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LiRoT: A lightweight incremental reasoner for the Web of Things

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

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)
→ Reduce reasoning memory footprint
• Small datasets (= 1000 explicit facts)
• Dynamic data → incremental reasoning

ES32 platform

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

Future works
• Conversion of the algorithm to:
  • WASM for GPU
  • VHDL for FPGA

Publications and references
Do Arduinos dream of efficient reasoners?
Extended Semantic Web Conference 2022
A. Bento, L. Médini, K. Singh, F. Laforest

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Rule-based reasoning
• RDF data is stored in triples (e.g. coswot:Room1Thermometer1 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:

Running example

Thermometer
Thermometer :value “25”

Reasoner

CO₂ sensor
CO₂ Sensor :value "850"

Window
Window :state :Open

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

Comparison between LiRoT, Apache Jena and RDFox on desktop

Comparison between different optimizations on ESP32 platform

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