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On Participatory Service Provision at the Network Edge with Community Home Gateways

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Abstract

Edge computing is considered as a technology to enable new types of services which operate at the network edge. There are important use cases in ambient intelligence and the Internet of Things (IoT) for edge computing driven by huge business potentials. Most of today's edge computing platforms, however, consist of proprietary gateways, which are either closed or fairly restricted to deploy any third-party services. In this paper we discuss a participatory edge computing system running on home gateways to serve as an open environment to deploy local services. We present first motivating use cases and review existing approaches and design considerations for the proposed system. Then we show our platform which materializes the principles of an open and participatory edge environment, to lower the entry barriers for service deployment at the network edge. By using containers, our platform can flexibly enable third-party services, and may serve as an infrastructure to support several application domains of ambient intelligence.

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Keywords: edge computing, community clouds

1. Introduction

Important use cases in ambient intelligence and the Internet of Things (IoT) drive edge computing research and deployment. Major vendors provide nowadays edge computing solutions, such as[2,11,12,13], showing the usage of edge computing in many industrial and consumer-oriented scenarios. Many of these solutions, however, are based on proprietary hardware and software platforms, and put barriers to a flexible extension with third-party services. End-users face vendor-specific solutions which are not interoperable with those of the others. Providers of ambient intelligence services may find the access to market for their services aggravated because of not having computing infrastructures available, e.g. set-top boxes or home gateways which could host their services.

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The possibility of extending infrastructures with additional services, however, is needed to satisfy new user requirements. For instance in the scenario of smart homes, improved privacy and security must be included. Evolving contexts and new conditions need that edge systems can be updated in a secure way, and that they can be customized easily. Such extension to support new use cases, however, should not require to replace the whole system, but be enabled by design.

An open platform is needed where end users will benefit from being empowered to choose among several providers the most suitable services. Furthermore, end users may select an optimization criteria for these services at their choice, such as performance, security, privacy or the offered functions. Such an environment will also bring benefits for commercial providers specialized in edge services. The entry barrier for new actors to deploy services in such an open edge system will be much lower than pursing this purpose within proprietary frameworks which impose vendor lock-in.

In this paper we argue for an open edge computing environment driven by end users in which – in contrast to the above models – the platform is open for any interested stakeholder to actively participate in the service provision. Our approach combines current trends which, each by itself, have shown to be very successful and promising, namely 1) the rise of application platforms providing privacy preserving access control technologies, 2) increasing availability of powerful and energy-efficient hardware at users' premises, permanently operated, such as the Raspberry Pi, mini-PCs and enhanced home gateways, 3) containerization of services, as exemplified by Docker.

A first instance of this vision, where we run experiments of the presented work, has already become operational by a real deployment implemented as a community network cloud in Guifi.net[22]. It is formed by computing and communication resources provided by end users to host local services. The software platform which is installed on the devices is open and can be administered by the participants. User collaboration is part of the model of an open edge computing environment.

In this paper, based on our experience, we elaborate further on different aspects to be considered to foster participatory service provision, and position it as an approach to enable important use cases of IoT scenarios.

2. Motivating application scenarios

Once IoT devices and personalized mobile services become fully rolled out, the amount of data created at the user premises will soon increase in magnitudes. New requirements for ambient intelligence and IoT services at the network edge will appear. These services will need to address:

1. Privacy of the IoT data: Currently much IoT data is analyzed remotely at cloud data centers. End users are often unaware of the amount of data sent through their gateway to the service provider. Obtaining consent for this procedure from the user is often part of the service's installation process and part of the steps clicked by the user. Much of this data contains private information and if it is linked with the users' identities, personal information may become public or misused. The value of the user data is another issue to be considered. User data may help to create value for third-parties.
2. Tailored edge data analytics: An increased number of ambient intelligence services may benefit from data analytics support services running at the edge layer to take more informed decisions, become context-aware, and optimize resource usage. The access to shared information among different edge devices may in addition help to identify new meanings from the data, which may not be possible remotely where this access to shared data is not possible.
3. Resilience: There might be an increase in safety critical applications in home environments enabled by the technological capabilities. Such services may be found for instance in the domain of e-Health or surveillance and security. Relying on centralized remote cloud services, however, creates risks to such services becoming disrupted[14]. Distributed edge services may add resilience if they are able to take over temporarily critical functions in case of failures in centralized remote services.

Participatory service provision at the network edge could be enabled by decentralized cloud services hosted on edge devices. Such edge devices on which the services are deployed can be materialized by enhanced home gateways[4]