Green Coding Workshop
Green Coding Berlin
Who we are

https://www.green-coding.berlin
Agenda
24.11.2023

• **PART 1 -**
  • Hello [5 Mins]
  • Requirements / Systems we use [10 Mins]
    • Note: We offer breakouts for professional practitioners! (Talk to Didi and Dan :)
  • Basics [15 Mins]
    • Where do software emissions come from
    • What is energy / power / CO2
  • How to get to power metrics in a system [10 Mins]
  • Easy tools to get first energy readings (perf_events, scaphandre, XGBoost ML, SDIA Model etc.) [30 min]
  • Cloud [30 Minutes]

• **PART 2**
  • Quick presentation GMT - Eco-CI - PowerHOG
    • Hands-On in Groups
Requirements
For the workshop

• You must have a Github account.
• Linux System? -> Live Systems?
• Windows Systems? -> WSL2
• macOS Systems?
• Basic Install for everybody:
  • sudo apt update
  • sudo apt install curl git stress-ng -y
  • # or
  • brew install stress-ng
  • brew install curl
Where do software emissions come from?

Components

• Operational emissions - We will do this hands on!
  • Energy (and thus CO2 through fossil fuels)
• Embodied Emissions - Done through data sheets
  • Carbon (workshop focus)
• Water consumption
• Land use
• Toxic Metals
• ...
Embodied Carbon
Using Life-Cycle-Assessment databases

- Boavizta
  [https://dataviz.boavizta.org/manufacturerdata](https://dataviz.boavizta.org/manufacturerdata)

- Microsoft
  [https://tco.exploresurface.com/sustainability/calculator](https://tco.exploresurface.com/sustainability/calculator)

- Dell

- ... many more

Source: [https://dataviz.boavizta.org/manufacturerdata](https://dataviz.boavizta.org/manufacturerdata)
Quick recap on energy and CO2
Technical details - What you must know for this workshop

• What is a TDP?

• What is a kWh?
  • Watts * usage time

• From TDP to kWh
  • https://www.green-coding.berlin/co2-formulas/#from-specs-to-kwh

• What is a Joule?
  • https://www.green-coding.berlin/co2-formulas/#from-joules-to-kwh

• From kWh to CO2e / Grid Carbon Intensity
  • https://app.electricitymaps.com/map

• From Network to CO2e
  • https://www.green-coding.berlin/co2-formulas/#gigabytes-to-kwh
Getting from energy to CO2

Using grid emission factors

• Electricitymaps
  https://www.electricitymaps.com/

• Bundesnetzagentur
  https://www.smard.de/home

• Wattime
  https://www.watttime.org/

• Carbon-Aware-SDK
  https://github.com/Green-Software-Foundation/carbon-aware-sdk

• ... many more

Source: https://app.electricitymaps.com/zone/DE
How do we measure energy?
Two easy methods: Wall-Plug vs. Hardware/Software-Interfaces. Servers: IPMI

Intel RAPL

Wall-Plug power meter
How do we measure energy?
A possible alternative: Through battery drain on mobile devices

Example: Coconut Battery for macOS / iOS

Android Battery usage (model)
Scaphandre - Hubblo
open-source RAPL based command line tool

- Neat feature: Can split by process
Let's run Scaphandre!

via https://hubblo-org.github.io/scaphandre-documentation/tutorials/compilation-linux.html

• ## Could not get it working with current version ...
• # from https://www.rust-lang.org/tools/install
• curl --proto '=https' --tlsv1.2 -sSf https://sh.rustup.rs | sh
• source "$HOME/.cargo/env"

• git clone https://github.com/hubblo-org/scaphandre.git
• cd scaphandre
• cargo build # binary path is target/debug/scaphandre
• git checkout v0.5.0
• sudo ./target/debug/scaphandre run stdout -t 0

• # But if you have docker in rootless mode:
• sudo docker run -v /sys/class/powercap:/sys/class/powercap -v /proc:/proc -ti hubblo/scaphandre stdout -t 15

• # now we run stress to see changes in separate terminal
• stress-ng -c 1
**perf_events**

- `sudo apt install linux-tools-$\{uname -r\}`
- `perf list | grep power` # to see what we have available on the system
- `perf stat -e power/energy-pkg/` # to read package

## Mini Benchmark
- `perf stat -e power/energy-pkg/ sleep 10` # to get system baseline over ten seconds
- `perf stat -e power/energy-pkg/ stress-ng -c 1 -t 10` # to get system baseline over ten seconds

# Look at IPC
- `perf stat -e instructions,cache-misses stress-ng -c 1 -t 1` # to get system baseline over ten seconds

# Look at "default" defailed view
- `perf stat -d stress-ng -c 1 -t 1` # to get system baseline over ten seconds
codecarbon.io
Slide only due to time constraints :)

- Python
- RAPL-based
- NVIDIA GPU support
Windows Tools
Intel Power Gadget

• Not distributed anymore.

• But you can try: https://www.computerbild.de/download/Intel-Power-Gadget-24653156.html
Cloud environments
SDIA Model - 1/3

• Assumes that 65% of the machines total energy is related to the CPU. We can extrapolate from there

  • total_machine_power = ((cpu_utilization * TDP) /0.65) * CPU_CHIPS
Cloud environments
SDIA Model - 2/3

- Assumes that 65% of the machines total energy is related to the CPU. We can extrapolate from there
  
  \[
  \text{total\_machine\_power} = \left(\frac{\text{cpu\_utilization} \times \text{TDP}}{0.65}\right) \times \text{CPU\_CHIPS}
  \]

- Example for 12% CPU Utilization and 2 chips with a 160 W TDP:
  
  \[
  \left(0.12 \times 160\right) / 0.65 \times 2 = 59.08 \text{ W}
  \]
Cloud environments
SDIA Model 3/3

• That, more or less, is for instance what CloudCarbonFootprint does. However, they integrate more components like memory etc. with static offsets.

  • https://www.cloudcarbonfootprint.org/docs/methodology/#energy-estimate-watt-hours

• For hard disks they use $0.001 \text{ kWh/Gb}$ for instance

• How can we improve that ...?
Cloud environments
XGBoost estimation 1/3

• Using ML Models based on power curves of actual machines
  • Non-Linear!
• https://www.spec.org/power_ssj2008/results/https://www.spec.org/power_ssj2008/results/
Cloud environments

XGBoost estimation 2/3

• Using ML Models based on power curves of actual machines
  • Non-Linear!

• Caveats:
  • CPU Frequency is needed to be assumed constant

• See our article on this in detail:
  • https://www.green-coding.berlin/case-studies/cpu-utilization-usefulness/
  • https://www.green-coding.berlin/case-studies/hyper-threading-and-energy/
  • etc.
Cloud environments
XGBoost estimation 3/3

• Let's install it!
  • [https://github.com/green-coding-berlin/spec-power-model](https://github.com/green-coding-berlin/spec-power-model)
Appetizer for deep dives
How to get good measurements?

• Architectures (Mikrocontrollers vs. Multi-Tasking systems)
• Stable systems (Timers, Services, Processes)
• Temperature
• Component scalings (HyperThreading, Turbo Boost, PowerCaps)
• Calibration (Resource congestion / Headroom)
• Overhead
• ... (watch our blog :) )
Part #2

In breakout groups

Green Metrics Tool Linux&WSL / Eco-CI / macOS
Green Metrics Tool - Cluster Setup

Current machines in the Green Metrics Tool Cluster

- Fujitsu ESPRIMO P956 - Blue Angel compatible (Ubuntu)
- Fujitsu TX1330 M2 - Single-Tenant Server (Ubuntu)
- Quanta Leopard - Multi-Tenant Server - SoftAWERE compatible (Ubuntu)
- Intel Mac 13" Q3-2015
- M1 Mac 13" Q1-2022