

Power profiling with the Firefox Profiler

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Firefox Profiler

https://profiler.firefox.com

What's the Firefox Profiler

- Built-into Firefox
- Initially for performance work
- Main sources of data:
 - \circ Samples
 - Stacks
 - Counters
 - Markers









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Power profiling

Why? User experience!

Excessive power use = poor user experience

- Noisy fans
- Hot laptops
- Short battery life

Why? Sustainability!

Mozilla made climate commitments:

- being carbon-neutral.
- reducing its <u>GHG footprint</u> year over year
- leading openly by sharing materials, tools, and methodologies.
- exploring approaches to develop, design, and **improve products**

from a sustainability perspective



Emissions Distribution 2019



Understanding local power use

(cheap) Wattmeter



- Affordable
- Reasonably accurate
- Can't track things over time

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Better wattmeter



- Connects over bluetooth
- Data readable from another computer



Still difficult to match with what was done



How <u>Microsoft did it</u>?

Browser efficiency comparison - Webdriver Windows 10 Anniversary Update

Methodology summary

The Microsoft Windows team measured the average power consumption of the CPU, GPU, and Wifi antenna while Microsoft Edge, Chrome, Firefox, and Opera ran a complex yet representative set of user activities.

•••

Measuring power

Power was measured on the Surface Book because it has integrated hardware instrumentation that's able to measure the real power consumption of the CPU, GPU and Wifi antenna while the automation is being executed. This is done using the <u>Maxim 34407</u> <u>Power Accumulator chip</u>. The results of the Maxim chips were read using the built in Windows tool "Performance Monitor". Performance Monitor was opened and configured to measure each component independently:

- \Energy Meter (CPU_CORES)\Power
- \Energy Meter (GPU_TOP)\Power
- \Energy Meter (WLAN_BT)\Power



Devices with MAXIM power meters



- Surface Book 1, Surface 3
- Many other devices expose it in their ACPI table, but don't actually have the chip
- Energy meters in perfmon.exe:

| cicce counters non computer. | | Counter | Parent | Inst | Computer |
|-------------------------------------|----------|----------------|--------|------|----------|
| <local computer=""> v</local> | Browse | Energy Meter - | | | |
| Distributed Transaction Coordinator | × ^ | * | | BAT | |
| DNS64 Global | | * | | CPU | |
| Energy Meter | | | | GPU | |
| Event Log | • | | | | |
| Event Tracing for Windows | | | | | |
| Event Tracing for Windows Session | ~ | | | | |
| Fax Service | ~ | | | | |
| FileSystem Disk Activity | | | | | |
| Instances of seected object: | Search | | | | |
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A good surprise...

| | | Added counters | | | | |
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| <local computer=""></local> | Browse | 1.02.001.0 | | | 1 | |
| Distributed Routing Table | ~ | | | | | |
| Distributed Transaction Coordinator | • | | | | | |
| DNS64 Global | • | | | | | |
| Energy Meter | ^ | | | | | |
| Energy | | | | | | |
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- Some machines report energy meter channels with familiar names.
- Windows 11 with Intel CPUs.

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Energy Meter Interface API

- The perfmon.exe UI is horrible, but...
- There's a documented API!
 - unit is picowatt-hour
 - can be queried many times per second
 - accessible in user land
 - (no requirement to install a specific driver)
- Usable for profiler counters:

Bug 1774844 - Use the Windows Energy Meter Interface to record power use data in profiles



| ••• | Firefox 103 – Wi | indows 10 - 6/21 × + | | | | | | | ~ | |
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| Screenshots | | | | | · · · · · · · · · · · · · · · · · · · | | | | | **** |
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Power profiling - platform support

Windows:

- Windows 10 devices with hardware power meters (Surface Book 1, Surface 3, ?)
 CPU, GPU, Wifi power use
- Windows 11 Intel CPUs
 CPU, GPU, DRAM power use
- Windows 11 22H2 (TBC) AMD Ryzen CPUs
 1 track per core!



Power profiling - platform support

Mac:

- Apple Silicon
 - Undocumented API, returning a per-process value!

task_info(mach_task_self(), TASK_POWER_INFO_V2,

(task_info_t)&task_power_info, &count);

- Intel x64-64 CPUs
 - diagCall64 (dgPowerStat, ... called from asm gives us the RAPL MSR.
 - (copied from an <u>8 years old implementation</u>)



Power profiling - platform support

Linux:

- Use RAPL perf events
- sudo sysctl kernel.perf_event_paranoid=0
 Access to power data is restricted since October 2020
 due to a side channel attack.
- AMD CPUs supported since Linux Kernel 5.8
- Doesn't work with Ubuntu's Firefox snap package



Power profiling - configuration

There is a 'Power' preset for easy configuration.



Windows 11 & Apple Silicon since Firefox 104 — Linux & Intel Macs since 107

Reducing overhead

- Longer interval
- No periodic stack sampling

| | | O Profile Info | ć |
|------------------|--------------------------------------|----------------|----------|
| • • • • • | | | <u> </u> |
| Profile Informa | tion | | - |
| Main process | | | |
| started: | Wed, Feb 1, 2023, | 7:26 PM | |
| Interval: | 10ms | | |
| Buffer capacity: | 1GB | | |
| Buffer duration: | Unlimited | | |
| Features: | ∘ js | | |
| | screenshots | | |
| | stackwalk | | |
| | nostacksampling | 9 | |
| | ipcmessages | | |
| | ∘ cpu | | |
| | markersallthread | ls | |
| | processcpu | | |
| | power | | |

Examples

| 0 | 1 | | | | | | | | | | | | | |
|------------------------------|----------------------------------|-----------------|--|--|---------------|-------------------|--------------|--------------------|--------------|-----------------|-----------------|---------|---------|--------|
| ••• | ${f W}$ Wikipedia, the free ency | clopedia× | Firefox 111 - | - macOS 12.3.1 - | - 2/1/× | + | | | | | | | | \sim |
| $\leftarrow \rightarrow C$ | O A https: | //profiler.fire | fox.com/pub | lic/anmjcjmr | 538npfnq | sk0ed1bnq5tc | 3xjtxm6cb4 | 0/network- | chart/?globa | alTrackO 🏠 | | | ∩ ~ . | ර = |
| Firefox 111 – macOS 12 | 2.3.1 Full Range (9.4s) > 2 | 2.6s > 702ms | s 346ms | | | | | | | O Profile Info | ৫ Re-upload | % Pe | rmalink | Docs 🖸 |
| 8 / 442 tracks 🔻 | 7.20s 7.25s | 7.30s | 7.35s | 7.40s | 7.45s | 7.50s | 7.55s | 7.60s | 7.65s | 7.70s | 7.75s | 7.80s | 7.8 | 5s |
| Screenshots | | biant d' | interes in the second sec | Annes Anne | | | | | | | | | | |
| Parent Process PID: 84177 | | | 1.1. | (* | | | | | | | ţ " | | | |
| Network | | | | | | | | | | | | | | |
| Renderer | | | • | | | | | | | | | | | |
| Process Power | ~ | | ~ | ~ | ~ | | | | | | | | | |
| wikipedia.org PID: 93889 | | | | | 1 1 | 8 81 Y | | | | | | | | |
| Network | | | | | | | | | | | | | | |
| Process Power | | ~ | \sim | | - | - | | | | | | | | |
| Marker Chart Mark | ker Table Network | | | Energy used | in the ourrou | Power: 5.73 | W | a (0 a) | | | | | | |
| | | | | Energy used | sed in the vi | isible range: 135 | μWh (0.060 m | g CO₂e) g CO₂e) | Filter N | etworks: Q Ente | er filter terms | | | |
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| https://upload.wikimedia.or | g/wikipedia/com /70px-Media | Wiki-2020-icon. | .svg.png | | | | | | | > | × Legal Privacy | Cookies | English | (US) ~ |

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Loading Wikipedia homepage - <u>https://share.firefox.dev/3RqH4Ke</u>



Starting Firefox - https://share.firefox.dev/3X0PHMP

Blinking the cursor

Measure tiny things:



Ever wondered how much power it takes to blink the caret in the address bar? Now you can know! <u>https://share.firefox.dev/3U8hLqp</u>



Using efficiency mode on Windows 11

| 👏 Firefo> | «Nightly | Efficiency mode | Ø | 0% | 21.7 MB | 0 | |
|---|--------------|-----------------|------------------|-------------------------------------|----------------------------------|-------------------|--|
| | | | Th lin | is process is iι nit resources ι | n efficiency m ised by the pr | ode to rocess. | |
| Parent Process PID: 16128 | | | | | | | |
| Power: CPU cores file:// Content PID: 18652 | | | by | The power use by using 100% | | | |
| Marker Chart | Marker Table | Filter | Markers: 🔍 Prior | ity a C | ore drops | from | |
| | IPC | | | | | | |
| IPCIn | Other | | | 10 | V to 2W. | | |
| NotifyObservers | | | | | | | |
| Process Priority | | ♦ | | | | | |

Wifi power use

When unplugging the charger...

| WiFi | |
|--|--------------------|
| 10.3µs WindowProc - WM_POWERBROADCAST | han har han |
| uMsg: 536 | |
| wParam: 10 | Enter filter terms |
| Thread: Parent Process | |
| Page: chrome://browser/content/browser.xhtml | |
| WindowProc | |



Wifi power use

Running speedtest.net

• On this machine:

| Parent Process | | | |
|----------------|---------|--|--|
| Ρ | ID: 672 | A. A. Martin and the second se | |
| | Network | | |
| | WiFi | | have been and the second second second |

• And on another machine:

| Parent Process | | 1 | 1 | 1 1 | 11 |
|----------------|---------|---|---|--|----|
| P | D: 672 | | | | |
| | Network | | | | |
| | WiFi | | | and the second according to the second station | A |



Profiler overhead and CPU load

| 🖋 Firefox 111 – macO | DS 12.3.1 | Full | Range (* | 17s) > | 2.6s > 1 | 8s | | | | | | | | | | O Pro | ofile Info | 🖞 Upload L | ocal Profile |
|---------------------------------|------------------|--------|----------|-----------|---------------------|----------------------------|-----------------------|----------------------|---|----------|-------|--------|-------|-------|--------------|-------------|--------------------------|------------------------|--------------|
| 14 / 371 tracks | ▼ .5s | 12. | 6s | 12.7s | 12.8s | 12.9s | 13.0s | 13.1s | 13.2s | 13.3s | 13.4s | 13.5s | 13.6s | 13.7s | 13.8s | 13.9s | 14.0s | 14.1s | 14.2s |
| file:// Content PID: 97691 | | | | | | | | ~~~ | | | | | | | | | | | |
| Process Power | ~ | \sim | ~~ | ~ 1 | \sim | | \sim | \sim | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ | \wedge | | | | | | | | | |
| Socket Process PID: 94636 | | | | | Energy us | ed in the vis | Power: ible range: | 4.23 W 528 μWh (0 |).23 mg CO₂ | 2e) | | | | | | | | | |
| Process Power | | ~ | ~ | | ~~~ | ~~~^ | | ~~~ | | \ | ~~~ | | | | | | | | |
| Web Content (1/4) PID: 97657 | | | | | | | | | | | | | | | | | | | |
| Process Power | ~ | | ~~~ | ~~~~ | ~~~~ | v~~~ | ~~~~ | | ~~~ | ~~~~ | | ~~~~ | 1 | | | | | | |
| Web Content (2/4) PID: 97677 | | | Energy | used in t | Po he visible ra | wer: 2.6 mV nge: 0.82 μ | V Wh (0.000 r | ng CO₂e) | | | | | | | | | | | |
| Process Power | ~ | ~ | | | | | ~ | | | | | | | | | | | | |
| firefox.com (1/2) PID: 97315 | | | | | | | | | | | | | | En | ergy used in | the visible | Power: 0.4 range: 0.8 | 16 mW 32 μWh (0.000 |) mg CO₂e) |
| Process Power | ~ | \sim | \sim | | ~~~ | ~^ | | ~~~ | ~~~ | | | ~~~~ | 1 | | | | | | |
| Web Content (3/4) PID: 97690 | | | | | | | | | | | | | | | | | | | |
| Process Power | ~ | ~ | ~~ | | ~~~~ | ~~~ | | | \sim | \sim | ~~~~ | \sim | 1 | | | | | | |
| firefox.com (2/2) PID: 94642 | | | | | | | | | | | | | | | | | | | |
| Process Power | ~ | | | | ~~~ | | | | | ~~~~~ | | ~~~ | 1 | | | | | | |

Bonus

A few more things

Firefox task manager

With one click profiling (the 'power' feature is enabled)

| | 🖓 Process Manag | ger | × M | MDN Web Docs | | | | |
|------------------------------|-----------------|---|----------|------------------|--|--|--|--|
| \leftarrow \rightarrow G | Nightly a | about:process | es | | | | | |
| Name | | | | | | | | |
| Nightly (82362) | | | | | | | | |
| > 16 active threads | s out of 86: M | lainThread 0.3 | 7%, (413 | 382907) 0.4%, (4 | | | | |
| M https://mozilla.or | rg (82410) | n | | | | | | |
| M Tab: MDN Web Do | OCS | Profile all threads of this process for 5 seconds | | | | | | |
| > 31 inactive threa | ds | | | | | | | |
| 🔷 About nadoc (92) | 261) | | | | | | | |

CO₂ equivalent

Power: 2.68 W Energy used in the current selection: 63 μWh (0.028 mg CO₂e)

Energy used in the visible range: 168 µWh (0.074 mg CO₂e)

Thanks to Chris Adams and Fershad from The Green Web Foundation.



Process CPU

| Scre | enshots | | |
|---------------|-------------------------|--|------------------|
| Pare PID: | ent Process 94635 | | When power |
| R | ≀enderer | | profiling is not |
| Ρ | rocess Power | An an annual least by the later that the second second second second second second second second second by the second s | |
| P | rocess CPU | many and the second of the sec | supported on |
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| R | D Inspector | Console D Debugger ↑↓ Network {} Style Editor | |
| Ŵ | Filter Output | Errors Warnings (412) Logs Info Debug CSS XHR Requests | |
| » e | experimental.enable | ProcessCPUTracks() | |
| | Ine process CPU | tracks are now enabled and should be displayed in the timeline. window-console.js:94:1 | |
| | - | | |

Note that this is an experimental feature that might still have bugs.

 $\,\,$ As an experimental feature their presence isn't persisted as a URL parameter like the other things.

 \leftarrow undefined

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Thanks! Questions?

- Share ideas, #profiler:mozilla.org on Matrix.
- Questions: <u>florian@mozilla.com</u>