IT & environment: an inconvenient combination?

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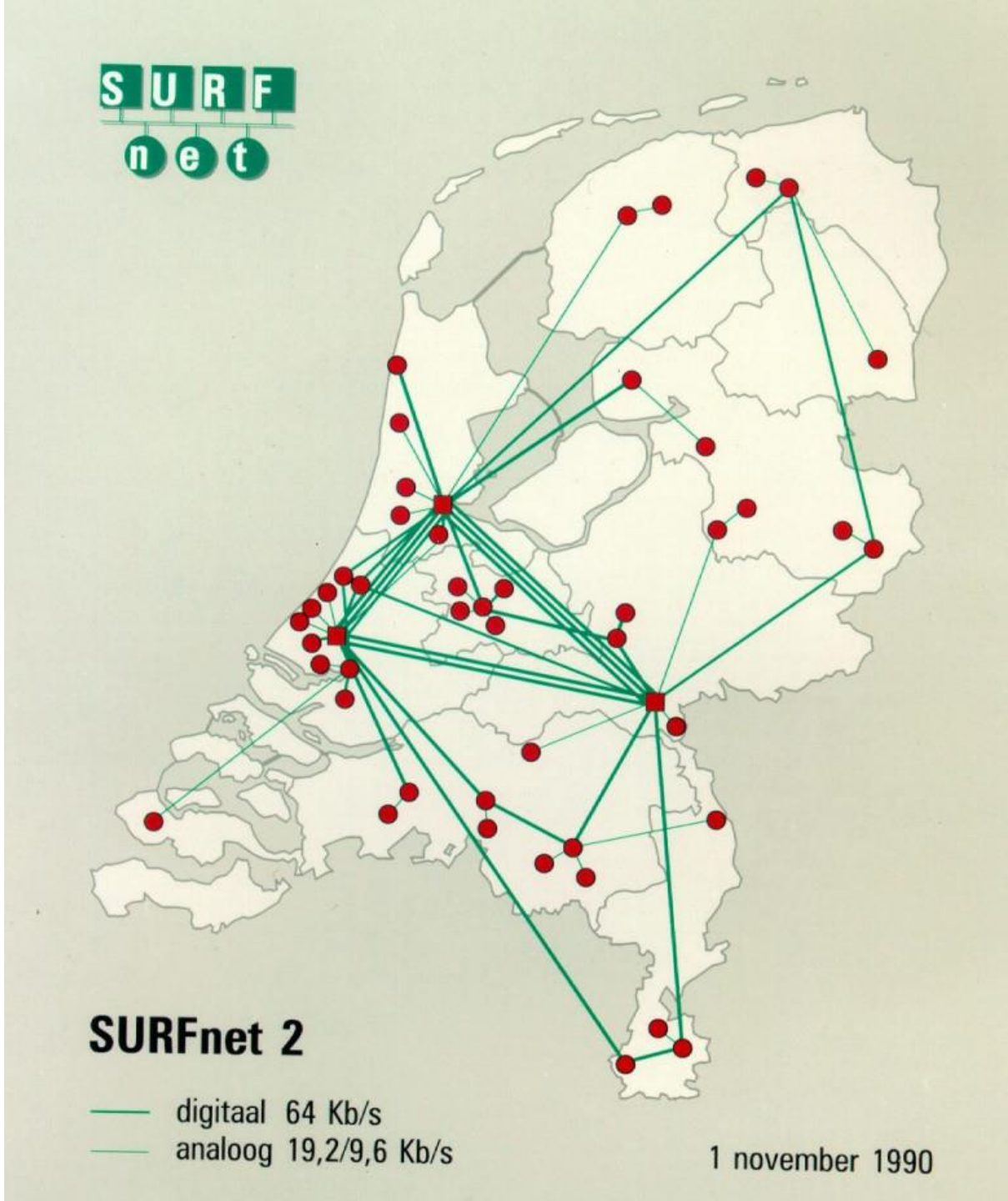
Our hidden impact

PROGRAMMING-ERROR: OEPS!

- Calculating some model on 80 servers did cost 7 days.
  Electricity consumption: 500W x 80 servers x 168 hours = **6.720 kWh**
- + cooling/network…. factor 2 (for small data centers, 1.1 for larger ones): **13.440 kWh**.
- Yearly electricity consumption of Dutch household: on average 2479 kWh (‘modaal’)…
  ~ 5,4 households-in-a-year

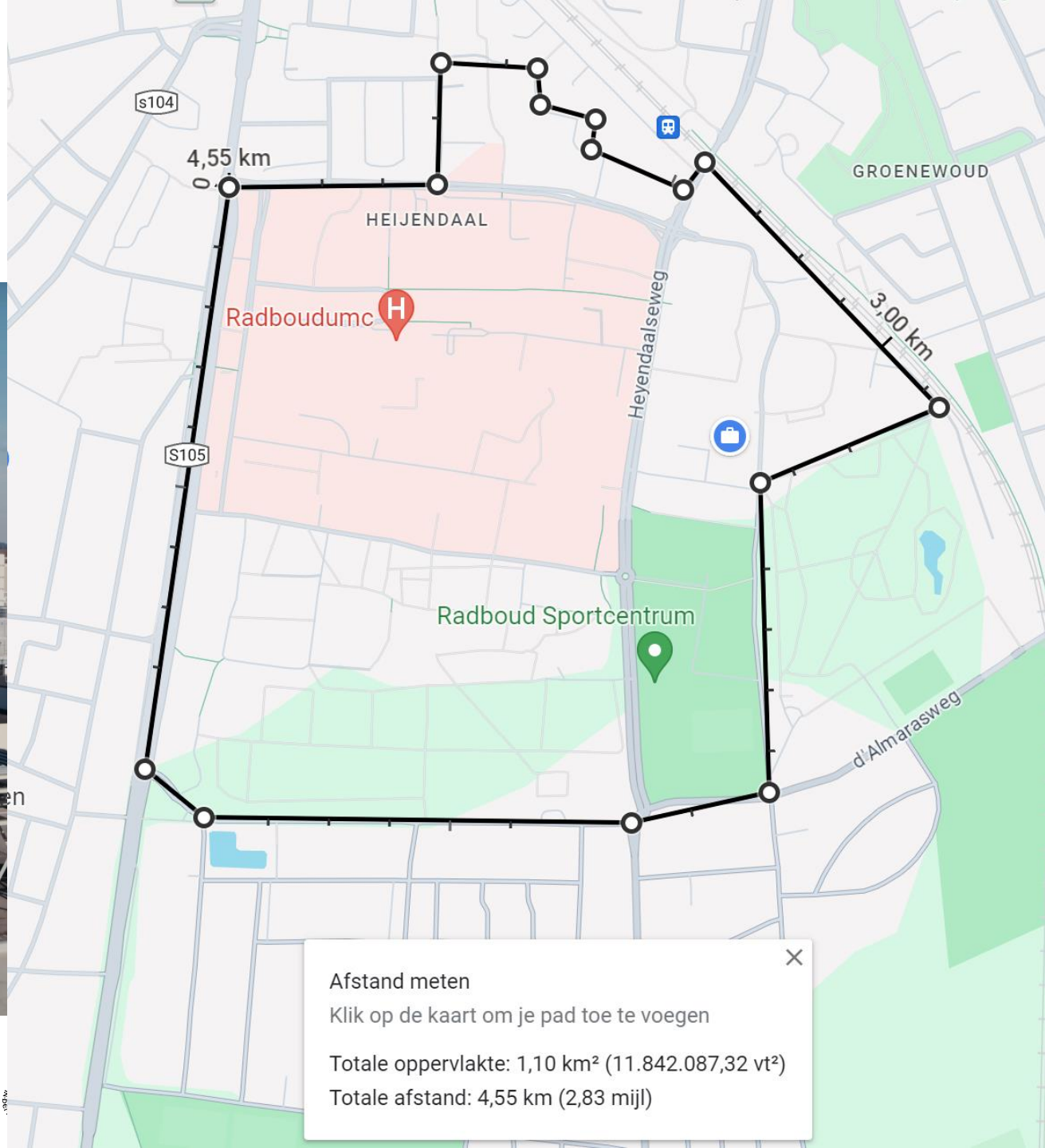
Internet...

Internetdistance



Provider / AMS-IX

Datacenters



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Impact of IT & AI

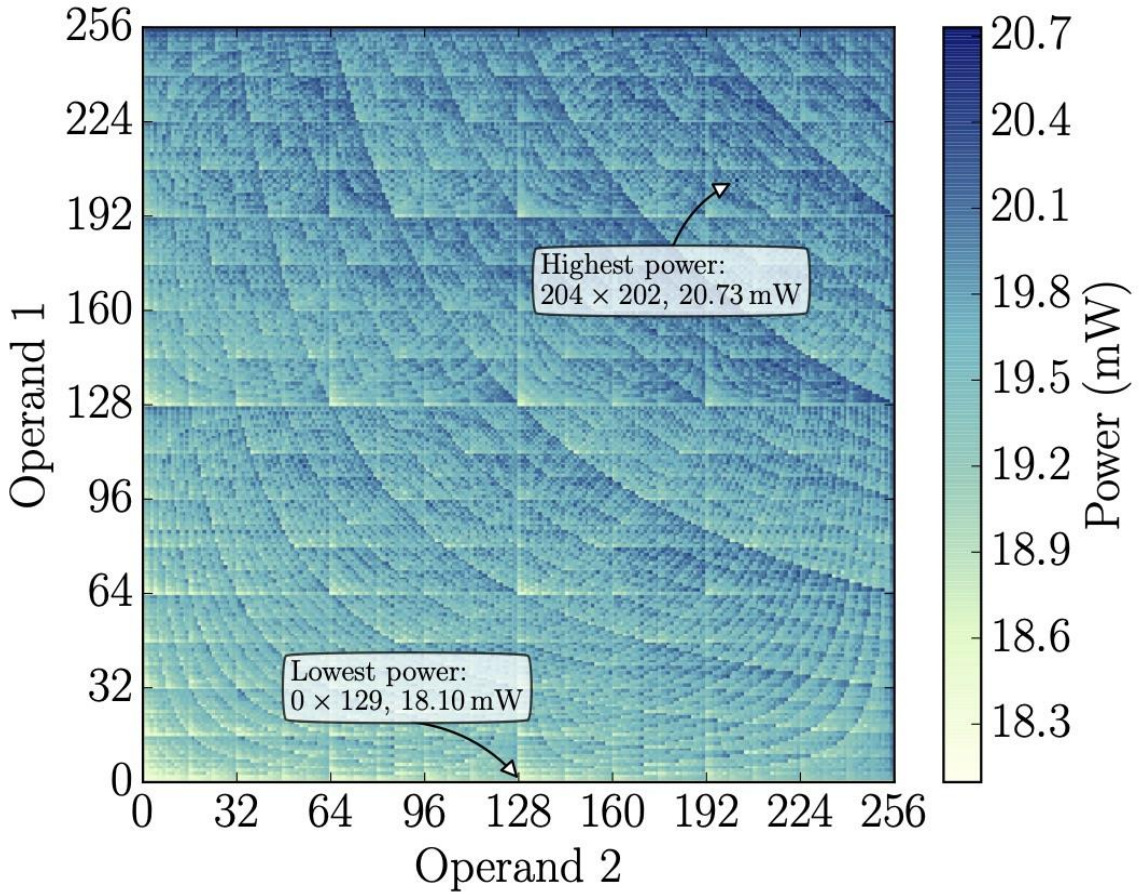


Fig. 1. Power map of `mul` instruction, total range is 15 % of SoC power.

Materials/production

- Cost energy
- Rare earth materials
- Working conditions
- E-waste

- Compute
- Storage
- Transmission
- Idle

https://arxiv.org/abs/1505.03374

Global trends in digital and energy indicators, 2015-2022

	2015	2022	Change
Internet users	3 billion	5.3 billion	+78%
Internet traffic	0.6 ZB	4.4 ZB	+600%
Data centre workloads	180 million	800 million	+340%
Data centre energy use (excluding crypto)	200 TWh	240-340 TWh	+20-70%
Crypto mining energy use	4 TWh	100-150 TWh	+2300-3500%
Data transmission network energy use	220 TWh	260-360 TWh	+18-64%

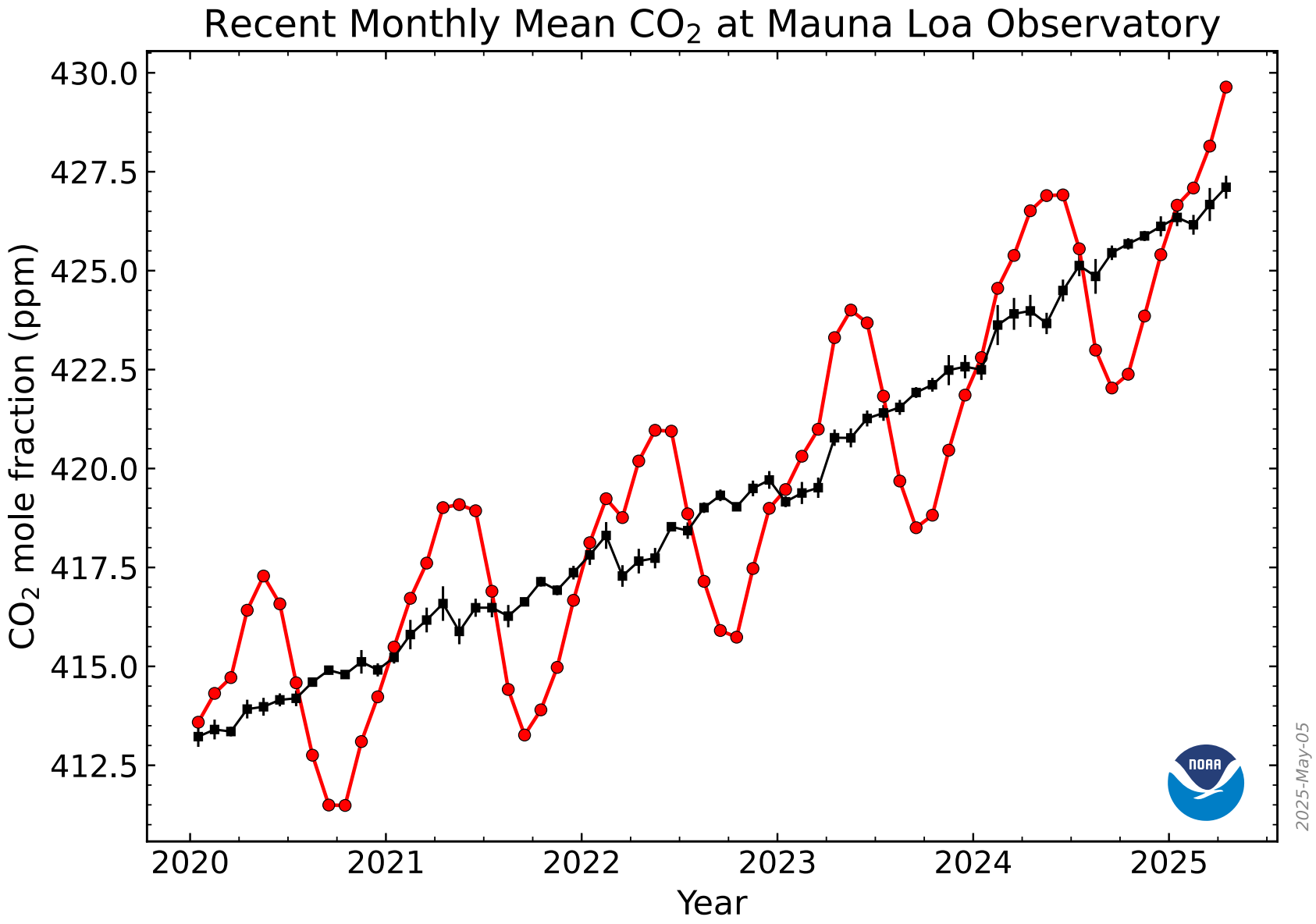
Sources: Internet users [ITU (2023)]; internet traffic [IEA analysis based on Cisco (2015); TeleGeography (2022); Telegeography (2023); Cisco (2019), Cisco Visual Networking Index]; data centre workloads [Cisco (2018), Cisco Global Cloud Index]; data centre energy use [IEA analysis based on Malmodin & Lundén (2018); ITU (2020); Masanet et al. (2020); Malmodin (2020); Hintemann & Hinterholzer (2022); Malmodin et al. (2023)]; cryptocurrency mining energy use [IEA analysis based on Cambridge Centre for Alternative Finance (2023); Gallersdörfer, Klaaßen and Stoll (2020); McDonald (2022)]; data transmission network energy use [Malmodin & Lundén (2018); Malmodin (2020); ITU (2020); Coroama (2021); GSMA (2022); GSMA (2023); Malmodin et al. (2023)].

https://www.iea.org/energy-system/buildings/data-centres-and-data-transmission-networks

Primair verbruik (2940 PJ)

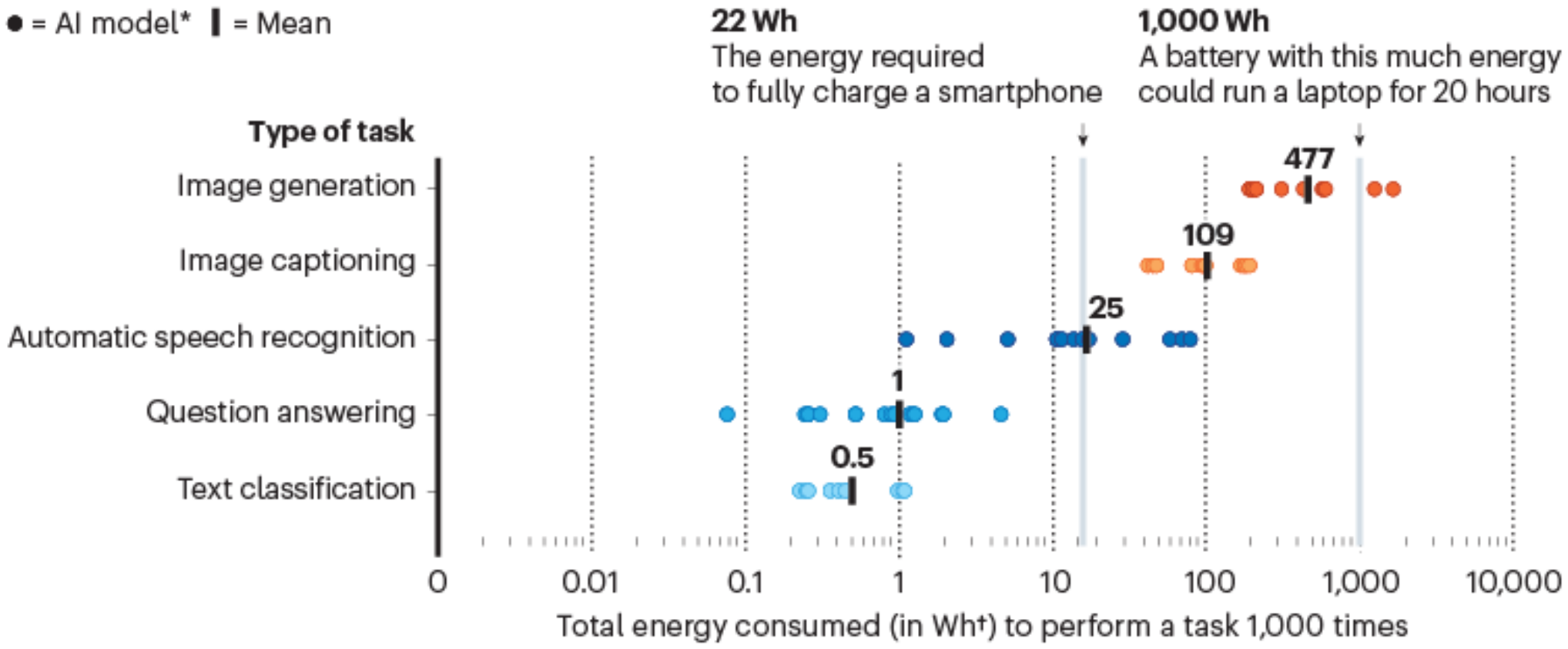
Energiebronnen

Ber


Recent Monthly Mean CO_2 at Mauna Loa Observatory
CO_2 mole fraction (ppm)
430.0
427.5
425.0
422.5
420.0
417.5
415.0
412.5
2020
2021
2022
2023
2024
2025
Year
NOAA
2025-May-05

AI'S ENERGY FOOTPRINT

The power consumed by artificial intelligence (AI) tools varies greatly depending on the task. An AI model that provides answers to queries is much less energy-intensive than one that generates images from text prompts, for example. And the data show that even AI models of the same type can vary widely in energy consumption.



*Tests conducted on 20 popular open-source models. Each dot represents one model;
†1 Watt-hour represents power consumption of 1 W extended over 1 hour.

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Software is everywhere

Sustainable IT is a 'wicked problem'

Because IT is all around us, and it is hard to:

- **predict behavior of humans;**
- **predict behavior of software;**
- **predict energy consumption of hardware.**

Example questions:

- **how much does IT on the campus consume?**
- **what is the effect of IT on mental health?**
- **is it worth relying on IT (and Big Tech) in primary education?**
- **should we solve IT problems with IT?**
- **…**

Often it involves trade-offs between sustainability goals (and other goals). And interdisciplinary solutions!

Restrained digitalization

Sometimes don't digitalize

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Systems


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS

Examples

	economy	**society**	**environment**
sustainability in **IT**	software with minimal cost & easy to adapt	inclusive software	software with minimal resource usage
sustainability with **IT**	precision argiculture to lower costs (with IoT sensors)	software supported education	software with green effect

Sustainable digitalization is deciding which processes in a chain to support with software, and which to make or not make digital, with sustainability taken into account.

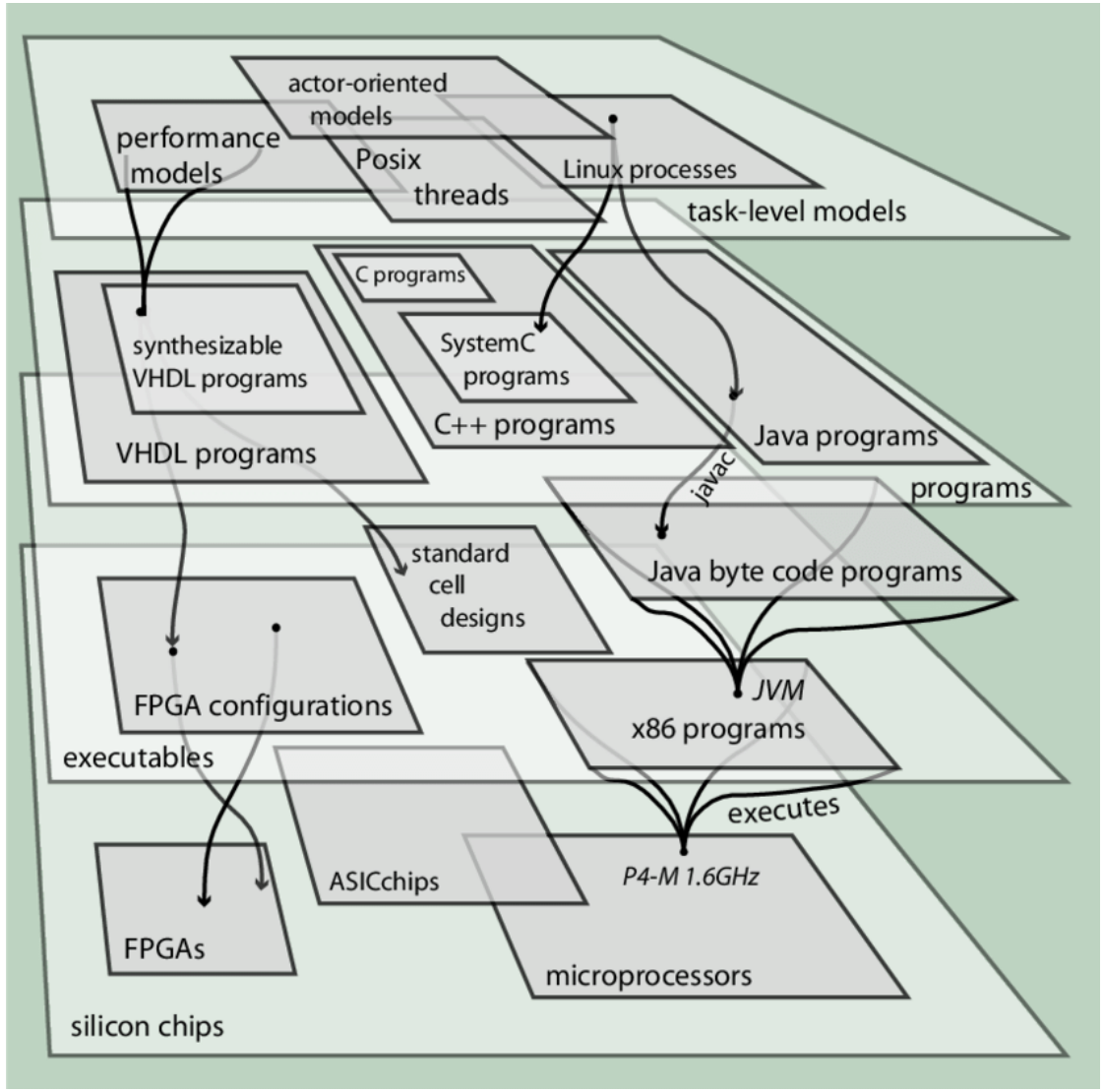
Sustainable software is made using **sustainability-by-design**: be aware of social and environmental impact. This has two flavors: impact **of IT**, or **with ICT**.

Green software is:
- software with **minimal environmental impact** (of IT), or
- software with **a green effect** (with IT).

Challenges

CHALLENGE 1

Too many layers



CHALLENGE 2

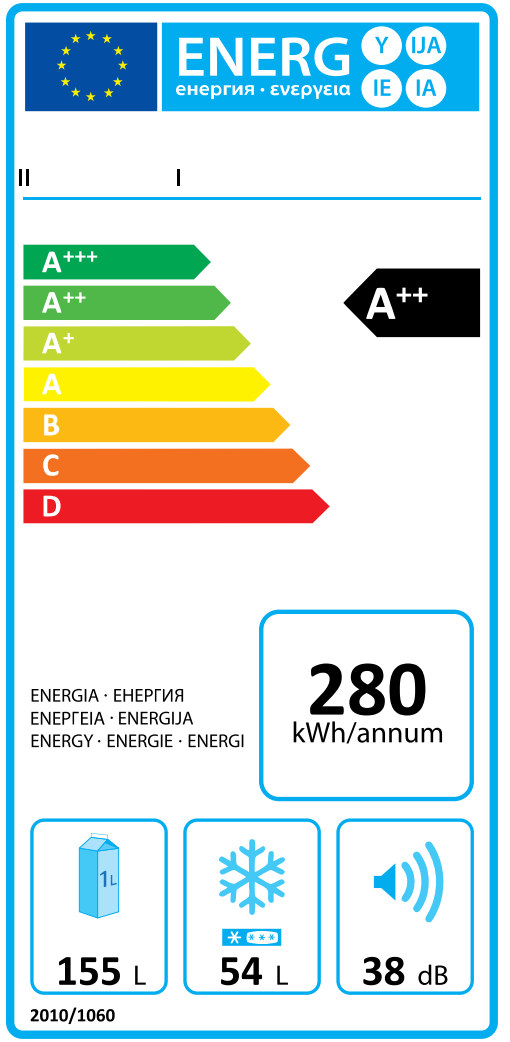
Expected use unclear

CHALLENGE 3

The polluter does not pay

CHALLENGE 4

Too many hardware/standards/usages + lack of rules



CHALLENGE 5

Complex landscape of stakeholders

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Solutions

Roy van der Steen, Bernard van Gastel: The organizational hurdles of structurally reducing the energy consumption of software. 2023. In Proceedings of BENEVOL 2023, 2023

solution 1
create ‘incentive’

solution 2

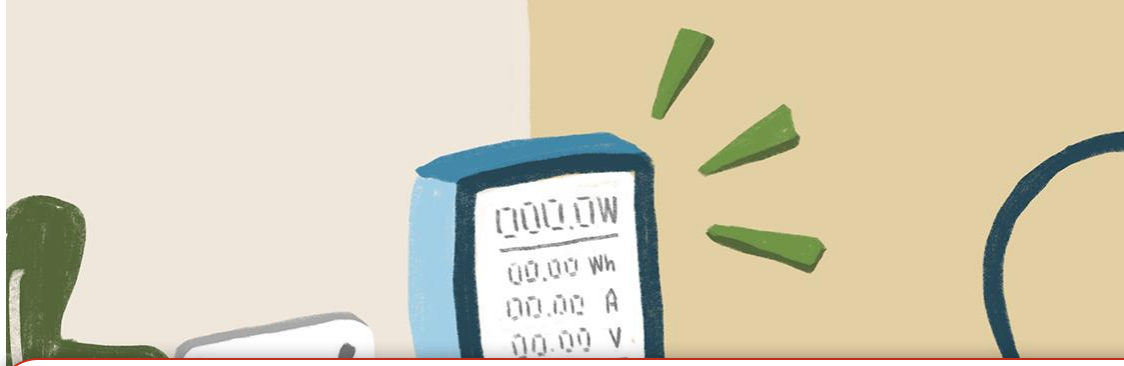
support teamwork with right tooling and infrastructure

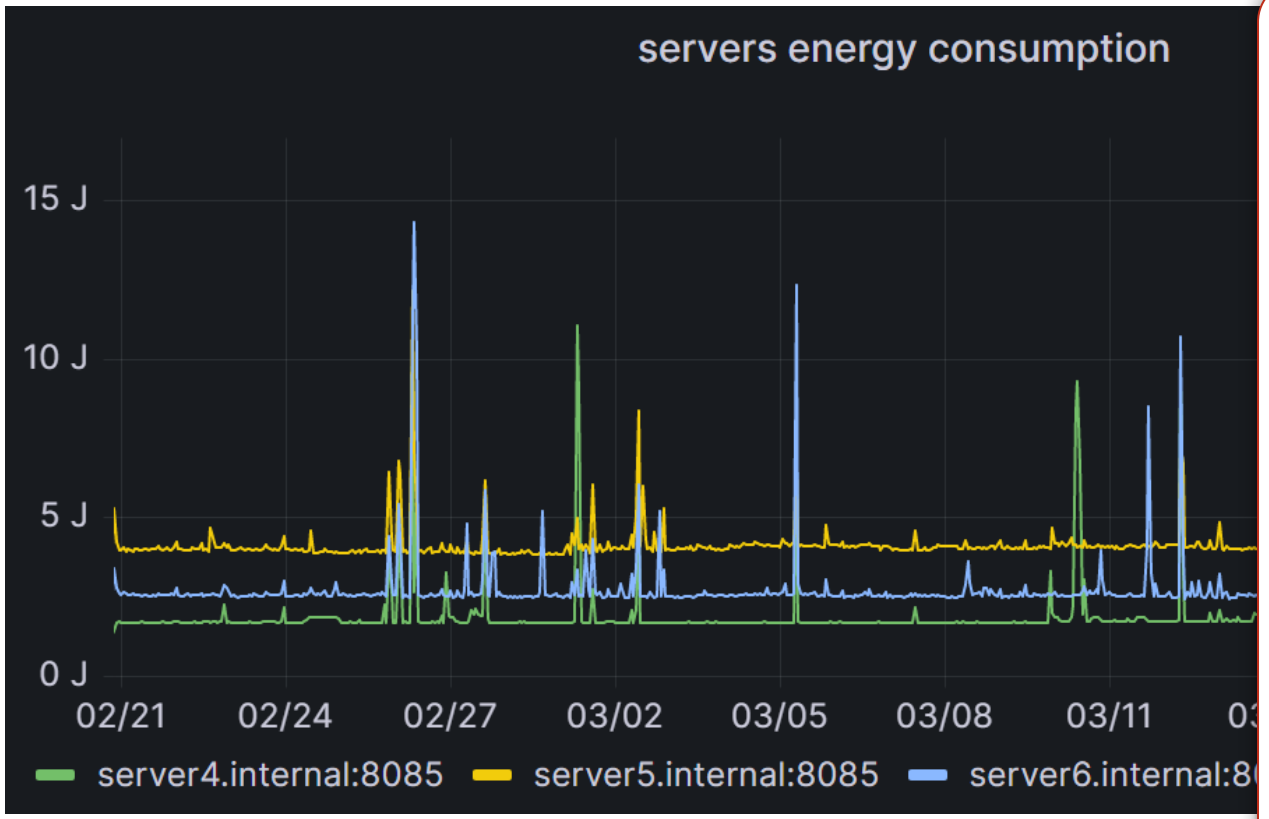
solution 3

share knowledge (and discuss misconceptions)

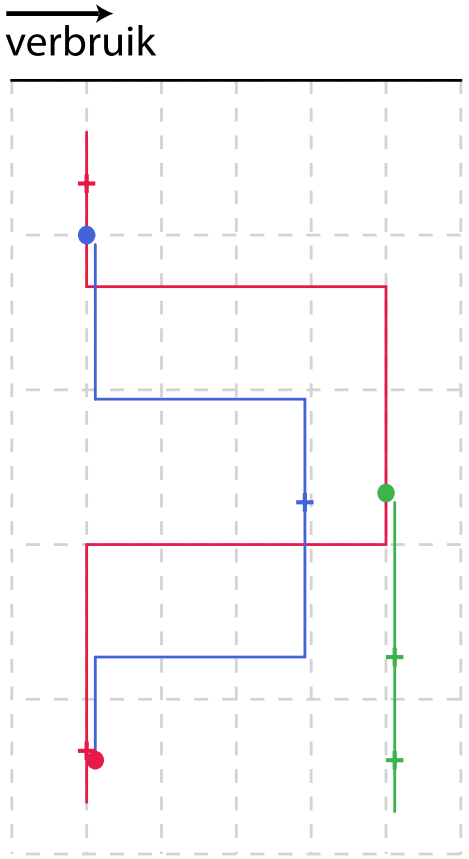
Measuring

Measuring is hard






```
1   int main() {
2       x = Temp.readInt();
3       if ( x ≤ 10 ) {
4           Ketel.switchOn();
5       } else {
6           Pomp.switchOn();
7       }
8       if ( x < 10 ) {
9           Ketel.switchOff();
10      } else {
11          Pomp.switchOff();
12      }
13      return 0;
14  }
```



Software Energy Lab

Now we can measure…

- But what about idle energy consumption?
- From measuring a few scenarios on specific hardware, what can we conclude?

For in house developed software running on your own machines, this works!

Most running software does not fall in that category.

Changing hardware

UNTIL NOW: GENERAL-PURPOSE CPU (AND A BIT OF GPU)

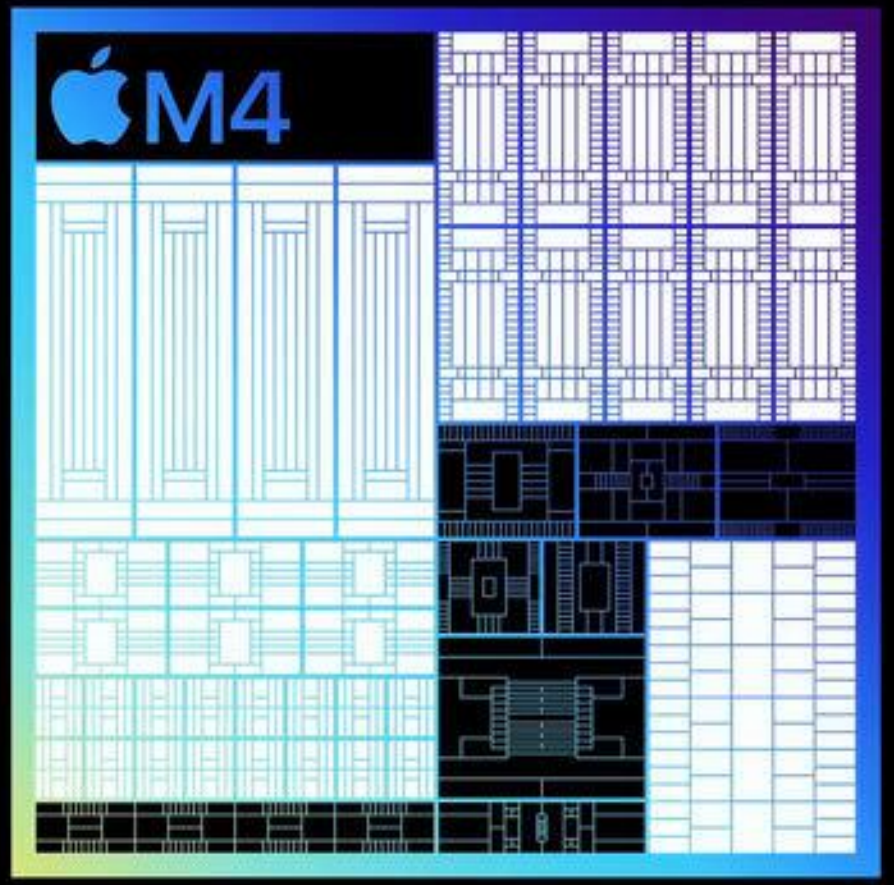
4 performance cores

Improved branch prediction
Wider decode and execution engines
Next-generation ML accelerators

6 efficiency cores

Neural Engine

16-core design
Faster and more efficient



10-core GPU

Next-generation architecture
Dynamic Caching
Mesh shading
Ray tracing

Display engine

Tandem OLED support
Brightness and color compensation
10Hz–120Hz ProMotion support

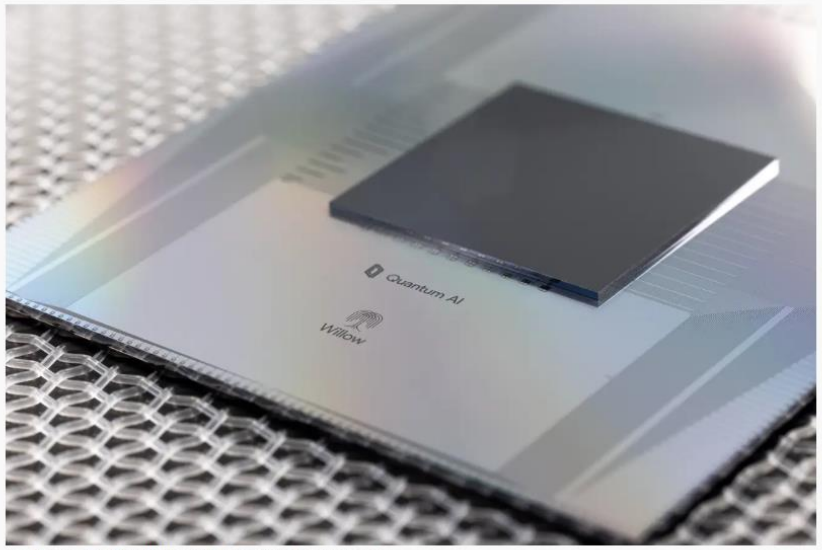
LEGACY CODE CHALLENGE

EMERGING TECHNOLOGIES

Google says its new quantum chip is way faster than the world's most powerful supercomputer

Google said its new chip Willow demonstrates that it's possible to build "a useful, large-scale quantum computer"

By **Britney Nguyen** Updated December 9, 2024



Google Quantum AI Willow chip Photo: Google Quantum AI

In This Story

GOOGL -1.24%

A new, state-of-the-art quantum chip from Google (GOOGL -1.24% ▼) has cracked the code on an almost three-decade-long problem, according to the company.

Suggested Reading

DEI's undoing: How Walmart, McDonald's, and more are adapting to Trump

Amazon, Disney, Starbucks and 5 other big companies that help pay for employees to go to college

The 14 best American cars to buy right now, according to Consumer Reports

https://qz.com/google-quantum-chip-willow-ai-frontier-supercomputer-1851716474

π Science and technology

Quantum computing and AI: less compatible than expected?

On October 9th, 2024 4 min reading time

Filippo Vicentini
Assistant Professor of AI and Quantum Physics at Ecole Polytechnique (IP Paris)

Key takeaways

- There is a belief that quantum computing could revolutionise artificial intelligence and in particular deep learning.
- However, quantum computing will not necessarily advance AI because it encounters difficulties in processing information from neural networks and voluminous data.
- In particular, quantum computers are very slow and only very short calculations can be carried out without breakdowns.
- However, AI machine learning is an essential tool for learning how to design and operate quantum computers today.

https://www.polytechnique-insights.com/en/columns/science/quantum-computing-and-ai-less-compatible-than-expected/

digitaal / nieuws

Hoe een stokoude programmeertaal de overheid in zijn greep houdt

Een programmeertaal uit de jaren zeventig vormt het hart van de Belastingdienst-ICT: 'toch is het de toekomst'

Sjoerd Hartholt 19 januari 2024

– Lex van Lieshout/ANP

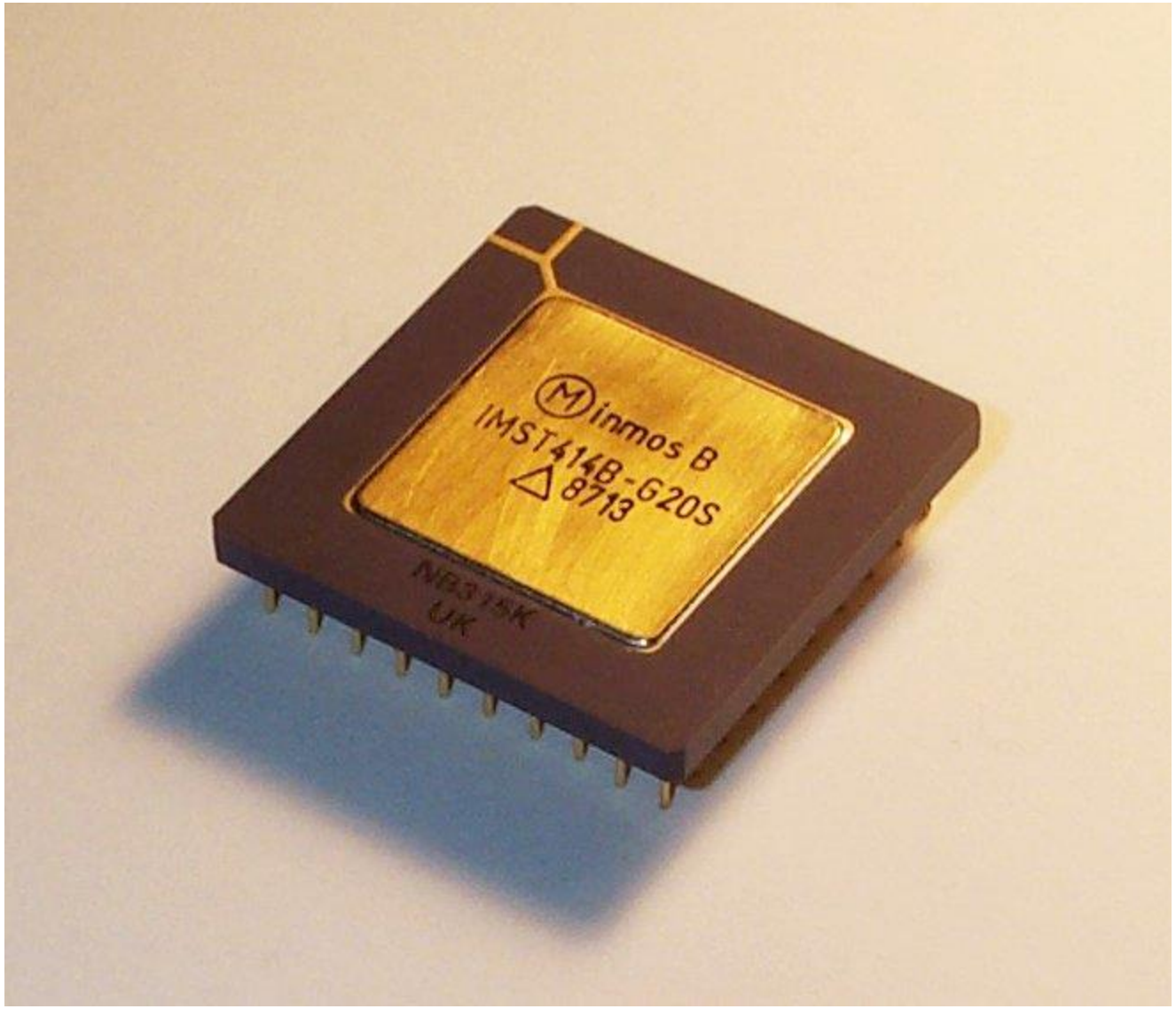
De programmeertaal COBOL bemoeilijkt modernisering van de IT van de rijksoverheid. Daarnaast wordt de groep vaak oudere programmeurs die ermee kan werken steeds kleiner. Tijdens het evenement The Future of Cobol & Mainframe deden de Belastingdienst, AcICT en CIO Rijk donderdag een boekje open over de enorme uitdagingen. Intussen was er ook veel lof en waardering voor de ruim halve eeuw oude programmeertaal.

Het is dringen geblazen in de congreszaal van Centrum Wiskunde en Informatica, dat samen met COBOL-opleider Quuks een evenement optuigde waar onder meer programmeurs, zij-instromers, hoogleraren, bankiers en bestuurders en ambtenaren bijeen komen om de COBOL-uitdaging te bespreken. Dat deze een immense omvang heeft wordt duidelijk wanneer algemeen directeur Koos Veefkind van de Belastingdienst het woord neemt.

The programming language is central to the Dutch Tax Authority's ICT infrastructure - in fact, **70%** of all financial transactions are processed using COBOL.

https://www.binnenlandsbestuur.nl/digitaal/informatiehuishouding/hoe-een-stokoude-programmeertaal-de-overheid-in-zijn-greep

Transputer



USAGE CHALLENGE

Data Centres Can Cut Energy Use By Up To 30% With Just About 30 Lines of Code, Research Shows

Published February 3, 2025

Written by
Fiona Jackson

New research has found that data centres can reduce their energy usage by up to 30% simply by altering around 30 lines of code in the Linux kernel's network stack.

Research has found that data centres can reduce their energy usage by up to 30% simply by altering around 30 lines of code in the Linux kernel's network stack. Scientists from the University of Waterloo in Canada identified inefficiencies in the way servers process incoming network traffic.

The breakthrough comes from interrupt request suspension, a technique that optimises CPU power efficiency by reducing unnecessary interruptions during high-traffic conditions. Typically, when a new data packet enters the network, it triggers an interrupt request, causing the CPU core to pause its current task to process the data, slowing things down.

The new code reduces interrupt requests by allowing the system to actively check the network for new data packets when needed instead of waiting for each individual interrupt. However, since this approach is power-intensive, the system reverts to interrupt handling when traffic slows.

https://www.techrepublic.com/article/data-centres-energy-reduction-code/

Study: Only 13% of provisioned CPUs and 20% of memory utilized in cloud computing

Cast AI analysis finds drastic over provisioning

March 01, 2024 By: Georgia Butler Have your say

A study conducted by Cast AI has found that companies only use around 13 percent of the CPUs they provision, and 20 percent of memory, on average.

The analysis - from a company that provides a Kubernetes cost optimization platform - is based on 4,000 clusters running on Amazon Web Services (AWS), Google Cloud Platform, and Microsoft Azure between January 1 and December 31, 2023.

The clusters included in the report are those of 50 CPUs or more. Little difference between cloud providers was found - with AWS and Azure both averaging utilization rates of 11 percent, though Google was slightly better, with 17 percent.

– PRNewsfoto/Frost & Sullivan

Memory utilization split between the big three cloud providers was 18 percent for Google, 20 percent for AWS, and 22 percent for Azure.

The utilization rate was slightly improved for larger clusters - with those containing 1,000 or more CPUs averaging 17 percent utilization.

https://www.datacenterdynamics.com/en/news/only-13-of-provisioned-cpus-and-20-of-memory-utilized-in-cloud-computing-report/

SUSTAINABILITY | ENERGY & POWER SUPPLY

How 'Load Shifting' May Help Improve Data Center Sustainability

A technique pioneered by Google is gaining currency as m

Bloomberg News
February 26, 2024

A data center under construction in Phoenix, Arizona IMAGE: BLOOMBERG

(Bloomberg) -- Tech giants are racing to ward off a carbon time bomb caused by the massive data centers they're building around the world.

A technique pioneered by Google is gaining currency as more power-hungry artificial intelligence comes online: Using software to hunt for clean electricity in parts of the world with excess sun and wind on the grid, then ramping up data center operations there. Doing so could cut carbon and costs.

"By chasing the sun from Europe to the US West Coast and back again, the company was able to slash computing emissions for certain workloads for itself and clients by **34%** rather than relying on servers in either location alone"

Cen
Safe

FEB

ENE
Ene
Ram
Solv
Pow

FEB

Exclusive DCK R

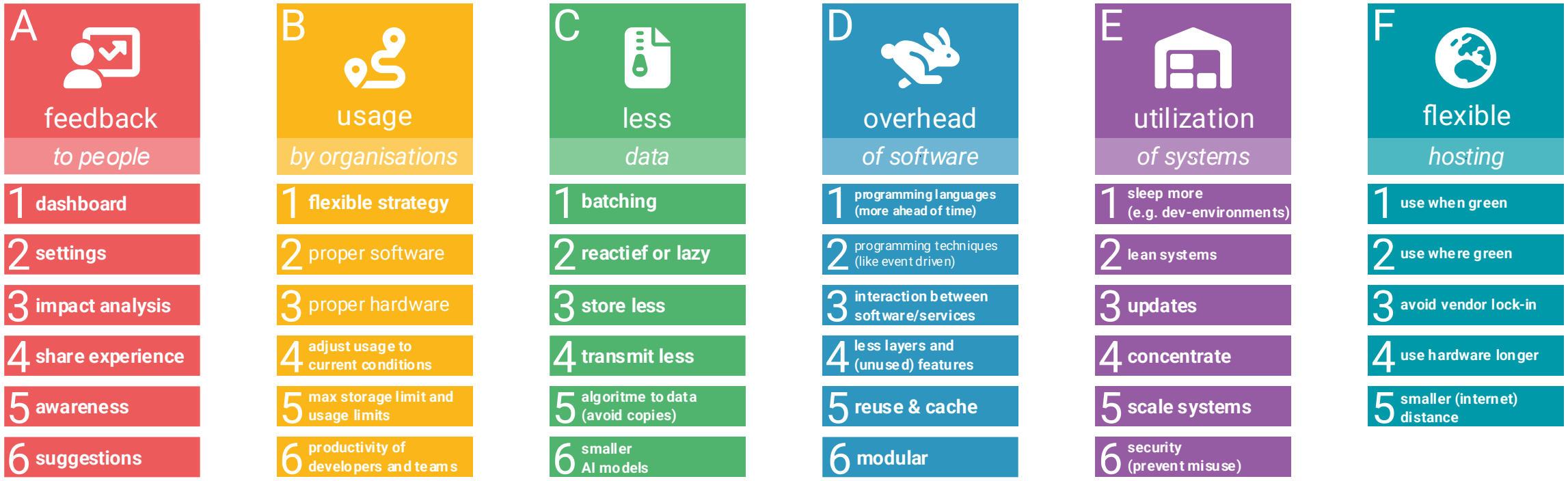
Decoding Data Center Ef
A Guide to Energy and S

JAN 29, 2025 | 1 MIN REA

Data Center Knowledge's
Report

https://www.bloomberg.com/news/articles/2024-02-25/ai-increases-data-center-energy-use-google-pioneered-technique-could-help

Infographic green software strategies



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Thanks!

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