LiRoT: A lightweight incremental reasoner for the Web of Things
Alexandre Bento, Lionel Médini, Kamal Singh, Frederique Laforest

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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)

\( \rightarrow \) Reduce reasoning memory footprint
- Small datasets (≈ 1000 explicit facts)
- Dynamic data \( \rightarrow \) incremental reasoning

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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Alexandre Bento, INSA Lyon
alexandre.bento@liris.cnrs.fr
Lionel Médini, UCBL
lionel.medini@liris.cnrs.fr
Kamal Singh, Université Jean Monnet
kamal.singh@univ-st-etienne.fr
Frédérique Laforest, INSA Lyon
frederique.laforest@liris.cnrs.fr

Laboratoire d’InfoRmatique en Image et Systèmes d’information
LIRIS UM R 5205 CNRS / INSA de Lyon / Université Claude Bernard Lyon 1 / Université Lumière Lyon 2 / Ecole Centrale de Lyon

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:

\[ (?v \owl:someValuesFrom ?w) \land (?v \owl:onProperty ?p) \land (?u \ ?p \ ?x) \rightarrow (?u \ rdf:type \ ?v) \]

Running example

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

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Proposed approach: LiRoT
- 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

Experimentations

Comparison between LiRoT, Apache Jena and RDFox on desktop

Comparison between different optimizations on ESP32 platform

\[ \text{LiRoT} \]

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