TOOLING THE TOOLS

INVESTIGATING RAPL ACCURACY AND COMPONENT-LEVEL POWER CONSUMPTION USING POWER RAIL INTERCEPTS
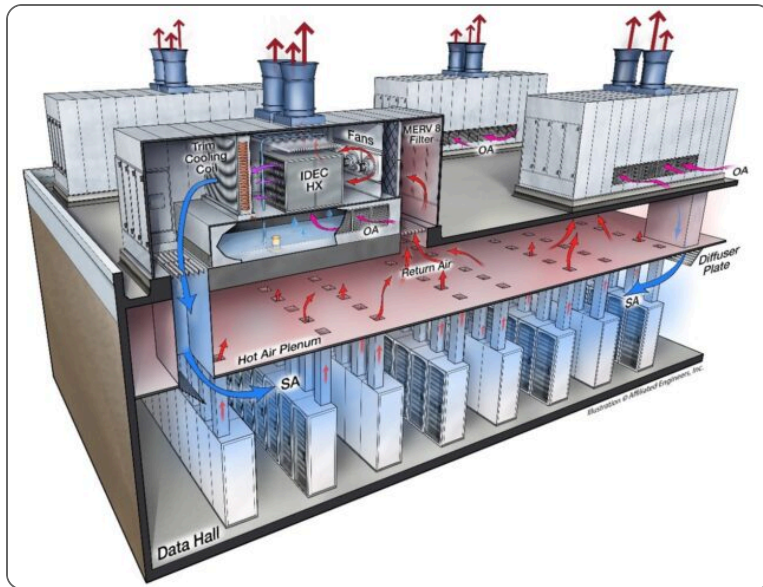
Andy Huo | Mooselab | Ericsson | Oct 27 2025

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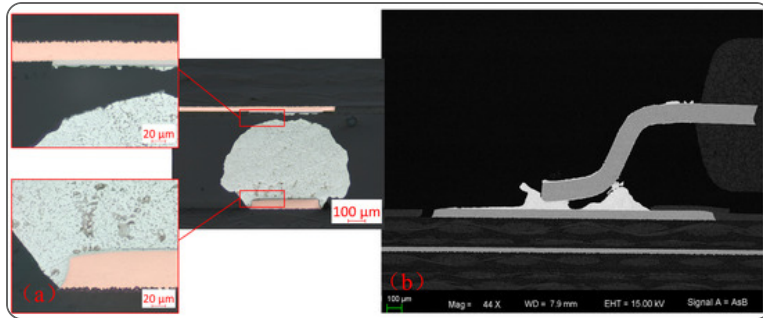
- As a rule of thumb, a 10 °C increase reduces component life by half.
- A 5 °C rise above 40 °C increases hard-disk failure risk by ~30%.
- Improving power/thermal efficiency: keeps components within optimal temperature longer.
- Components live longer.
- Less thermal throttling

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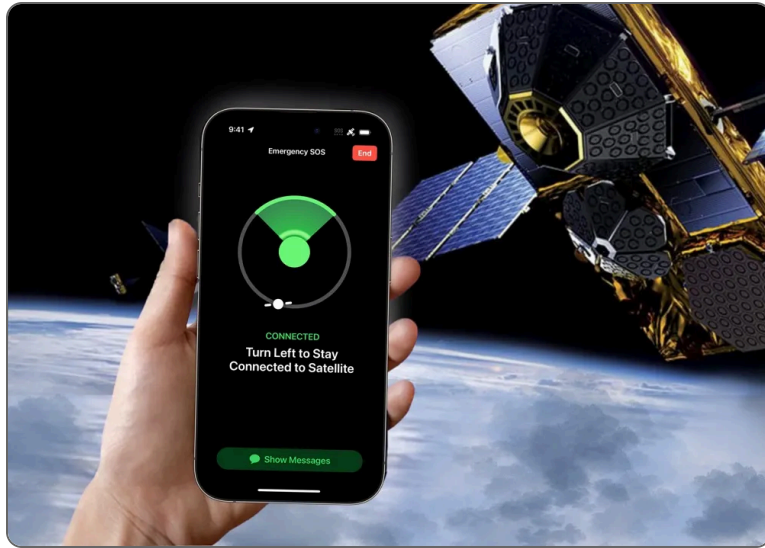
- Improve battery life
- More work done per watt in power constrained edge computing and satellites
- Improve service life for critical components

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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
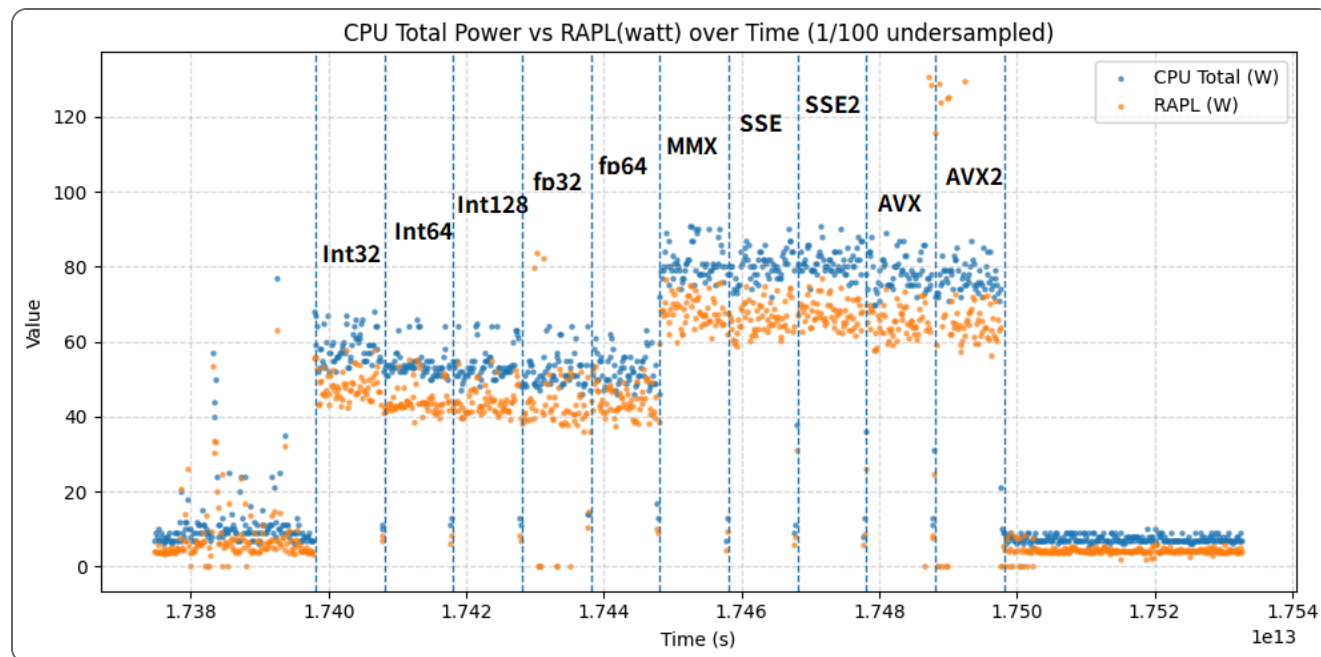
WHY IS THIS A PROBLEM
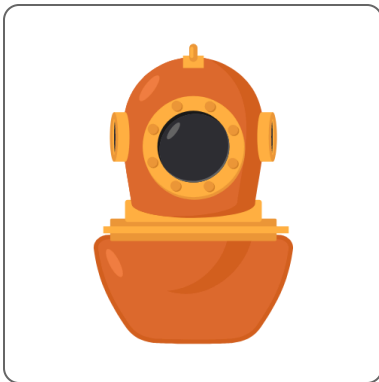
- More than half the energy-awareness tools use RAPL (single point of failure)

- Data source and methodology is undisclosed for newer CPU models
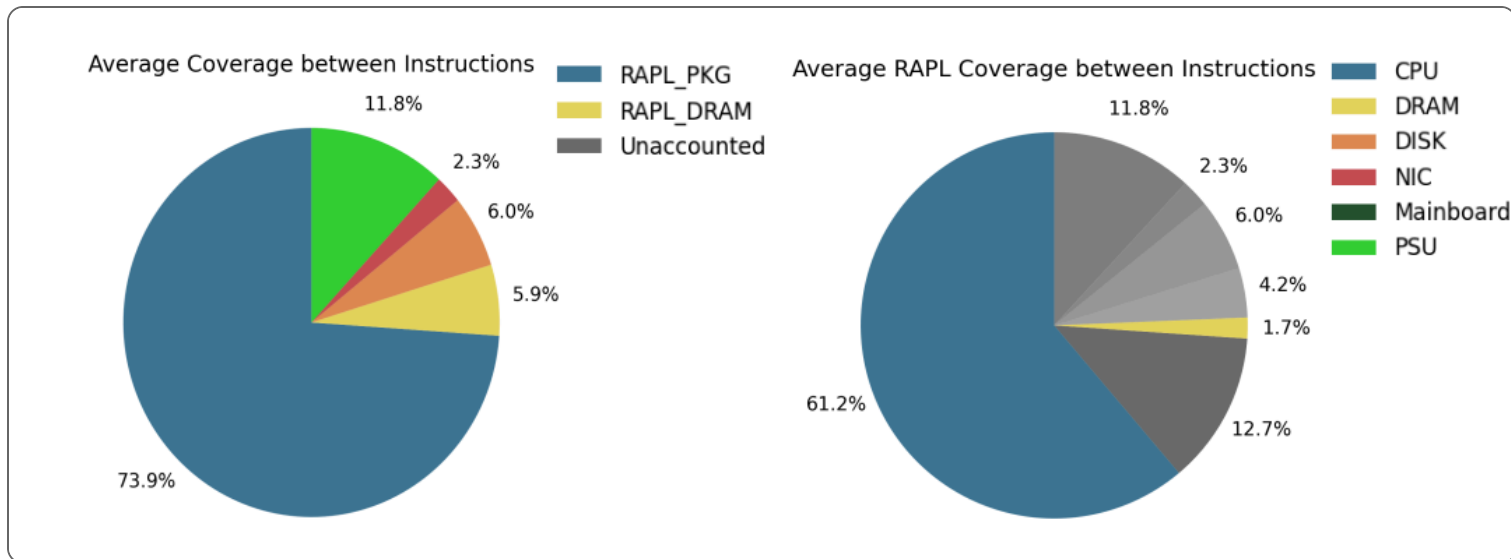- Known inconsistencies in prior research

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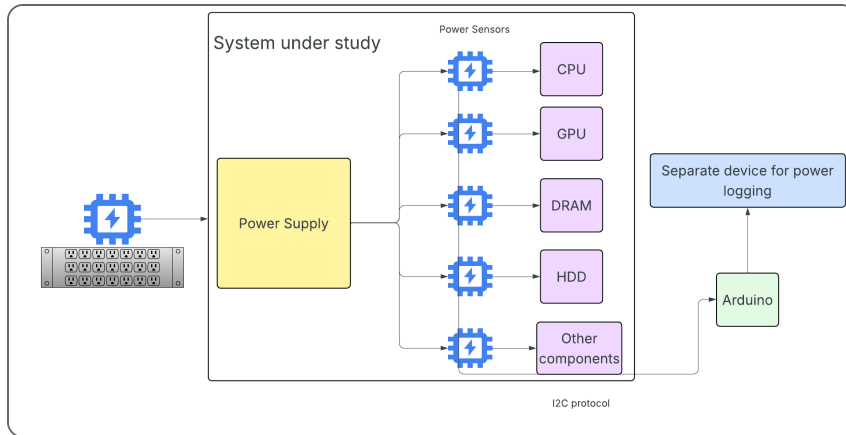
- Sensor intercepting power lanes
- Microcontroller (data collection)
- Data processed externally: minimal overhead

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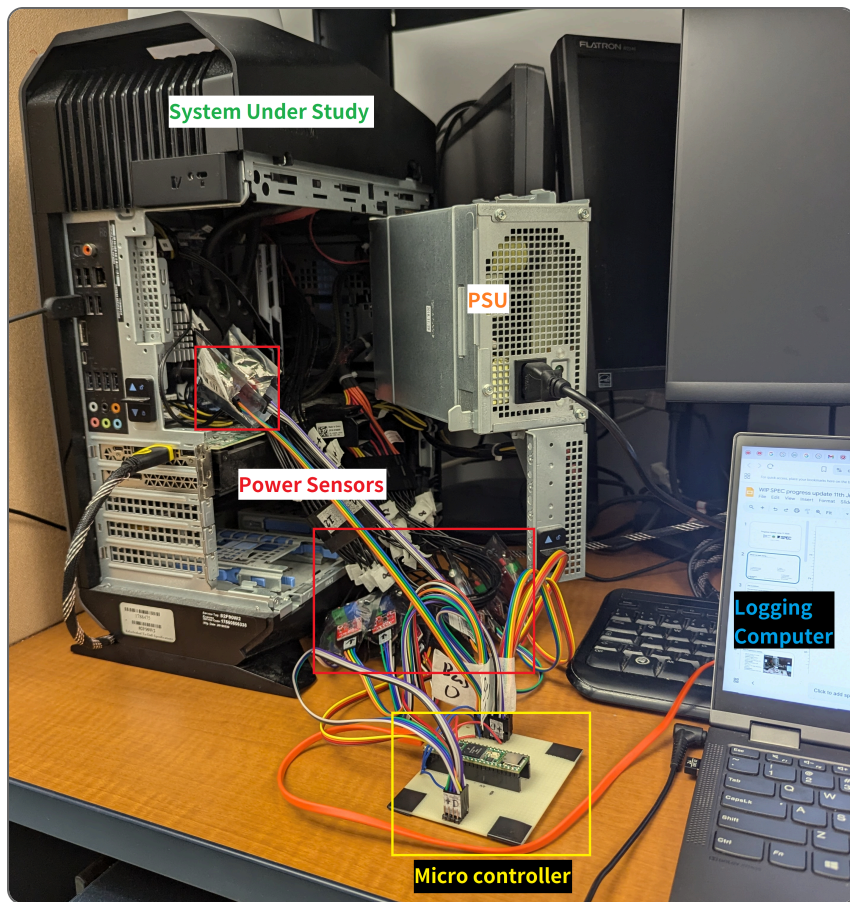
- Industry standard precision sensors
- Sensor calibrated with precision Laboratory power analyzers
- High speed microcontroller
- Trace compass integration

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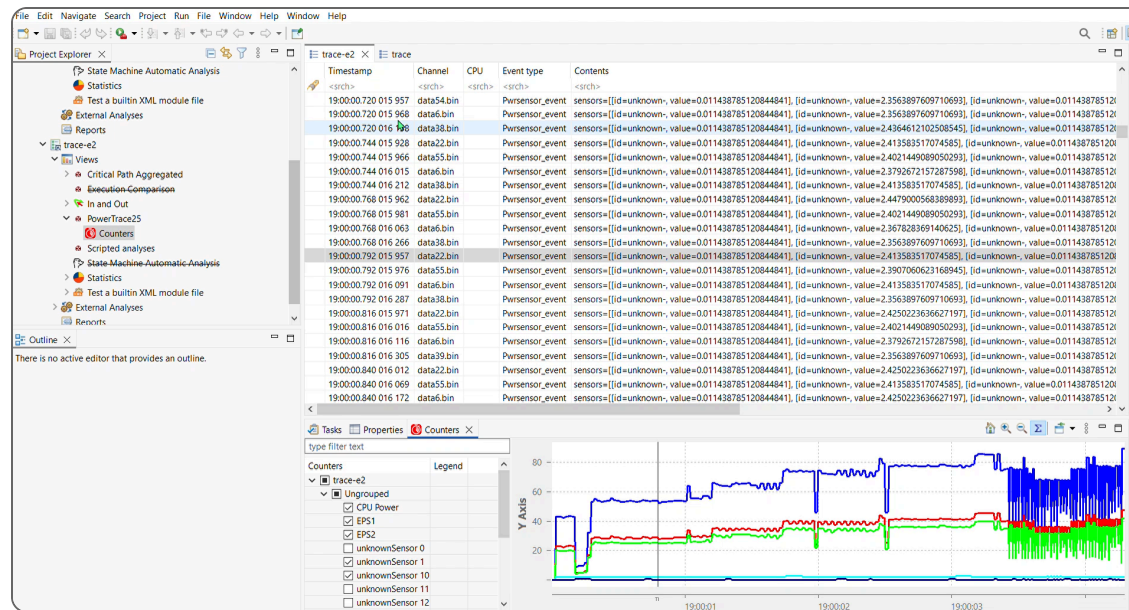
- Trace Compass integration with custom plugin
- Sensor traces generated by microcontroller
- RAPL: custom script generating LTTNG UST trace points.

QUESTIONS?

Thank you for listening!

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Speaker notes