six authors or more give all authors’ names and do not use “et al.”. Papers that have not been published, even if they have been submitted for publication, should be cited as “unpublished” [4]. Papers that have been accepted for publication should be cited as “in press” [5]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [6].

G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

K. Elissa, “Title of paper if known,” unpublished.

R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.

Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.