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LiRoT: A lightweight incremental reasoner for the Web of Things

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1. Experimentations

- LiRoT uses 46-91% less memory than RDFox and 91-98% less than Apache Jena
- LiRoT has similar or better performance than RDFox for datasets of 500-1000 explicit facts, depending on the task and ruleset, and is generally faster than Jena
- Incremental maintenance requires memory overhead, but improves performance

2. Publications and references

Do Arduinos dream of efficient reasoners?
Extended Semantic Web Conference 2022
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3. Conclusions

- Optimizing RETE reduces the memory footprint significantly
- On laptop and with small datasets (scope of CoSWoT), LiRoT performs better than Jena and RDFox
- LiRoT is the only reasoner to run on Arduino platforms

4. Future works

- Conversion of the algorithm to:
  - WASM for GPU
  - VHDL for FPGA

5. CoSWoT

- Platform for the WoT
- Use Semantic Web technologies (ontologies, reasoning)
- Constrained and heterogeneous devices
- Decentralized architecture
- Applications in smart building and agriculture

6. Challenges and hypotheses

- Traditional reasoners are built for desktop computers or servers
- Targeted platforms are more constrained (desktop computer: ≈ 10GB RAM vs. ESP32: 320KB SRAM)

7. Running example

Thermometer

Thermometer :value "25"

Reasoner

(CO₂ Sensor :value "850")

Window

Window :state :Open

8. CoSWoT project

2022-2024

- Web of Things
- Industrial applications

9. Proposed approach: LiRoT

- LiRoT [Bento22]: Lightweight incremental reasoner based on the RETE algorithm [Forgy89]
- Adapt the Backward/Forward algorithm to optimize incremental maintenance
- Custom Memory optimizations
  - Merge memory spaces for nodes that have equivalent conditions
  - Index terms to avoid duplicates
  - Encode data in CBOR (ongoing work)
- Open-source implementation in C

https://gitlab.com/coswot/lirot

10. More experiments

- Comparison between LiRoT, Apache Jena and RDFox on desktop
- Comparison between different optimizations on ESP32 platform

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11. Rule-based reasoning

- RDF data is stored in triples (e.g. coswot:Room1Thermometer rdf:type sosa:Sensor)
- Generic rules (multiple conditions with variables) are applied to explicit triples to derive new information (implicit triples). Example of a rule: