Ph.D. in Information Technology
Thesis Defense

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Edoardo LONGO – XXXIV Cycle

INTERNET OF THINGS PROTOTYPES AND COMMUNICATION PROTOCOLS FOR EDGE NETWORK ARCHITECTURES

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Abstract:

Internet of Things (IoT) devices are the key enabler for the envisioned smart cities. In many application scenarios, 5G and Edge computing will work together to bring computational power and storage closer to IoT devices. Nevertheless, cloud-based IoT systems do not make use of edge computing which can grant real-time communication between devices, greater data privacy and location awareness support. In addition, many communication protocols still rely on centralised systems instead of the envisioned distributed architecture at the network's edge.

In this Ph.D. thesis, we study two aspects of the convergence between IoT and 5G edge computing. First, designing and implementing two IoT applications that offload computational-intensive tasks to the edge. Second, proposing a distributed publish-subscribe communication protocol for IoT edge computing nodes. Special attention is paid to the MQTT pub/sub protocol and the role of communication between MQTT brokers. In our first contribution, we propose a combined solution of two IoT prototypes for a smart campus scenario, called Smart Waste Bin and Smart Gate. To support complex decision algorithms and information fusing, the device intelligence runs on the edge of the 5G network rather than on a cloud server or locally on the devices themselves. We discuss the entire design of the system prototypes, from the analysis of requirements to the implementation details. Results indicate that moving the artificial intelligence to the edge of the network is beneficial from latency and energy consumption perspectives. The second contribution presents a new benchmarking framework for distributed MQTT brokers. The system, called BORDER, helps to evaluate the general performance of MQTT brokers beyond the envisioned application domain.

Finally, in our main contribution, we propose an evolution of the MQTT protocol. Currently, it is based on a single-server topology that does not scale well considering the massive numbers of IoT devices expected in the next future. In this thesis, we aim to implement a distributed MQTT broker system to increase failure recovery, network scalability, and, thus, make MQTT even more effective in the IoT and edge domain. We explore three different algorithms to achieve such a distribution,

focusing particularly on the creation of the MQTT brokers overlay network. The stages of the MQTT evolution are tested in different scenarios and performance metrics such as end-to-end delay, resource and bandwidth consumption are analysed.

In conclusion, this work shows the capabilities of edge-enabled IoT devices and a solution for efficient communication systems for distributed servers located at the edge of the network.

PhD Committee

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