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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



ESP32 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

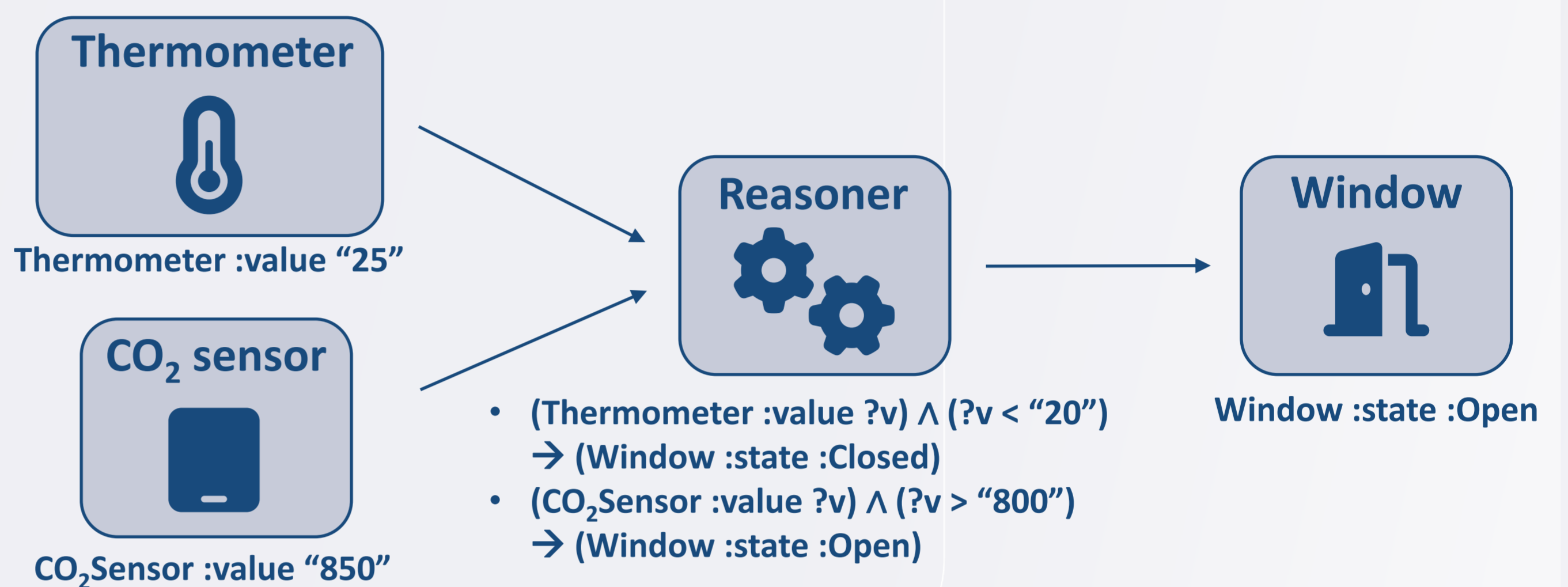
The CoSWoT project is supported by grant ANR-19-CE23-0012 from Agence Nationale de la Recherche.

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:

$$(?v \text{ owl:someValuesFrom } ?w) \wedge (?v \text{ owl:onProperty } ?p) \wedge (?u ?p ?x) \rightarrow (?u \text{ rdf:type } ?v)$$

Running example



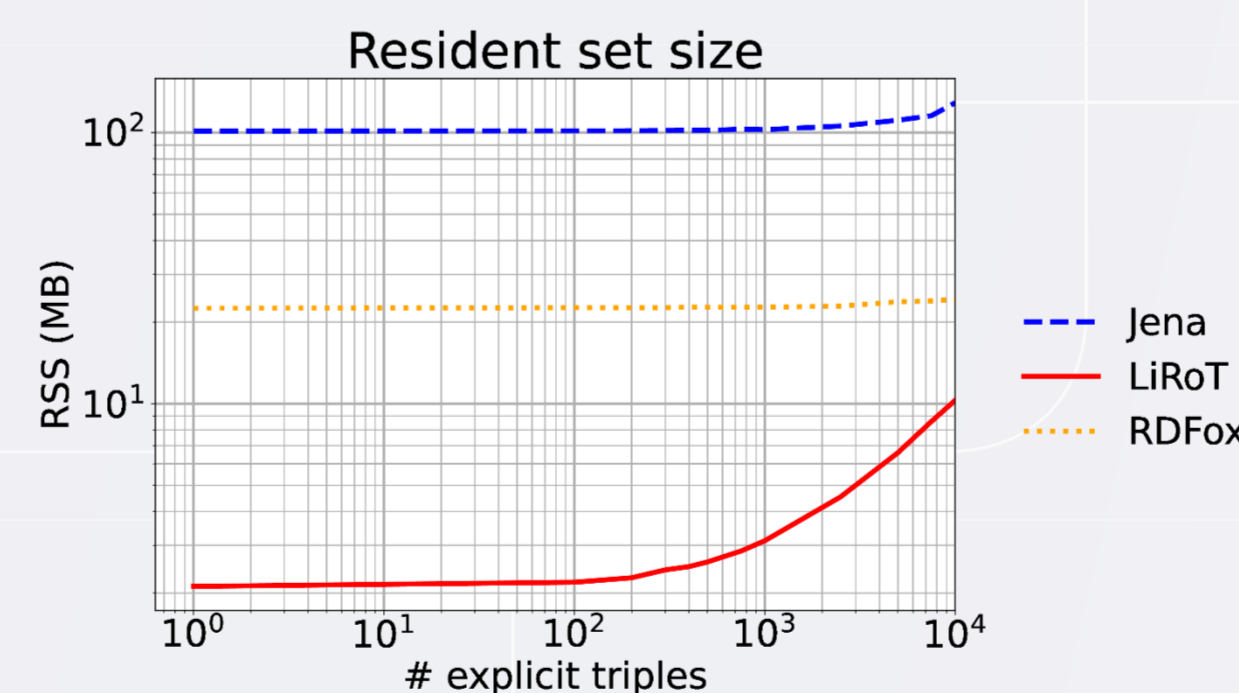
Proposed approach: LiRoT

- 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
- For desktop and Arduino platforms

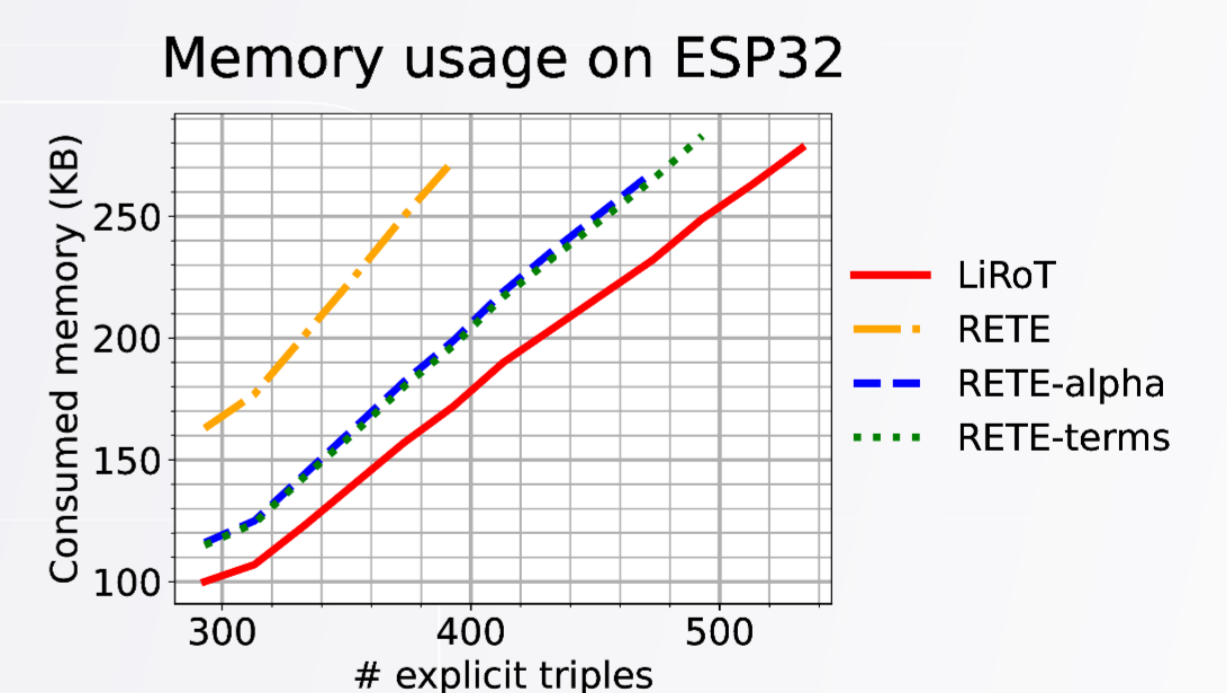


<https://gitlab.com/coswot/lirot>

Experimentations



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