

# TOOLING THE TOOLS

## INVESTIGATING RAPL ACCURACY AND COMPONENT-LEVEL POWER CONSUMPTION USING POWER RAIL INTERCEPTS

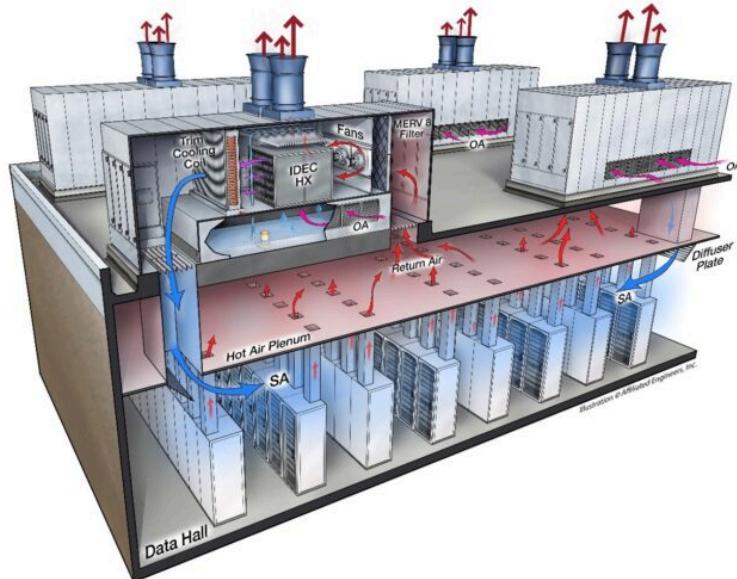
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# WHY IMPROVE CODE ENERGY EFFICIENCY

It's not just about the trees...

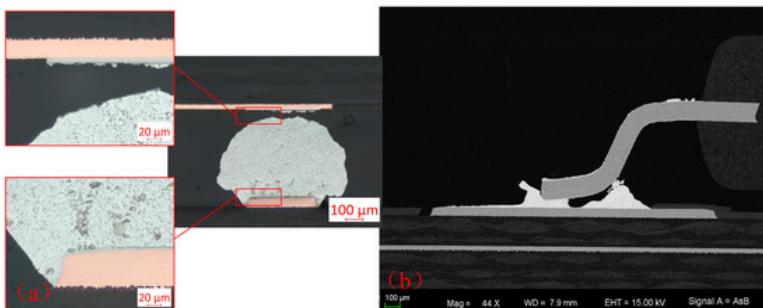
- Data centers: Reduce cost
- Mobile / Edge computing: Improve battery and service life
- Satellites (Solar power): Increase productivity

# COOLING A DATA CENTER:



- Almost all energy used during computation is converted to heat.
- Thermal management systems are responsible for up to 40% of all energy consumed in a data center.
- Reduced thermal load -> more servers doing more work in same infrastructure

# TEMPERATURE AND COMPONENT WEAR AND TEAR



- As a rule of thumb, a  $10\text{ }^{\circ}\text{C}$  increase reduces component life by half.
- A  $5\text{ }^{\circ}\text{C}$  rise above  $40\text{ }^{\circ}\text{C}$  increases hard-disk failure risk by  $\sim 30\%$ .
- Improving power/thermal efficiency: keeps components within optimal temperature longer.
- Components live longer.
- Less thermal throttling

# EDGE COMPUTING AND SATELLITES



- Improve battery life
- More work done per watt in power constrained edge computing and satellites
- Improve service life for critical components

# WHAT IS RAPL (RUNNING AVERAGE POWER LIMIT)

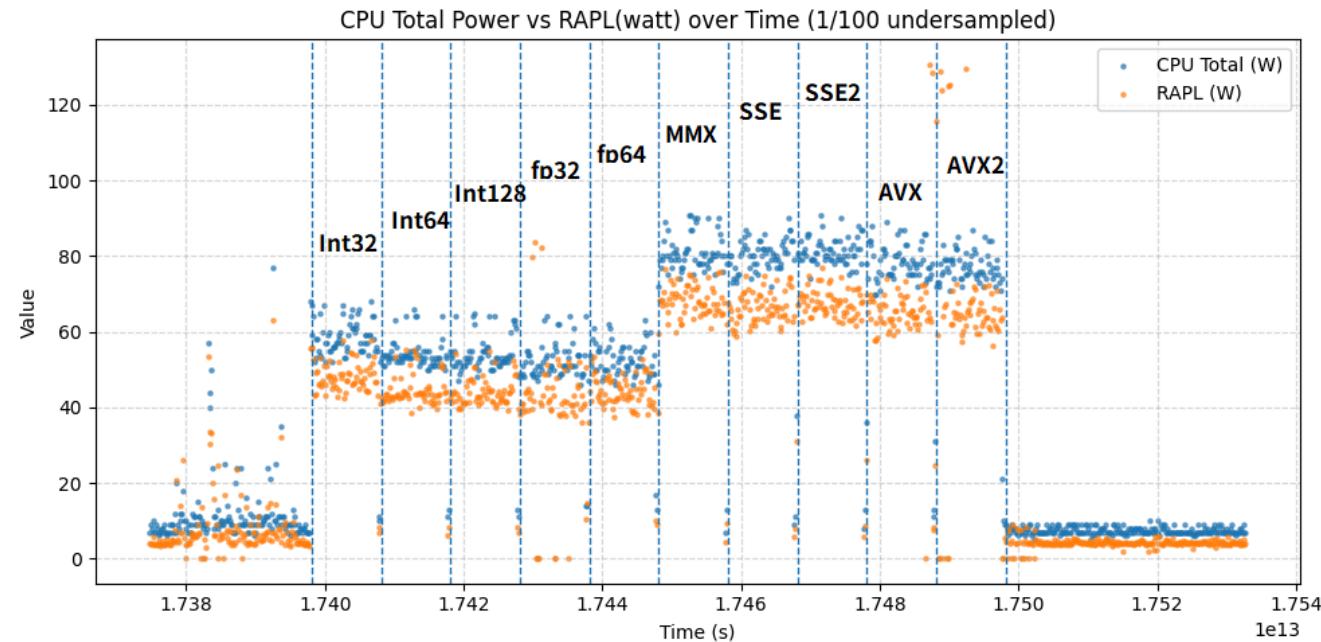
- Energy prediction models that estimates CPU and DRAM power consumption
- Possible factors:
  - Instruction counts
  - On-chip sensors
  - Telemetry from motherboard (SVID and IMON interface)
- \* inferred data source, specific details are undisclosed

# WHY IS THIS A PROBLEM



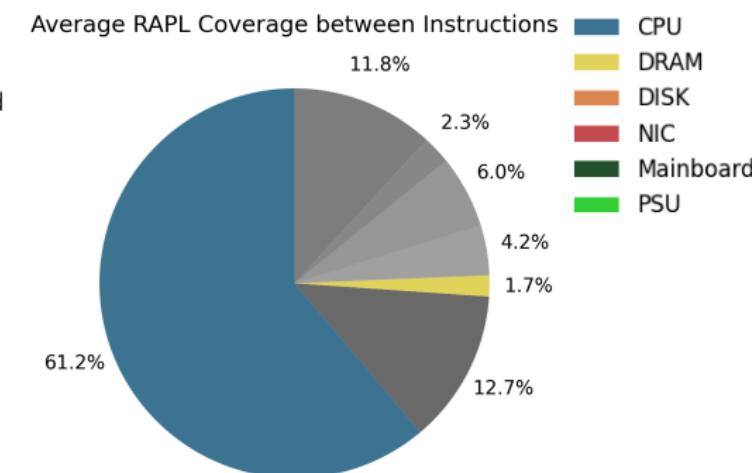
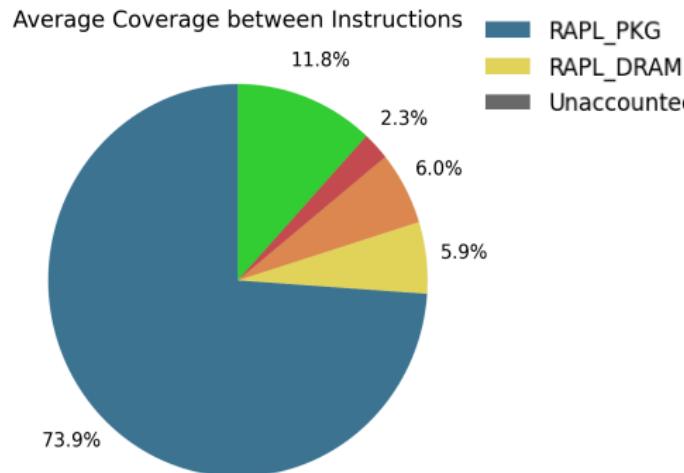
- More than half the energy-awareness tools use RAPL (single point of failure)
- Data source and methodology is undisclosed for newer CPU models
- Known inconsistencies in prior research

# RESULTS



- RAPL underestimates energy consumption by 20-30%
- Underestimations observed under all CPU instruction types across multiple architectural generations

# COVERAGE: HOW MUCH WALL POWER IS RAPL CAPTURING?

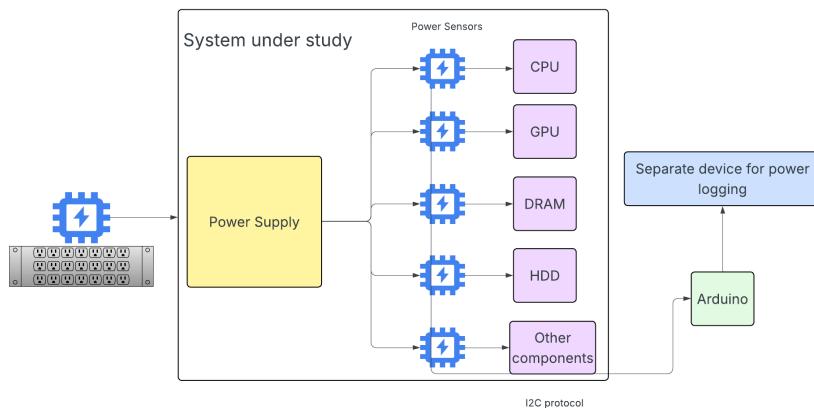


- Key takeaway: Under CPU heavy workloads (best case), RAPL covers only ~60% of total energy consumption

# METHOD OF INVESTIGATION

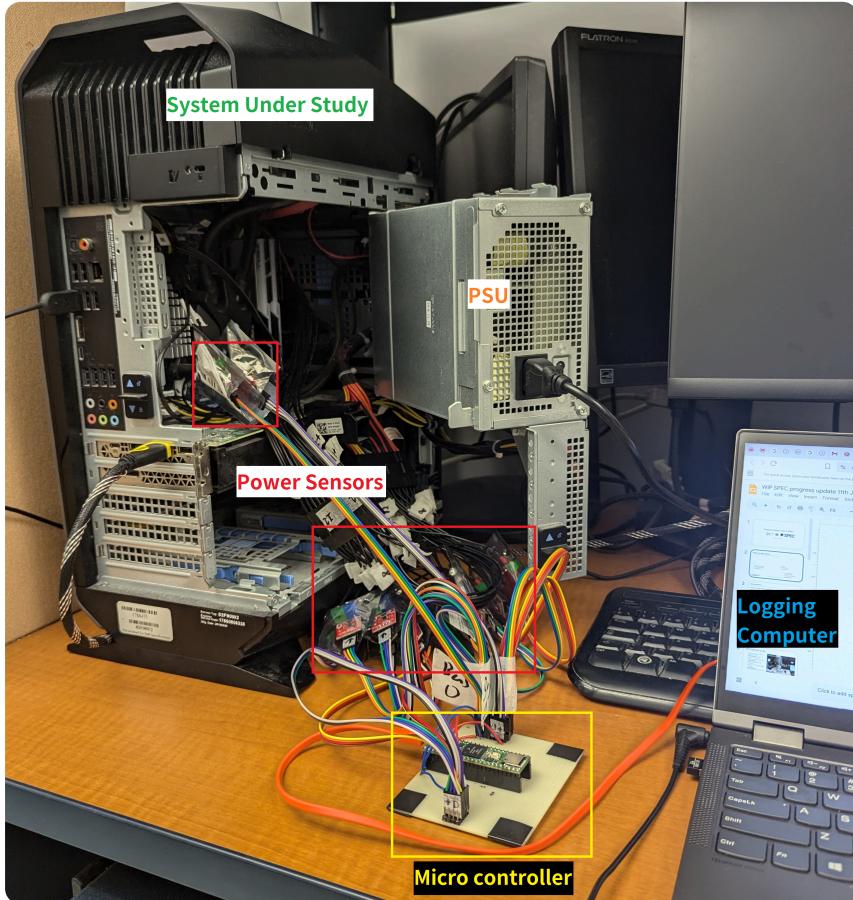
- Precision sensors for obtaining ground truth for energy consumption
- Implementation:
  - Sensors intercept power lanes from power supply to components
  - Sensors measure voltage and current
  - Sensors Relay data to tracing apps (eg. TraceCompass)

# MEASUREMENT TOOL PROPOSAL



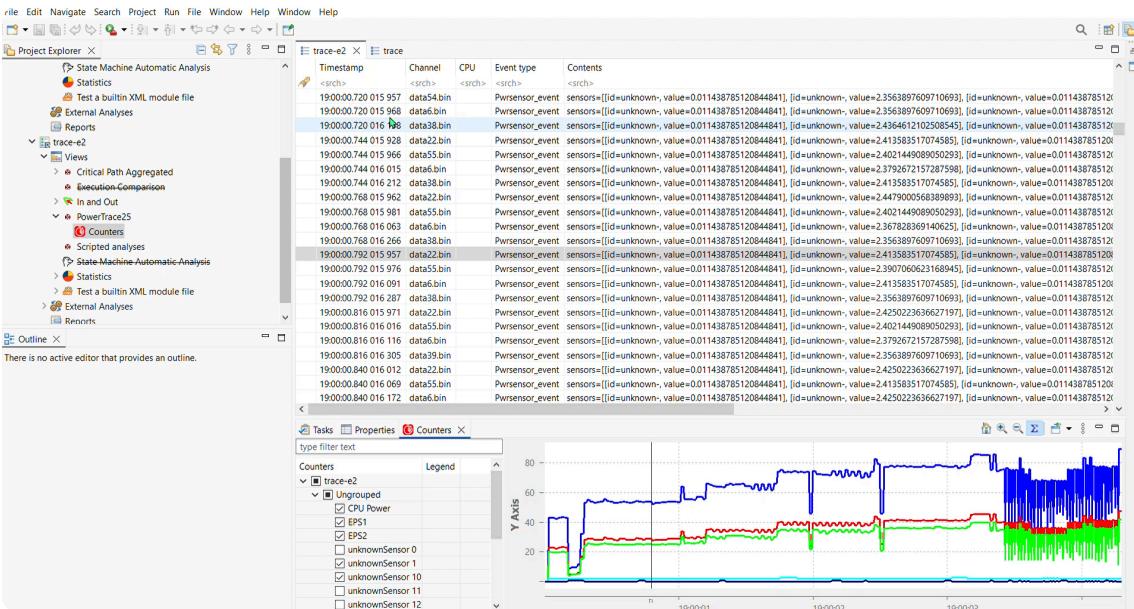
- Sensor intercepting power lanes
- Microcontroller (data collection)
- Data processed externally: minimal overhead

# MEASUREMENT TOOL IMPLEMENTATION



- Industry standard precision sensors
- Sensor calibrated with precision Laboratory power analyzers
- High speed microcontroller
- Trace compass integration

# INTEGRATION WITH TRACE COMPASS



- Trace Compass integration with custom plugin
  - Sensor traces generated by microcontroller
  - RAPL: custom script generating LTTNG UST trace points.

# QUESTIONS?



Thank you for listening!

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