Calculating the Energy Consumption of a Website

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Motivation

Environmental Concerns

- Awareness
- Insight
- Motivation
Research Question

How to calculate the energy consumption of a website?

Sub questions:

- What are the energy consuming components of a website?
- What data can be measured at these components?
- How does this data relate to the total energy usage of the underlying machine?
Energy consuming components of a website

Client Side                                  Server Side

Client Browser                             Business Logic Apache

Tier 1                                      Tier 2

Network

Tier 3

Related Work

Relative power impact of different resources on dynamic power consumption.

CPU = 58%
MEM = 28 %
Disk = 14% [1]

Architecture

CPU second (s)
- Active processing of one core

CPU usage (%)
- Percentage of the total CPU's capacity

Power (W)
- Total amount of Wattage going into baremetal machine

Memory (bytes)
- In buffer & cache
Approach

Assumption:
The data of each layer is correlated with the others over time.

Test:
1. Plot
2. Fit - Linear Regression on Training set
3. Test - accuracy (mean squared error) on Test set

Answer research question
- Creating formula translating the CPU(s) of a Hosting Packages → Power used by the hardware.
Part 1 - Pre-processing

+ Hosting Nodes only contain packages
+ Known which packages run on which hosting node

\[ CPU_{hn_i} \approx \sum CPU_{pack_i} \]

Points in interval  776
Hosting nodes  48
----------------------------------  x
Data points  37,248
Part 1 - Results

$$\text{Datapoint} \ (x,y) = \ (CPUhn_i, \sum CPU_{\text{pack}_i})$$

$$CPUhn_i = 0.97 \times \sum CPU_{\text{pack}_i} + 0.054$$

Mean Squared Error = 0.0054
Part 2 - Pre-processing

- Hardware nodes only run HN + VPS
- No knowledge on which HN and/or VPS’s run on which Hardware node.
- CPU of hardware nodes is measured in percentages instead of seconds.

\[ \Sigma CPU_{hw} \approx a \times (\Sigma CPU_{hn} + \Sigma CPU_{vps}) + b \]

Data points = 776
Part 2 - Results

datapoint \((x,y) = (\sum CPU_{hw}, \sum CPU_{hn} + \sum CPU_{vps})\)

\(a = 2.82\)
\(b = 219.81\)

mean squared error = 530.83
C.a. 23 %
Part 3 - Pre-processing

\[ P_{hw_i} = a \times CPU_{hw_i} + b \]

Points in interval = 776
Hardware nodes = 12 \times \frac{1}{12}
Data points = 9.312

CPU (%)  
Power (W)  
Memory (MB)
Part 3 - Results

Datapoint \((x, y, z(\text{color})) = (Phw_i, CPUhw_i, MEMhw_i)\)

mean squared error = 934.62 (c.a. 30 W)

\[
\text{Power}(w) = 0.32 \times CPUhw + 3.3 \times MEMhw + 87.34
\]
Final Formula

\[ \sum \text{Phw} = a \sum \text{CPUpack} + b \sum \text{CPUvs} + c \sum \text{MEMhw} + d \]

\[ a = 0.867663 \]
\[ b = 0.895096 \]
\[ c = 3.30113 \]
\[ d = 1118.6 \]

Verify this formula by plotting measured power at a certain time against the predicted power at the same time, and calculate the mean squared error.
Power Prediction

Datapoint \((x,y) = (\sum Phw_i, \sum Phw_predict)\)

Mean Squared Error: 1536.22
C.a. 40 Watt
Energy Consumption of a Website

$$\sum P_{hw\_predict} = a\sum CPU_{pack} + b\sum CPU_{vps} + c\sum MEM_{hw} + 1118.6$$

Assumption 1: \[MEM_{hw} = MEM_{pack}\]

virtualization\_tot = 418

hn\_tot = 48  \rightarrow 48/418 = 11\%$

$$\sum P_{hw} = a\sum CPU_{pack} + c\sum MEM_{pack} + 0.11\times1118.6$$

packages\_tot = 8162

$$P_{hw} = a\times CPU_{pack} + c\times MEM_{pack} + (0.11\times1118.6)/8162$$

power min 0.768 W

power average 4.23 W

power max 12.25 W
Conclusion

With an accuracy of ± 40 W it is possible to estimate the energy consumption of a website given the CPU in seconds, and Memory in bytes of that website.
Discussion & Future work

Calculated Energy Consumption might differ from reality:

- Other resources/processes might influence the power consumption
- Linear regression might not be sophisticated enough to calculate power consumption from the data
- Relationship MEMhw and MEMpack should be researched
- Look at other tiers for complete power consumption
- Generalize for other hosting companies
Questions?