A Survey on Techniques for Energy-Efficient Microservice-based Software Architectures in the Cloud

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1 Context of energy consumption in microservices

- Improve energy efficiency in the Cloud: Operational costs and sustainability
- Why microservices?
  - Contrast to Monoliths: scalability, flexibility, resilience
  - Granularity enables targeted software evolution and interventions
- Microservices challenges
  - Contrast to Monoliths: Requires complex observability
  - Controlling a single or small number of microservices can impact energy efficiency and performance of an entire application

2 Systematic Literature Review (SLR)

Search Query (to the end of 2023)

```
 ("cloud" OR "cloud-based")
AND  ("microservice" OR "microservices")
AND  ("energy efficient" OR "energy efficiency" OR "power
efficiency" OR "power efficient")
AND  ("evaluation" OR "performance evaluation")
AND NOT  ("edge" OR "edge computing" OR "fog" OR "fog computing")
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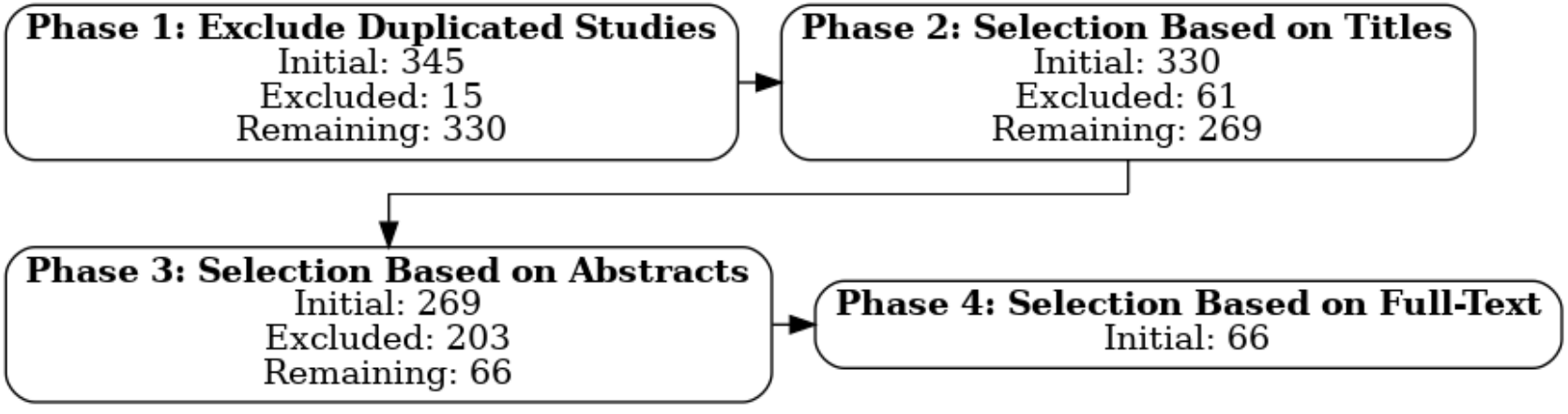
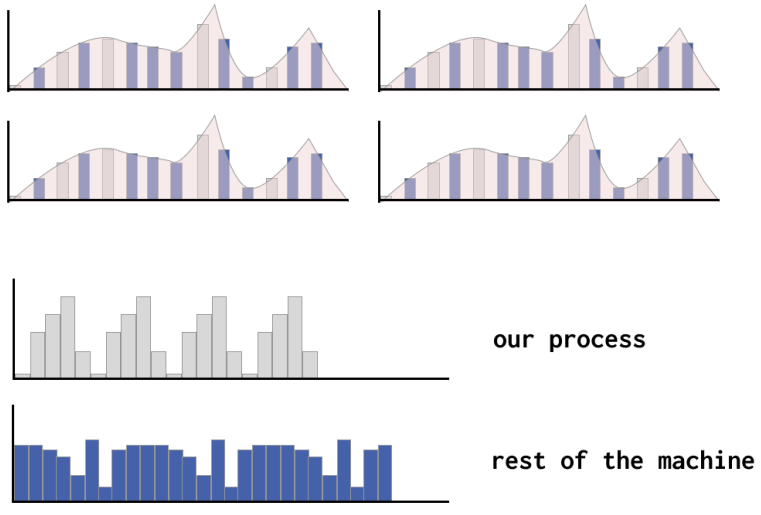


3 Application energy monitoring

- Monitor the energy consumption at the granularity of a microservice

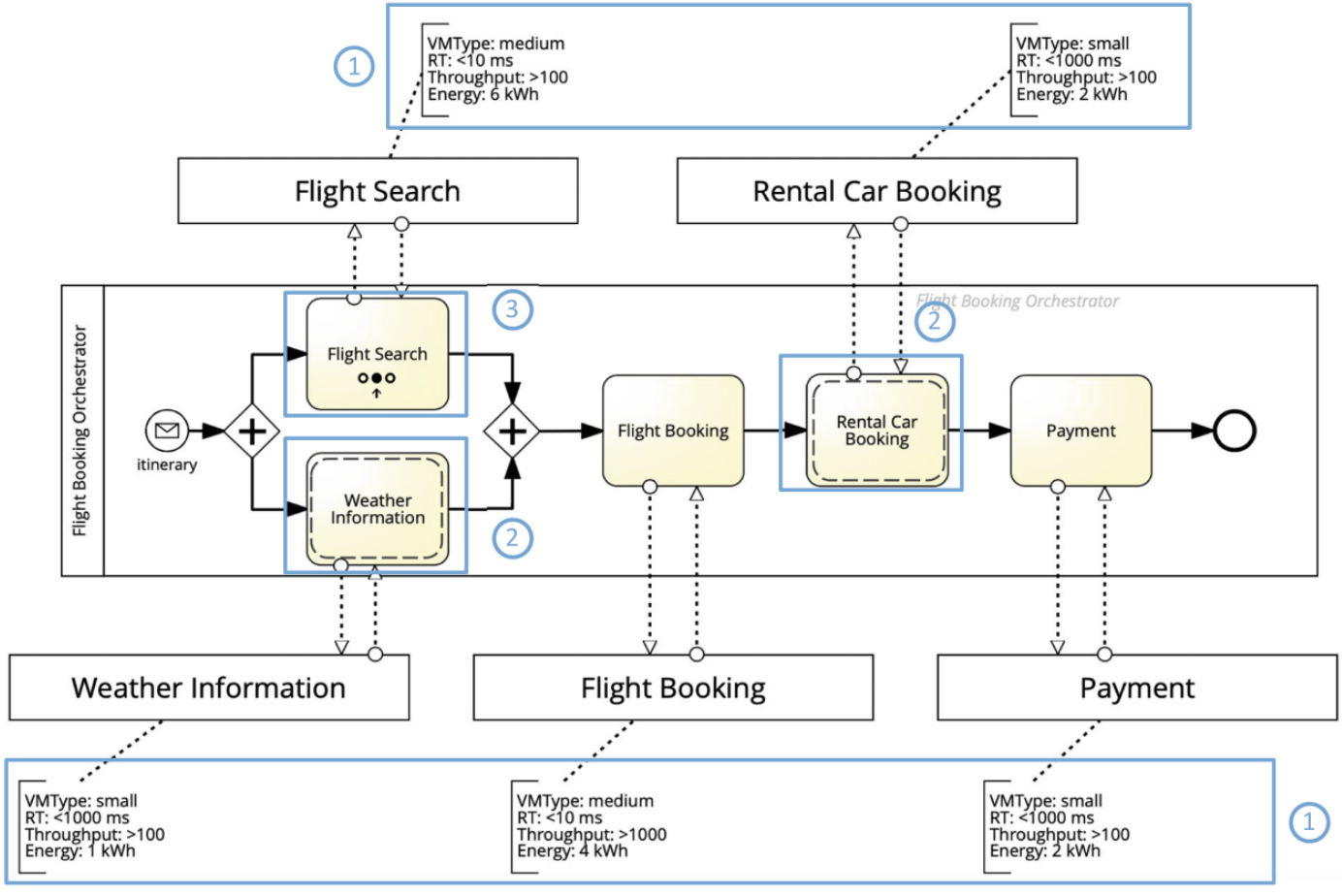
  VM → process → container → microservice

- Intel RAPL, NVIDIA NVML...



Scaphandre per-process power measurement `https://tinyurl.com/powerprocess`

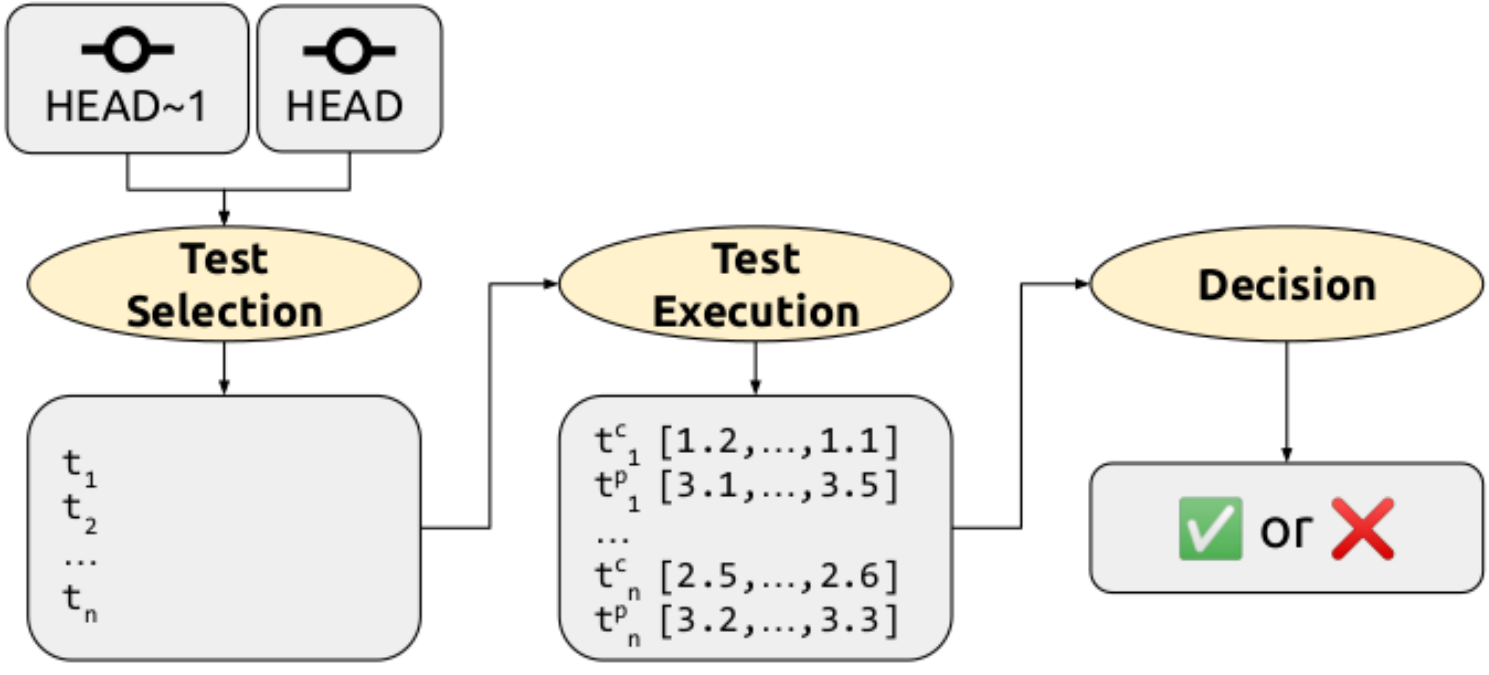
4 Dependency graph modeling and Application metadata for energy-awareness



Microservices dependencies and added metadata [Vitali, 2022]

5 Energy consumption assessment at test time and Simulation of energy consumption

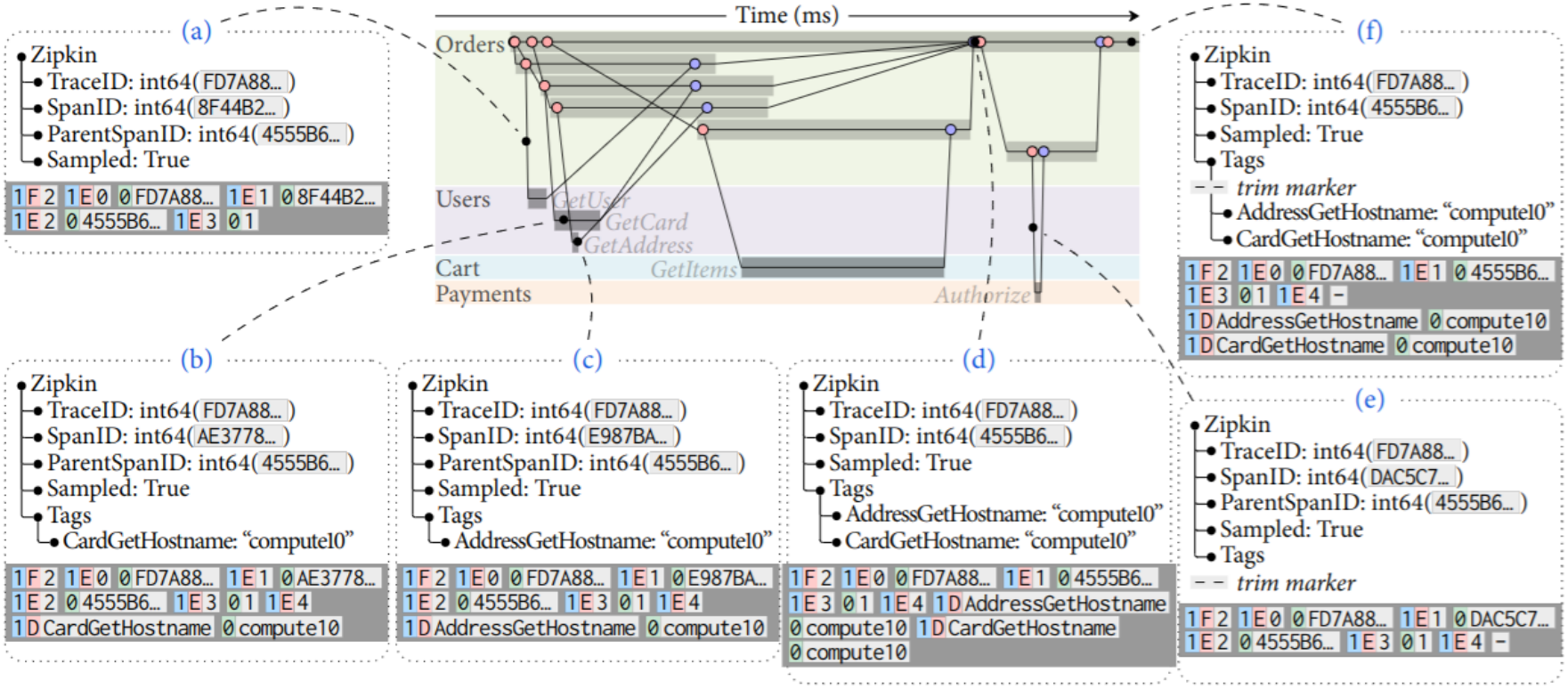
- Energy Regression Testing (ERT) is a type of simulation that can be incorporated to CI pipelines



Overview of key steps involved in ERT [Danglot et al., 2023]

6 Distributed tracing for energy-awareness

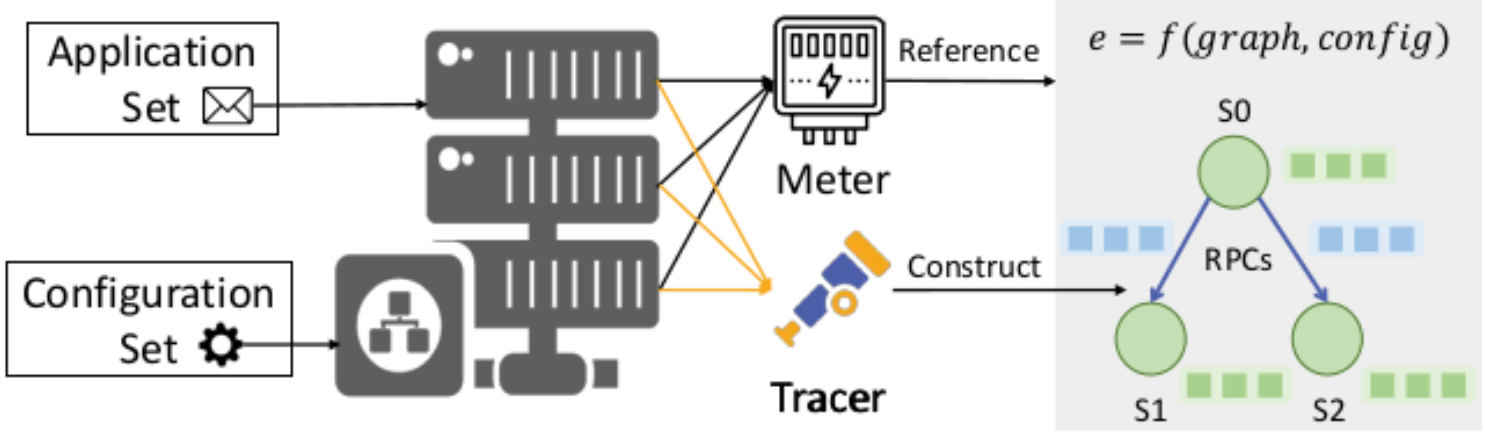
- Energy consumption information can be added to the baggage context at the request granularity



Tracing overview [Mace and Fonseca, 2018]

7 Conclusion

- Energy-aware information to feed control mechanisms at runtime
- Comply with a previously defined energy budget
- Combination of techniques in instrumentation, application and configuration knowledge for energy estimation



Candidate solution with workflow for energy estimation [Anand et al., 2023]

Thank You

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