ICT PHD

Research project for a PhD curriculum in ICT, Computer Engineering and Science

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Proposed Title of the research: Edge computing platforms for the support of complex applications

Keywords: Distributed Systems, Cloud Computing, Edge Computing, Load Balancing, Optimization Problems

Research objectives

The research aims at proposing innovative techniques for the management of an Edge computing platform. Edge computing is a new paradigm for the development, deployment and delivery of innovative applications processing huge amount of data in a scalable way. Application may involve the execution of IA algorithm (for example to process images from sensors) and can include the management of personal or sensitive information. The application fields are extremely heterogeneous and include: smart cities / smart roads / smar cars, smart agriculture, e-health, industrial plants. In this research we consider that applications are composed of multiple micro-services organized as a Directed Acyclic Graph (DAG). Part of these micro-services can rely on ML models that are specific to the application realm. For each task multiple ML models can be available, with different computational demands and quality guarantees. Furthermore, ML model based on neaural networks can be dynamically split into multiple micro-services with each micro-service including some layers of the models, to make more fine-grained its deployment. Each application is subject to QoS constraints, for example in the form of a maximum response time. Additional elements of concern are the network characteristics, with latency and bandwidth limitation, security issues or specific hardware requirements (e.g., GPUs for IA applications). The research aims at tackling the problems of managing such infrastructures considering multiple aspects ranging from computing load (including dynamic changed in the load) to network characteristics and up to power efficiency. Several approaches can be used, from classic multi-objective optimization problems to reinforcement learning.

Proposed research activity

The research activities can be summarized as follows:

- Propose model for complex applications described as DAGs of simple micro-services that are to be composed
- Define optimization problems to solve the placement of micro-services over a distributed infrastructure.

- Model the possibility to dynamically split a NN model into multiple micro-services and model the inter-layer communication overhead.
- Implement and test solutions for the deployment of the considered applications, including problems of service replication, cloud-based offloading etc. . .
- Define and compare models and solution for static or stationary (i.e. slowly changing) allocation strategies against dynamic approaches with periodic re-configuration of the infrastructure
- Model and propose ML-based approaches (e.g., based on reinforcement learning) for the deployment problem
- Define on-line load balancing algorithms to mitigate local overload conditions
- Validation of the solutions using both small-scale realistic testbeds and large scale simulation
- Analyze a real testbed based on vehicular networks on the MASA (Modena Automitive Smart Area) infrastructure
- Improve the state of the art of simulation with respect to the case study of vehicular networks
- Guaranteeing security of the proposed infrastructure defining threat models and proposing and validating solutions

Supporting research projects (and Department)

This project will be carried out at the Department of Engineering "Enzo Ferrari" and will be supported by research funds provided by Prof. R. Lancellotti.

Possible connections with research groups, companies, universities.

The research may involve the undergoing collaborations with research groups at:

- University of Bologna (prof. Di Modica)
- University of Ferrara (prof. Tortonesi)
- University of Roma "Tor Vergata" (Prof. Chiaraviglio)
- University of Roma "Tor Vergata" (Proff. Lo Presti, Cardellini)
- Politecnico di Milano (Prof. Ardagna)
- King's College of London (Prof. Pierazzi)
- Unimore – DISMI (Prof. Iori)

Specific case studies may involve local enterprises active in data processing and facility management (e.g., Doxee, Coopservice). The research group can leverage several on-going projects that can provide realistic scenarios to test the research ideas.

Depending on the specific themes, the Ph.D. student can spend a period of up to 6 month at the King's college London university working under the supervision of prof. Pierazzi.