Institut de Recherche en Informatique de Toulouse
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PhD subject: Dynamic and secure management of data on fog architecture under QoS constraints with knowledge graphs

Context

France has set up a program called PEPR (Priority Research Programs and Equipment) in order to build or strengthen French leadership in scientific fields linked or likely to be linked to technological, economic, societal, health or environmental transformation and which are considered as priorities at national or European level.
In this context the program TASE - Advanced Technologies for Energetics Systems will fund the four years collaborative project AI-NRGY - Distributed AI-based architecture of future energy systems integrating very large amounts of distributed sources. AI-NRGY aims to propose a software architecture as well as the methods, models and algorithms required to implement smart distributed solutions likely to accelerate the digitization of energy networks. Due to their highly distributed, dynamic, heterogeneous and sometimes volatile nature, as well as their status as critical infrastructure, multi-energy networks will not be able to rely on one or the other of the two data processing paradigms which have presided over their control until today: local calculation and centralized calculation. The aim of this project is therefore to contribute to the implementation of distributed intelligence solutions. The data is used for different services such as prediction of energy usage, control of local consumption, etc.
The aim is to take advantage of the different distributed computing (at the edge, on the fog and at the cloud layer) in order to respond to major constraints of future electrical networks.
To achieve this, in this PhD, we will work on providing an adaptive distributed policy in terms of access and localization of data to satisfy performance, privacy or even characteristics of support equipment, in particular to distributed AI algorithms.

Objectives

The development of systems requiring the implementation of artificial intelligence closer to users or to data is a trend in many systems for the future. This is the case in this project around smart-grids but the problem is the same for example in smart-cities or in intelligent vehicles.

Three aspects must be considered:
- The generation of data is done with sensors, actuators or by direct interactions with users. In these systems the amount of data is massive, highly distributed, dynamic and potentially intermittent.
- The use of data is also dynamic in terms of purpose, location and access authorizations, for example.
- The viability of these complex systems implies satisfying a set of constraints (quantity of data located in one place for memory problems) and being able to provide a predefined quality of service, for example to guarantee a response time.

In this thesis, we propose to deal with all of this problem by relying on semantic models and rules to describe the data and their relationships but also to make decisions on locations, duplication, transmission of data in an edge type architecture computing. This architecture will be built on the oneM2M standard and may eventually make it possible to propose extensions in the standardization committees. Real deployment of oneM2M architecture will deploy and test semantic models and rules approaches in a real architecture.

The objective is to propose an innovative approach based on knowledge graphs representing the manipulated data as well as the systems collecting and processing them but also the uses made of these data. Knowledge graphs are known to help managing the heterogeneity and diversity of the entities involved (Tomašević et al 2015, Lork et al, 2019). Building on existing work (Lygerakis et al., 2022) (Li et al., 2022), in particular that proposed by IRIT (Seydoux et al., 2020), an approach based on distributed reasoning will have to be put in place to deploy optimized data management as close as possible to the data being manipulated.

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Work

The work will be organized in different phases:

- Make a review of the state of the art to understand:
  - the context of energy management, smart-grid, knowledge graph and distributed reasoning
  - the oneM2M philosophy in terms of service and resources
- Propose a model to capture data representation and relations
- Propose a model to represent access, constraint and quality of service
- Propose rules, polices and a distributed algorithm to manage dynamicity
- Validate the different proposals with simulation and real deployments

Technologies

Semantic web standards, Rest architecture, distributed reasoning architectures, JAVA

Environment

The internship will be done in the SEPIA team at IRIT (https://www.irit.fr/en/departement/dep-architecture-systems-and-networks/sepia-team/) and MELODI team at IRIT (https://www.irit.fr/en/departement/dep-artificial-intelligence/melodi-team/). A collaboration with other partners of the project INRIA, CEA and Mines paristech will be necessary. Inclusion in the eclipse OM2M (eclipse.org/om2m) team project of the eclipse foundation will be possible.
Several researchers at IRIT will be included in this project and one other PhD student and post-Doc. Master Internships will be created during the PhD to support the candidate on specific implementation, tests and deployment.

Duration

36 months, starting as soon as possible

Contacts

Thierry Monteil (thierry.monteil@irit.fr), Nathalie Hernandez (nathalie.hernandez@irit.fr)

Bibliography

Nicolas Seydoux, Khalil Drira, Nathalie Hernandez, Thierry Monteil: EDR: A generic approach for the distribution of rule-based reasoning in a Cloud-Fog continuum. Semantic Web 11(4): 623-654 (2020)
Lygerakis, F., Kampelis, N., & Kolokotsa, D. Knowledge Graphs' Ontologies and Applications for Energy Efficiency in Buildings: A Review. *Energies*, *15*(20), 7520 (2022).
Lork, C., Choudhary, V., Hassan, N.U., Tushar, W., Yuen, C., Ng, B.K.K., Wang, X., Liu, X.: An Ontology-Based Framework for Building Energy Management with IoT. Electronics 8(5), 485 (2019)
Tomašević, N. M., Batić, M. Č., Blanes, L. M., Keane, M. M., Vraneš, S.: Ontology-based facility data model for energy management. Advanced Engineering Informatics 29(4), 971–984 (2015)
Li, H., Hong, T.: A semantic ontology for representing and quantifying energy flexibility of buildings. Advances in Applied Energy 8, 100113 (2022)