

Finding your Way in the Fog: Towards a Comprehensive Definition of Fog Computing

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ABSTRACT

The cloud is migrating to the edge of the network, where routers themselves may become the virtualisation infrastructure, in an evolution labelled as “the fog”. However, many other complementary technologies are reaching a high level of maturity. Their interplay may dramatically shift the information and communication technology landscape in the following years, bringing separate technologies into a common ground. This paper offers a comprehensive definition of the fog, comprehending technologies as diverse as cloud, sensor networks, peer-to-peer networks, network virtualisation functions or configuration management techniques. We highlight the main challenges faced by this potentially breakthrough technology amalgamation.

Categories and Subject Descriptors

C.2 [Computer Communication Networks]: [Distributed Systems - Network Operating Systems]

General Terms

Computing Theory

Keywords

Fog computing; Network Function Virtualisation (NFV); peer-to-peer (P2P); Internet of Things (IoT); Sensor networks; Cloud computing; Configuration management

1. INTRODUCTION

The information and communication technologies (ICT) community typically takes time to agree on the real meaning, reach and context of the new terms that appear associated to new technology trends and their associated buzz/hype. *Web services, cloud computing, big data* are a few examples of hyped terms that were confusing when first coined.

The term *fog computing* is reaching this initial state of confusion now. Unlike the examples above, ‘the fog’ is not constrained to a particular technological area. As a result, we can expect the initial confusion about ‘what the fog is?’ to reach unprecedented levels.

As it often happens with new technologies, a consensus definition needs to be agreed on by the community to mitigate hype and confusion. The very first definitions tend to focus on just a few aspects, like scalability in the cloud or interoperability in web services. The fact that the fog agglutinates many converging technological trends makes this

problem even more severe. In fact, looking at any of the technologies related to the fog from a single angle may offer the false view that there is little new to it. For instance, recent definition attempts have presented it as just an evolution to our current cloud model. See, for instance, Cisco’s view of the fog [8].

In this paper, we offer a broader and integrative view of the fog. We present it as the result of several emerging trends on technology usage patterns on the one side, and the advances on enabling technologies on the other side. From the analysis of both aspects, we propose a definition of fog computing that encompasses its features and impact. Also, this work introduces the obstacles that will have to be overcome so that fog computing can mature and unfold its entire potential.

This paper is structured as follows. Section 2 discusses devices ubiquity as the main factor that will bring the fog, along with a brief overview of the main works that address the demands for smaller and more capable devices. Section 3 deals with the challenges on services and network management that fog applications will introduce, while Section 4 summarises the advances proposed at several levels to provide connectivity to the billions of devices that will be the norm in the fog. Section 5 explains how privacy demands by users will be another propeller of the technological changes that will shape the fog. With all those ingredients taken into account, Section 6 presents our definition of the fog, and Section 7 lists the open challenges that will have to be solved in the future to make the fog a reality. Finally, Section 8 summarises the conclusions of this work.

2. DEVICE UBIQUITY

There is a huge increase in the number of devices getting connected to the network. This increase is driven by 2 sources: user devices and sensors/actuators. Cisco conservatively estimates that there will be 50 billion connected devices by 2020 [10]¹. This explosion in the number of devices per person is explained by the proliferation of mobile devices (e.g. mobile phones and tablets, specially in developing countries). But these impressive numbers will soon be overpassed by the myriad of sensing/acting devices placed virtually everywhere (the so called *Internet of Things*, IoT, and pervasive sensor networks). *Wearable computing devices* (smart watches, glasses, etc.), smart-cities [13], smart

¹Today’s world population is estimated to be around 7 billion people, with 25 billion connected devices. That is, the number of devices will double in the next 5-6 years.