

TOOLING THE TOOLS

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

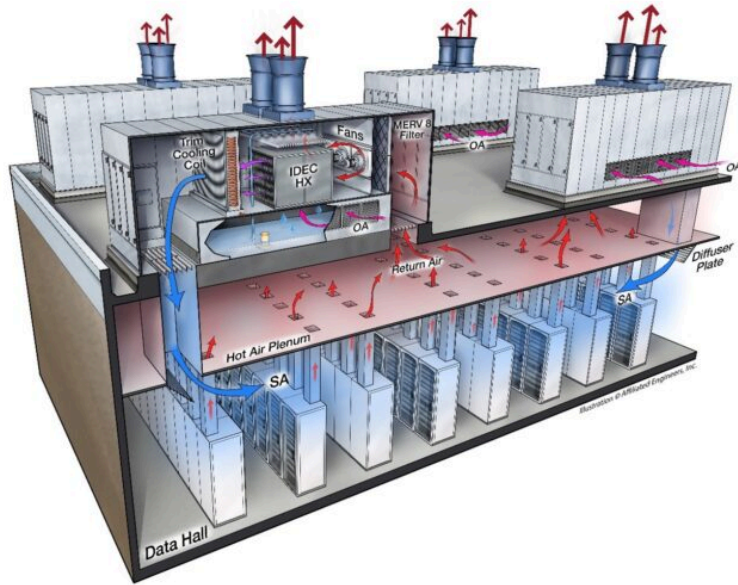
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WHY IMPROVE CODE ENERGY EFFICIENCY

It's not just about the trees...

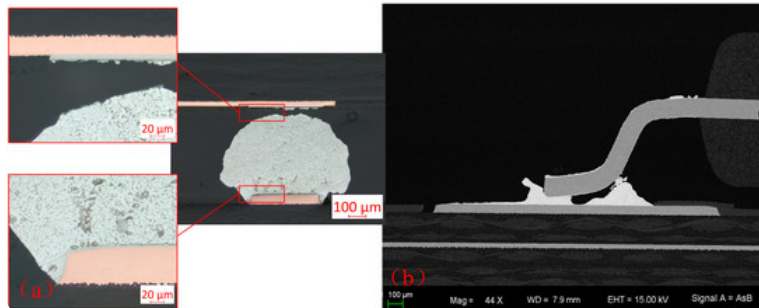
- Data centers: Reduce cost
- Mobile / Edge computing: Improve battery and service life
- Satellites (Solar power): Increase productivity

COOLING A DATA CENTER:



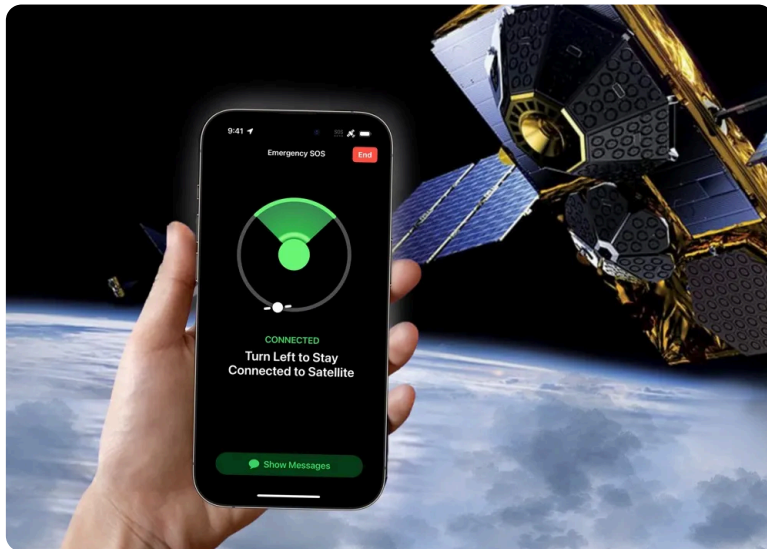
- Almost all energy used during computation is converted to heat.
- Thermal management systems are responsible for up to 40% of all energy consumed in a data center.
- Reduced thermal load -> more servers doing more work in same infrastructure

TEMPERATURE AND COMPONENT WEAR AND TEAR



- As a rule of thumb, a 10 °C increase reduces component life by half.
- A 5 °C rise above 40 °C increases hard-disk failure risk by ~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)

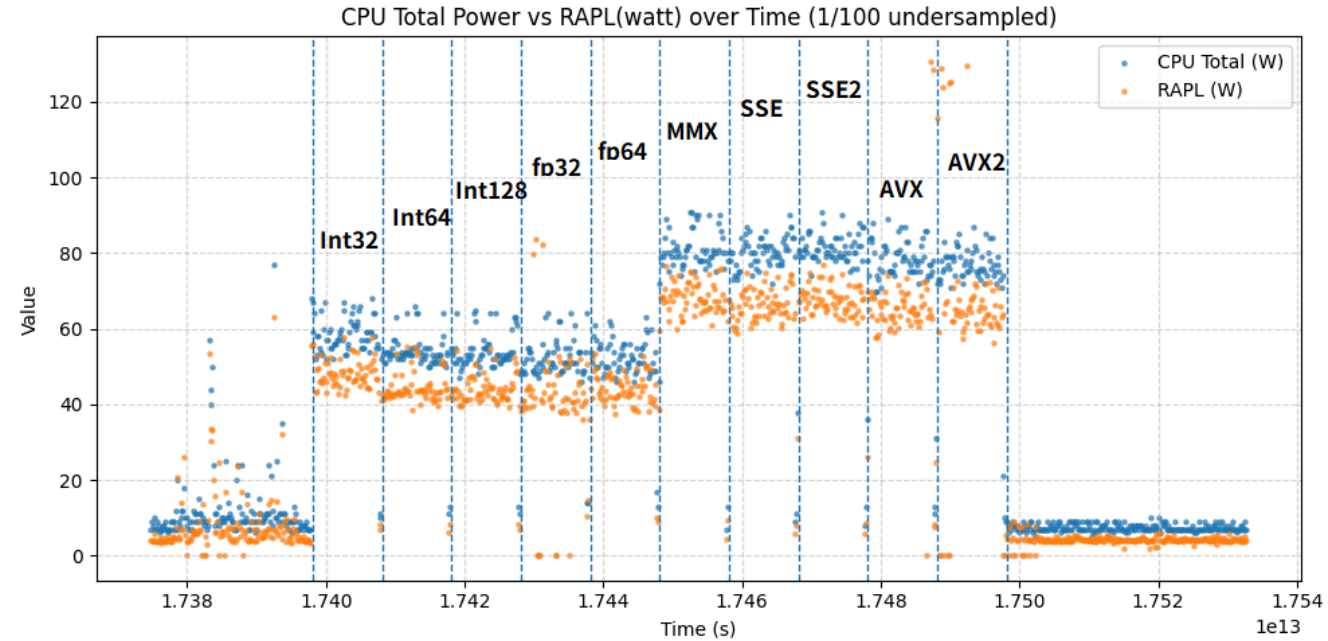
- Energy prediction models that estimates CPU and DRAM power consumption
- Possible factors:
 - Instruction counts
 - On-chip sensors
 - Telemetry from motherboard (SVID and IMON interface)
- * inferred data source, specific details are undisclosed

WHY IS THIS A PROBLEM



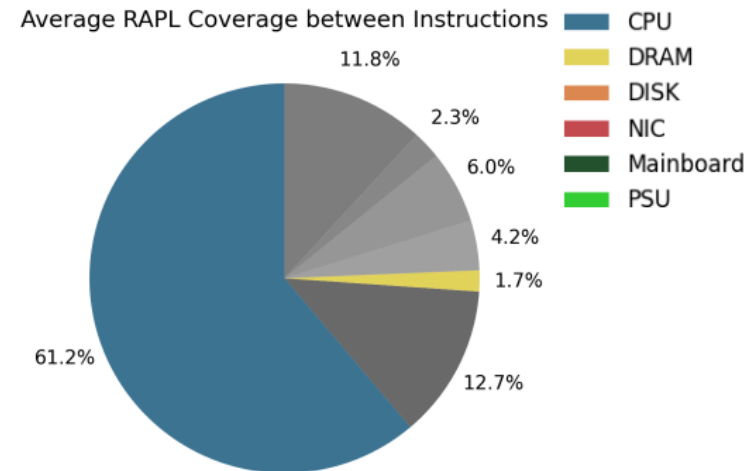
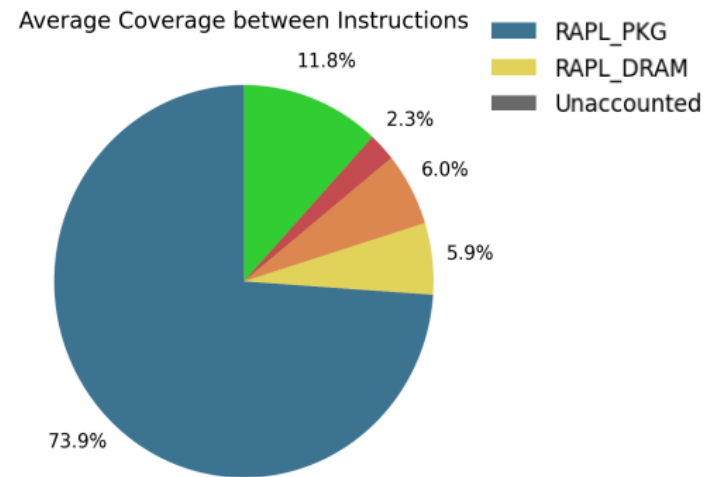
- More than half the energy-awareness tools use RAPL (single point of failure)
- Data source and methodology is undisclosed for newer CPU models
- Known inconsistencies in prior research

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?

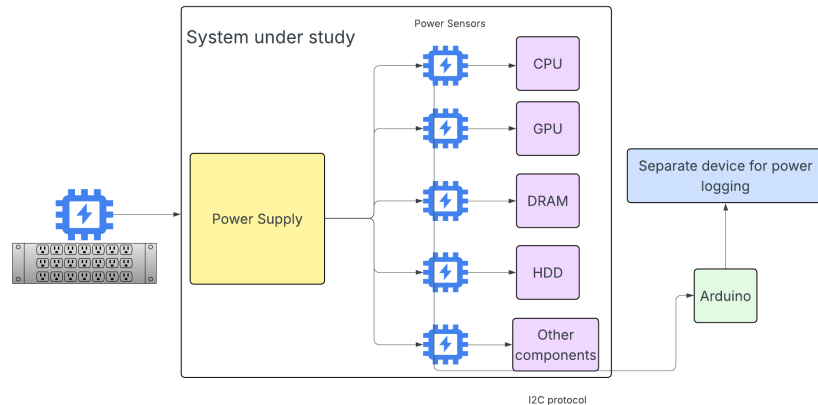


- Key takeaway: Under CPU heavy workloads (best case), RAPL covers only ~60% of total energy consumption

METHOD OF INVESTIGATION

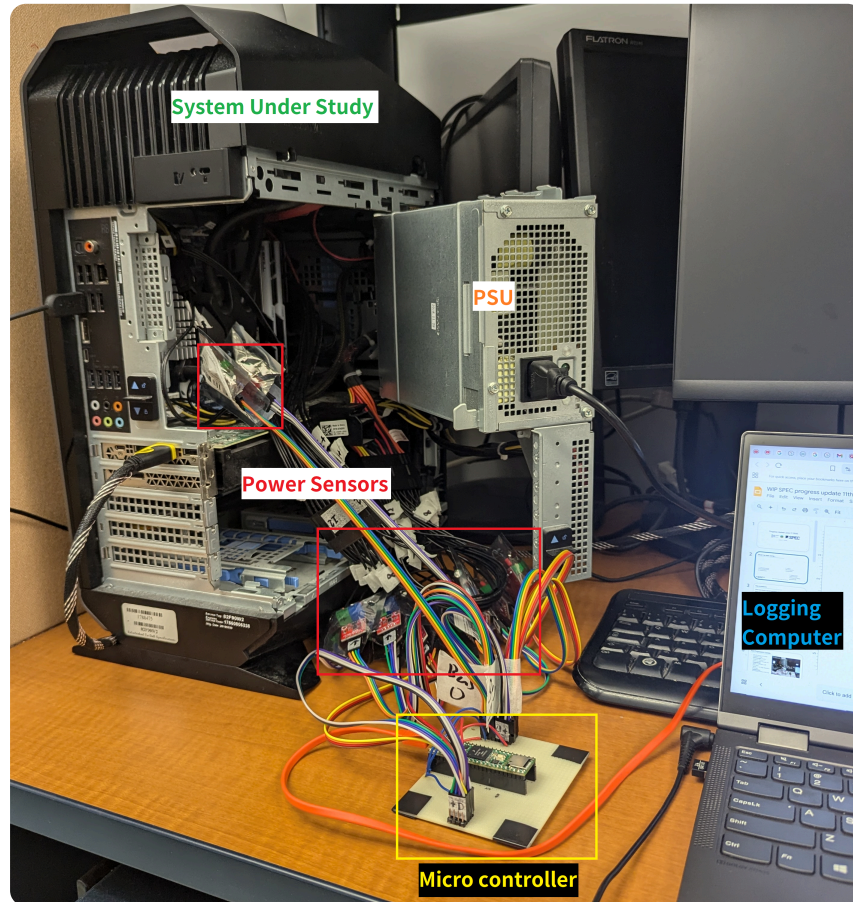
- Precision sensors for obtaining ground truth for energy consumption
- Implementation:
 - Sensors intercept power lanes from power supply to components
 - Sensors measure voltage and current
 - Sensors Relay data to tracing apps (eg. TraceCompass)

MEASUREMENT TOOL PROPOSAL



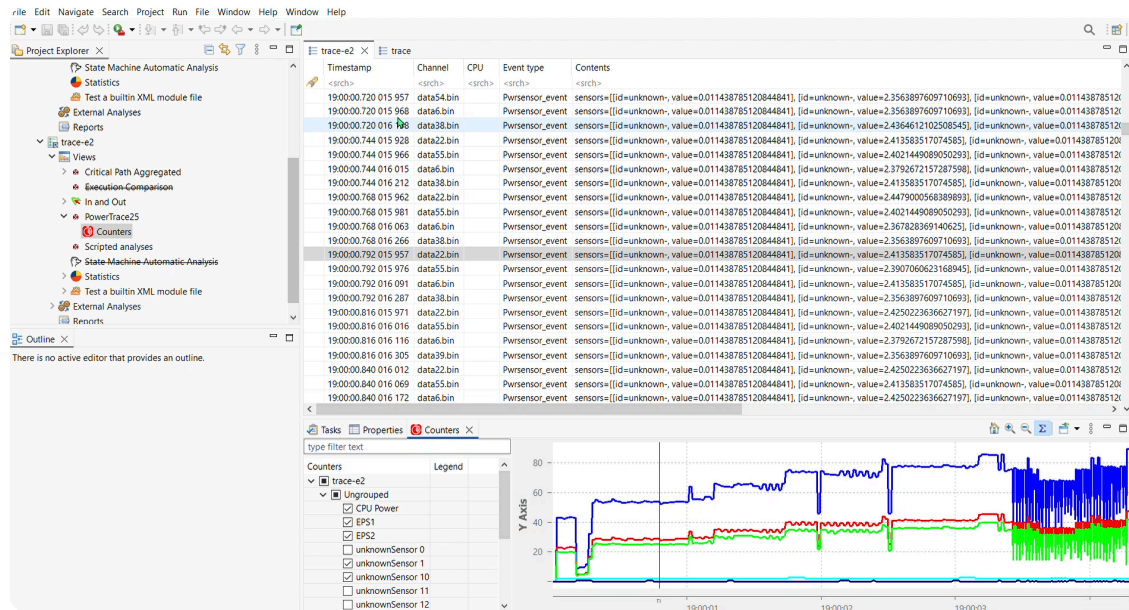
- Sensor intercepting power lanes
- Microcontroller (data collection)
- Data processed externally: minimal overhead

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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