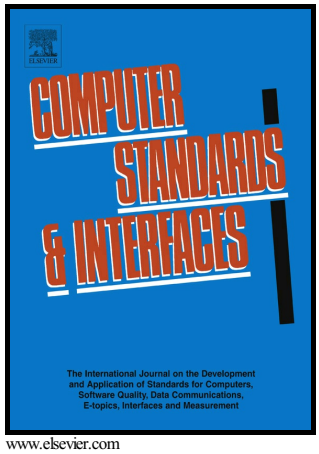




# Network Service Orchestration Standardization: A Technology Survey

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# Network Service Orchestration Standardization: A Technology Survey

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**Abstract**

Network services underpin operator revenues, and value-added services provide income beyond core (voice and data) infrastructure capability. Today, operators face multiple challenges: a need to innovate and offer a wider choice of value-added services, whilst increasing network scale, bandwidth and flexibility. They must also reduce operational costs, and deploy services far faster - in minutes rather than days or weeks.

In the recent years, the network community, motivated by the aforementioned challenges, has developed production network architectures and seeded technologies, like Software Defined Networking, Application-based Network Operations and Network Function Virtualization. These technologies enhance the highly desired properties for elasticity, agility and cost-effectiveness in the operator environment. A key requirement to fully exploit the benefits of these new architectures and technologies is a fundamental shift in management and control of resources, and the ability to orchestrate the network infrastructure: coordinate the instantiation of high-level network services across different technological domains and automate service deployment and re-optimization.

This paper surveys existing standardization efforts for the orchestration - automation, coordination, and management - of complex set of network and function resources (both physical and virtual), and highlights the various enabling technologies, strengths and weaknesses, adoption challenges for operators, and areas where further research is required.

## 1. Introduction

> Flexibility, agility and automation and a much faster time-to-market cycle, where the latter is something that we, as operators, lack today
> (Christos Kolias, Network Architect, Orange [1])

Network services are the primary value-added products for Network Operators (operators), enabling them to monetize their infrastructure investments. Operator service portfolios cover a wide range of functionalities, spanning from basic Internet connectivity services, such as IPTV delivery, to highly-available and secure connectivity between business sites. This operator business model has been highly successful, their user base continuously expands [2], while new services are adopted by end-users.

As a direct consequence, network infrastructures have grown significantly in the recent years and operators face significant challenges maintaining high revenues, while supporting innovative new network services. On the one hand, traffic volumes increase exponentially [3] and forces operators to upgrade infrastructures frequently. Additionally, the established service management model relies extensively on manual device reconfiguration by the network engineers, coordinated through Operational Support Systems (OSS), while link over-provision is used to enforce SLAs. Effectively, the predominant service management model incurs significant capital (CAPEX) and operational expenditures (OPEX) for the operator [4]. On the other hand, network infrastructures employ a widening range of heterogeneous technologies to support the diverse characteristics and dynamic demands of residential and enterprise network services. Unfortunately, the control and management interfaces of the relevant technologies do not keep abreast with the requirements of network applications for fluid and dynamic control. The different technological domains and layers exhibit significant interface proliferation, while vertical control integration in network devices impairs management flexibility and responsiveness. As a result, the futuristic vision of network operators to provide service-oriented control interfaces to end-user applications, still remains unfulfilled.

These limitations have motivated the network and systems community to develop new paradigms and architectures which improve network infrastructure flexibility, agility, programmability and elasticity and ensure low OPEX. Recent network paradigms, like Software Defined Networking (SDN) and Application-based Network Operations (ABNO), promote control convergence across network layers and logical centralization of network infrastructure management through the specification of common device control interfaces. In parallel, the Network Function Virtualization (NFV) paradigm promotes the "*softwarization*" and virtualization of network functions, in order to enable data plane processing with similar elasticity, scalability and resilience available in cloud environments. Furthermore, new network archi-