# The Architectural Design of Service Management and Orchestration in 6G Communication Systems

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**Abstract**

In this poster paper, we propose and demonstrate an architectural framework for service Management and Orchestration (M&O) in Sixth-Generation (6G) communication systems. This architecture was designed by the Hexa-X project, which is a European flagship project dedicated to developing a vision and technological enablers for 6G. To provide a comprehensive and high-level description, we consider three views: (i) Functional View; (ii) Structural View; and (iii) Deployment View. We first discuss 6G service M&O before delving deeper into each view.

# The Architectural Design of Service Management and Orchestration in 6G Communication Systems

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***Abstract*—In this poster paper, we propose and demonstrate an architectural framework for service Management and Orchestration (M&O) in Sixth-Generation (6G) communication systems. This architecture was designed by the Hexa-X project, which is a European flagship project dedicated to developing a vision and technological enablers for 6G. To provide a comprehensive and high-level description, we consider three views: (i) Functional View; (ii) Structural View; and (iii) Deployment View. We first discuss 6G service M&O before delving deeper into each view.**

***Index Terms*—6G, Management, Orchestration, Architecture**

## I. Service M&O Framework for 6G

Hexa-X, the European 6G flagship project, is researching and developing wireless technologies and architectural solutions for 6G. The ambition of the Hexa-X includes research and development of key enablers in the areas of: *(a)* fundamentally new radio access technologies at high frequencies and high-resolution localization and sensing; *(b)* connected intelligence through Artificial Intelligence (AI)- and Machine Learning (ML)-driven air interface and governance for networks; and *(c)* 6G architectural enablers for network disaggregation and dynamic dependability [1]. The Sixth Workpackage (WP6) of Hexa-X [2] is devoted to the research on intelligent service and network M&O in 6G. Its objective is to incorporate novel enhancements to the existing M&O architectures using a set of intelligent tools to be able to cope with 6G network requirements [2]. Due to the fact that AI/ML, and automation offer numerous benefits over legacy M&O approaches, such as improved time and cost savings, enhanced customization, decreased human-made errors, and increased innovation, the Hexa-X WP6 has been motivated to explore their various aspects and effects on the M&O of 6G [2].

In this regard, Hexa-X WP6 proposes an intelligent framework for 6G service M&O. The proposed framework, depicted on Figure 1, highlights that 6G networks are expected to be an extremely complex and heterogeneous environment, due to the humongous volume of devices and services that will coexist, requiring intelligent and flexible solutions that face every domain, from the core network to the extreme-edge domain. To that end, the entire 6G ecosystem must be transferred into a programmable environment, and the intelligent tools and software must execute their processes autonomously, implementing the so-called *device-edge-cloud continuum* management mechanisms [2]. This will undoubtedly simplify the M&O of 6G networks. The Hexa-X M&O architecture is implemented by means of three different views that aim at providing a coherent and comprehensive description of the complete M&O framework [2]. Each view is described in the rest of the paper.

## II. The Structural View of M&O Framework

The Structural View represents Network Slices (NSIs) and Network Services (NSs) at the Service Layer as being comprised of Network Functions (NFs) from the Network Layer and running on Network Elements at the Infrastructure Layer. All NSIs, NSs, and NFs are designed by the Design Layer and communicate using the cross-layer API Management Exposure. This approach brings closer the two worlds of operational teams and developers/vendors in the expected multi-stakeholder and multi-domain environments that will be generated future 6G networks. Compared with the Fifth-Generation (5G) architecture, Figure 1 integrates a set of innovations and adopts the Service-Based Model Architecture (SBMA) approach. Firstly, a new layer known as the *Design Layer* has been added as one of the innovations introduced by Hexa-X to address the challenges of telco-grade environments; the adoption of DevOps practices based on cloud-native principles; and the enhancement of overall service and network programmability. Another novel feature is the cross-layer functional block known as API Management Exposure, which enables and regulates communication among the different M&O resources within and across administrative domains, enabling the exposure of network elements in different layers [2]. Both innovations are greatly detailed in [2].

Furthermore, two Control Loops (CLs) have been included: *(i) DevOps CL*, which reflects the Continuous Integration (CI)/Continuous Delivery (CD) iterations between the Mobile Network Operator (MNO) scope (gray color) and the *Design Layer*; and *(ii) Infrastructure CL*, which automates the infrastructure discovery processes, associated monitoring, and facilitates network programmability. In order to represent the significance of the extreme-edge domain and the highly heterogeneous resources that will co-exist in 6G networks, Hyperscalers, Non-Public Networkss (NPNs), and extreme-edge resources have been added to the Infrastructure Layer. As shown in Figure 1, the Hexa-X M&O Framework represents Generic Functions at the Network Layer rather than specific functions, e.g., Communication Service Management Function (CSMF), Network Function Virtualization Orchestrator (NFVO), etc., to avoid any direct alignment with existing standards (i.e., it remains abstracted from them), and to be able to integrate with novel functions that may be defined for the 6G stack. Functions within the Network Layer are associated with different functional groups and are primarily implemented using Containerized Network Functions (CNFs) but with backwards compatibility.

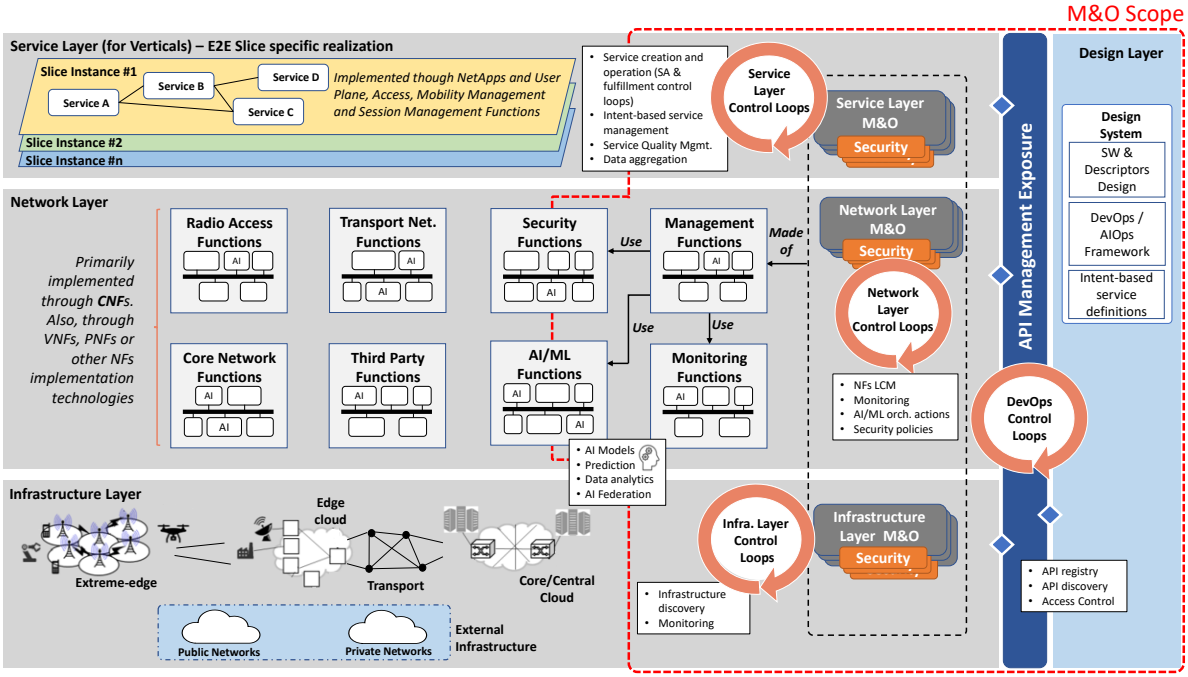


Fig. 1. The Hexa-X Service M&O Architectural Framework proposed for the 6G mobile communication systems [2].

There is a separation between the *M&O Scope* (shown with the dashed red line) and Managed Objects (MOs). MOs represent resources that can be managed by *Managing Resources* within the *M&O Scope*. According to the SBMA model, M&O resources represent management services owned by a concrete MNO, each featuring a specific M&O capability over the given MOs. These M&O resources can be mapped to vendor "boxed" solutions as they would be consumable or producible by management functions. Hexa-X distinguishes between two Management Functions Groups: *(i) Primary Management Functions*, depicted in Figure 1 as "Management Functions," which offer fulfilment, assurance, and artifact management capabilities, these being considered as the *Basic Management capabilities*; and *(ii) Complementary Management Functions*, which may be used by *Primary Management Functions* to aid and enhance their own capabilities, i.e., Monitoring Functions, AI/ML Functions, and Security Functions. Both Security and AI/ML Functions are split by the M&O Scope because certain parts of their functions could be designed to give direct support to the *Primary Management Functions*, whereas other parts could support MOs functionalities. Security Functions aim at protecting the confidentiality and integrity of operations and data to ensure the continuity of the provided services; AI/ML Functions provide the mechanisms to build out the knowledge and cognitive functionalities for controlling, managing, and optimizing the deployed services and help to decide which actions are to be performed at all the architectural layers. They are seen as a key enabler for AI-based orchestration and predictive orchestration techniques. Monitoring Functions provide information regarding the operational processes, in the form of trace files, alarms, KPI values, etc., to *Management Functions* so that they can perform M&O operations.

## III. The Functional View of M&O Framework

This view describes the "dynamic" aspects of the M&O system from a high-level perspective, describing relevant behaviors or mechanisms that would be implemented through the interactions among the basic building blocks described in the Structural View (Sec. II). It describes the main objectives of the so-called *Basic Orchestration actions* (i.e., that can be applied to any MO across every layer: instantiation, scaling, updating, upgrading/downgrading, terminating, etc.) and *Orchestration Processes*, which combine several *Basic Orchestration actions* to generate more complex M&O actions such as: E2E seamless integration, Programmable processes, Automation processes, and Data-Driven processes.

## IV. Deployment View of M&O Framework

This view considers and analyzes how the components from the Structural View may be deployed, contemplating infrastructure resources and topological aspects. It describes the main building blocks that can be used for the deployment of an architecture like the one depicted in Figure 1. The view describes how these building block components can be grouped together from small racks up to large-scale data centers, and explains how to integrate the extreme-edge resources in the orchestration domain to implement the device-edge-cloud continuum management concept.

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