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Towards a Proper Service Placement in Combined Fog-to-Cloud (F2C) Architectures

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Abstract – The Internet of Things (IoT) has empowered the development of a plethora of new services, fueled by the deployment of devices located at the edge, providing multiple capabilities in terms of connectivity as well as in data collection and processing. With the inception of the Fog Computing paradigm, aimed at diminishing the distance between edge-devices and the IT premises running IoT services, the perceived service latency and even the security risks can be reduced, while simultaneously optimizing the network usage. When put together, Fog and Cloud computing (recently coined as fog-to-cloud, F2C) can be used to maximize the advantages of future computer systems, with the whole greater than the sum of individual parts. However, the specifics associated with cloud and fog resource models require new strategies to manage the mapping of novel IoT services into the suitable resources. Despite few proposals for service offloading between fog and cloud systems are slowly gaining momentum in the research community, many issues in service placement, both when the service is ready to be executed admitted as well as when the service is offloaded from Cloud to Fog, and vice-versa, are new and largely unsolved. In this paper, we provide some insights into the relevant features about service placement in F2C scenarios, highlighting main challenges in current systems towards the deployment of the next-generation IoT services.

Keywords- Service placement and execution; resource allocation; cloud & fog computing; distributed systems; Quality of Service

1. Introduction

The advances in mobile computing—including emerging wireless communication protocols, the development of low-cost sensors and the growth of smart data processing in Machine-to-Machine (M2M) communication—, have recently facilitated the deployment of the so-called Internet of Things (IoT) framework. This framework has inspired a plethora of distinct IoT service ideas, tailored to different scenarios and business sectors, including Personal Health Assistants (PHA), Intelligent Transportation Systems (ITS), Smart cities, Smart Home, or Environment Monitoring, among others. Indeed, the predictions in [1] report that by 2021, 1 million IoT devices will be purchased and installed every single hour, what undoubtedly fuel an unstoppable deployment of innovative smart services. At the same time, the IoT framework has been unquestionably endorsed by the technological evolution in the cloud arena as well as by the recently coined fog computing (closely related to mobile edge computing or cloudlets, see [2] for a technology review). Cloud computing, including their corresponding infrastructure in form of Data Centers (DCs), has with no doubt facilitated the development of IoT services offering the distributed data-on-demand provisioning to and from IoT devices deployed in smart environments [3]. On the other hand, fog computing came up to address some of the specific service demands not suitably addressed by cloud, such as latency, while also bringing in novel opportunities, for example in terms of traffic offloading, energy consumption or security. A typical example includes real-time component tracking in manufacturing plants or real-time navigation in traffic control systems, both known to be completely intolerant to any degradations of latency [4]. In fact, in a spiral form, the smart scenarios built by IoT and cloud computing, along with the increasing hardware capacities observed on devices at the edge—notably, mobile devices, such as phones or even vehicles—stimulated the rapid positioning of fog computing [5].

More concretely, in fog computing a user running a service may benefit from proximal resources, thus decreasing the demand for remote cloud resources. In fact, the use of available resources located at the

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