



In the context of its activities across several 5G PPP projects, Nextworks has developed a strong asset of software prototypes for an advanced NFV MANO framework targeting 5G infrastructures and integrating innovative features for 5G telcos, service providers and vertical industries. The core of Nextworks service management and orchestration framework is built around the 5G Apps & Service Catalogue, TIMEO (Transport Infrastructure and MEC Enabled Orchestrator), SEBASTIAN (Service BAsed Slice Translation, Integration and Automation), the Plug & Play control of virtualized functions for 5G, and the 5GCity Software Development Kit. On top of these service management and orchestration framework, Nextworks has developed, in the context of the 5G-MEDIA project, a 5G media use case for UHD media content distribution over virtualized Content Delivery Networks (CDNs), which integrates and enhances open source CDN solutions with Nextworks' SmartHome Symphony product.

- The 5G Apps & Service Catalogue, started as part of the *SELFNET* project (5G PPP Phase 1) and further advanced in *5G-MEDIA* (5G PPP Phase 2), is a generalized catalogue of descriptors that allows service customers to bring their own VNFs and services into the 5G management and orchestration layer, with unified ETSI NFV standard format where applicable (aligned to the latest best of breed ETSI SOL specifications) and MANO specific translation towards ETSI OSM and other NFV-MANO stacks. It started as part as research activity and prototype in the *SELFNET* project and further advanced to a consolidated catalogue solution in *5G-MEDIA* project. Further extensions are planned in 5G EVE project (5G PPP Phase 3) to support onboarding and exchange of slice, service and function descriptors from multiple domains.
- TIMEO is an enhanced NFV Orchestrator originally developed in the context of *5G-Crosshaul* project (5G PPP Phase 1) and further extended in *blueSPACE* project (5G PPP Phase 2). It is an ETSI NFV compliant NFVO which implements the ETSI IFA interfaces and information models for service and VNF/MEC apps package lifecycle management. It extends the NFV MANO models with mechanisms to support advanced resource allocation strategies for transport network (SDN based) and network+IT, can interface to packet and optical network controllers via Transport API, can manage power states for network and computing devices and is able to handle management and monitoring of both VNFs and PNFs.

- SEBASTIAN is a tool for service-driven slice management and orchestration, implemented as part of Nextworks activities in *5G-TRANSFORMER* (5G PPP Phase 2) and extended in *SliceNet* (5G PPP Phase 2) and *5G EVE* (5G PPP Phase 3). It allows modelling and instantiation of vertical-driven services in 5G network slices, with multi-slice arbitration mechanisms. Key features of SEBASTIAN are the automated translation from business/service to network slice requirements; the slice arbitration for efficient service sharing, re-usability and composition; multi-tenancy with service isolation and SLAs management.
- The Plug & Play control framework, developed in the *SliceNet* project (5G PPP Phase 2), allows to deploy customized slice control instances for verticals in the form of isolated control environments where customized control logic can be plugged to build a truly tailored slice control at runtime. These functions have been designed from the beginning around the principles of modularity, flexibility and open interfaces, in order to simplify and fasten the introduction of novel features, algorithms and even platform components. In this sense, Nextworks assets are designed and prototyped to provide an extensible and integrated framework to foster and stimulate the research in the network slicing and NFV area, providing an agile platform to quickly and efficiently develop, integrate and experimentally validate innovative features in an ETSI NFV compliant environment.
- The *5GCity* Software Development Kit is a toolkit that allows wiring, in an arbitrary sequence, a pre-defined set of abstract functions defining the logical service chain of the Vertical service, generating the corresponding network service and virtual network function templates with all the complexity required by the NFV-MANO layer. The *5GCity* SDK abstracts infrastructure's low-level details and automatically translates functional components and business requirements into descriptors of virtual computing and networking resources for the operational service. In the *5GCity* project, the SDK module is planned to be used in the three city-wide pilots of Barcelona (ES), Bristol (UK) and Lucca (IT) to design the various network service and experimentation scenarios of the Neutral Host, Media industry use cases (immersive media and collaborative media), and waste management through video analytics.

The open and modular nature of the 5G Apps & Service Catalogue, TIMEO, SEBASTIAN, Plug & Play control and 5GCity SDK is key facilitator of an intense collaboration of Nextworks team with other researchers in 5G PPP, who can easily contribute to the evolution of the frameworks in their specific area of expertise. For example, the collaboration with academic partners allows to introduce new resource allocation algorithms, while the possibility to easily integrate new drivers for NFVI domains opens opportunities to interact with multi-technology infrastructure providers. These collaborations create multi-faceted value chains that continuously encourage to investigate new research directions.

This set of assets allows Nextworks researchers to early introduce innovative functionalities for the management of 5G infrastructures and the orchestration of 5G services, often anticipating the major themes and trends of the research. Starting from 5G PPP Phase 1, Nextworks has already developed

solutions for the joint orchestration of cloud and network resources, as part of a wider strategy for energy efficient service deployments, with a demonstration at the 5G Global Event 2nd in November 2016. In this particular case, TIMEO orchestrated the automated configuration of the fronthaul/backhaul network in the service lifecycle management (as further demonstrated at EuCNC conference in June 2017); the capability was further extended in the *blueSPACE* project to cover also optical-based transport networks (public demonstration at ECOC 2018 conference), a topic which is still attracting strong interest of network vendors and potential customer. Similarly, Nextworks started very early to design solutions for sharing and composition of network services in NFV frameworks, which constitutes the baseline enabler for the efficient management of network slices in shared and multi-tenancy environments. Relying on these concepts, SEBASTIAN already integrates basic mechanisms for service-driven management, composition and sharing of network slices (as demonstrated in EuCNC 2018, ECOC 2018, ICT 2018 and OFC 2019 conferences), with the objective of efficiently arbitrating the execution of multi-tenant and concurrent vertical services requesting network slices. This topic is expected to draw much attention during 5G PPP phase 3, when several 5G services will run in live trials. Here, Nextworks has already demonstrated a realistic 5G media use case that enables Media Service Providers to build flexible and adaptable media distribution service chains, made up of virtualized functions, and deliver UHD media contents while users are moving in a geographically distributed 5G networks, as successfully demonstrated at the Mobile World Congress 2019.

Deeply involved in the development of the main research areas in network slicing and orchestration for 5G, Nextworks is in a strong position to successfully propose highly innovative solutions to its customers, above all in the consultancy market. In this area, the development and demonstration activities performed over the 5G Apps & Service Catalogue, TIMEO, SEBASTIAN and the Plug & Play control platforms, already integrated with a 5G media vertical use case for UHD media content distribution over vCDNs, are key references and success stories to present the company expertise to potential customers, thus increasing competitiveness and differentiation from competitors. If that's true that today many companies are offering integration services around several of the orchestration platforms developed in mainstream open source projects, it is a fact that not so many are able to go beyond what is available there in terms of features and functionalities. Moreover, most of the potential customers in this area are developing their own proprietary MANO solutions, requesting specialized skills to enhance them and introduce innovative concepts. Nextworks' PoCs in public exhibitions are excellent opportunities to present new ideas developed by the company, demonstrating their technical feasibility and potential benefits.

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