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Automatic monitoring management for 5G mobile networks

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Abstract

5G mobile networks are pushing new dynamic and flexible scenarios that require the automation of the management processes performed by network administrators. To this end, Self-Organizing Networks (SON) arose with the goal of moving from traditional manual management processes towards an automatic and dynamic perspective. The orchestration of the monitoring services is an essential task to conduct self-configuration, self-healing, and self-optimization processes required by SONs. In this context, we propose a solution that efficiently orchestrates the monitoring services by managing the network resources automatically. In particular, we propose a 5G-oriented architecture that integrates the Software Defined Networking (SDN) and Network Functions Virtualization (NFV) technologies to monitor and orchestrate the whole life-cycle of monitoring services considering information of the network control plane.

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Keywords: Network monitoring; Software Defined Networking; Virtualization; Orchestration; 5G mobile networks

1. Introduction

The evolution of technologies has provoked a radical change in mobile networks and, therefore, in their internal management processes. Nowadays, the incoming fifth generation (5G) of mobile networks is pushing new scenarios in which dynamism and flexibility are essential aspects. These new scenarios are characterized when considering several Key Performance Indicators (KPIs)[1], defined by the 5G Public Private Partnership (5G-PPP). Among these indicators, the number of connected devices (from 10 to 100 times), the volume of mobile data per geographical area (1000 times higher), the end-to-end latency (less than 1ms), and ubiquitous 5G access including low density areas are some of the most relevant aspects that influence the evolution from traditional to future mobile networks.

This new situation requires the automation of the management processes performed by network administrators. In this sense, Self-Organizing Networks (SON) arose with the goal of moving forward from traditional manual management processes towards an automatic and dynamic perspective. To reduce the network management complexity, the

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Software Defined Networking (SDN) paradigm[2] can help SONs to automatically manage and orchestrate the network resources when considering the current network status. The SDN paradigm has the following three characteristics:

1. The ability to decouple the data plane, where the forwarding elements are located, from the control plane, where the routing decision is made.
2. The control element called *SDN Controller* that manages multiple network elements belonging to the data plane.
3. The global administration perspective that avoids making changes on each individual network element.

Furthermore, integrating the SDN paradigm with Network Functions Virtualization (NFV) techniques[3] allows decoupling the software implementation of Network Functions (NF) from the underlying hardware, providing flexibility in the management of the network resources. In this sense, NFV techniques allow deploying network functions (e.g., load balancers, firewalls, or gateways –SGWs and PGWs in 5G scenarios) as software instances, called Virtual Network Functions (VNF), running on generic hardware through software virtualization techniques.

One of the most challenging tasks of SONs is the management of monitoring services, which provide valuable information about resources and network status that is essential to provide the main functionalities of SONs: self-configuration, self-healing, and self-optimization[4]. In this sense, the orchestration of monitoring services is a critical and complex process that should be carried out in an automatic way. Otherwise, the management of these services would be impossible to perform due to the huge number of 5G devices consuming network services, the high mobility of these devices, or the bandwidth and latency of future mobile communications, among others. Despite the facilities provided by the NFV and SDN approaches, the mobility provided by future 5G mobile networks and the dynamic provision of services have hindered the management of the network infrastructure efficiently. Furthermore, we think that future mobile networks should orchestrate the network monitoring services by considering not only Data-Related Information (DRI), e.g., the information contained in network flows, but also the Control-Related Information (CRI). Aspects belonging to the SDN and NFV control planes, such as the number of gathered flows per second or the percentage of CPU and storage consumed by network resources at a given time, for example, are essential to ensure the correct provision of monitoring network services.

In order to overcome the previous challenge, we propose a novel solution that considers information of the network control plane to orchestrate monitoring services by managing network resources automatically. Our proposal defines a 5G-oriented architecture that integrates the SDN and NFV technologies to monitor and orchestrate the whole life-cycle of monitoring services by considering the SDN and NFV control plane. Our architecture is the only one, to the best of our knowledge, that manages the provision of monitoring services defining a set of policies that consider CRI and 5G aspects, such as the number of active users, the network infrastructure's location, or the users' mobility.

The remainder of the paper is structured as follows. Section 2 discusses some related work on other SDN-oriented solutions that monitor and orchestrate the network elements. Section 3 shows the components forming the proposed architecture, while the management policies and how they manage the virtual and physical network elements are presented in Section 4. Section 5 shows the process made by our solution to enforce the actions required to manage the network resources. Finally, conclusions and future work are drawn in Section 6.

2. Related work

An actual review of the Software-Defined Networking (SDN) paradigm[5] is focused on the current research status of multi-domain SDN and its future challenges. Among the diversity of proposals oriented to the SDN paradigm, monitoring services are crucial for many network management tasks, such as load balancing, traffic engineering, Service Level Agreement (SLA), and security, among others. In this sense, OpenNetMon[6] is a solution that uses the OpenFlow protocol to monitor all flows between predefined link-destination pairs on throughput, packet loss, and delay. By querying the switch about the number of bytes sent, as well as the duration of each flow, OpenNetMon is able to calculate the effective throughput per flow. To this end, this solution compares the flow statistics to compute the packet loss; particularly, the packet counters from the first and the last switch of each path between the link-destination pairs. Instead, the delay is measured by injecting probe packets directly into the switch data planes and determining a realistic delay for each flow. On the other hand, PayLess[7] is an efficient network statistics collector framework for the SDN paradigm. PayLess is built on top of an OpenFlow controller and is able to monitor, aggregate, and select the