Case study

Telefónica Germany is partnering with Blue Planet to execute its iFUSION transport SDN strategy

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1. Executive summary

This case study explains Telefónica's iFUSION strategy to deploy software-defined networking (SDN)-enabled disaggregated transport networks across its operational footprint. It provides a detailed discussion on the key strategy cornerstone (the hierarchical SDN controller) and includes a summary of the implementation and associated benefits at Telefónica Germany, where a partially disaggregated multi-vendor optical network has been deployed using Blue Planet's Multi-Domain Service Orchestrator (MDSO) as the end-to-end SDN controller for the optical network domain.

Telefónica's iFUSION strategy is designed to create a highly agile and cost-efficient transport network to support today's traffic demands, as well as future 5G traffic volumes and use cases, such as network slicing. As part of this strategy, Telefónica introduced an open SDN architecture for the programmatic control of the various transport networks (IP/MPLS, microwave and optical). The hierarchical SDN controller framework is at the heart of this new architecture and consists of an end-to-end multi-domain SDN controller at the upper level, with lower-level multi-vendor SDN controllers in each transport network domain. A variety of open standard southbound interfaces (SBIs) and northbound interfaces (NBIs) are utilized for communication between upper- and lower-level SDN controllers, and with underlying vendor-specific controllers, including the ONF Transport API (T-API) within the optical network and IETF-based standard APIs in the IP/MPLS network.

Within iFUSION, Telefónica has developed best practices for use-case definition, vendor selection, implementation and program governance, which it is using to execute the strategy with great success. Telefónica is also driving cross-industry collaboration and standardization for the new software-defined transport network (SDTN) architecture, mainly under the Telecom Infra Project's (TIP) Open Optical and Packet Transport (OOPT) project group in partnership with Deutsche Telekom, MTN, Orange, Telia Company and Vodafone.

Telefónica Germany has implemented this hierarchical SDN controller architecture for its partially disaggregated optical network, which includes decoupled open terminals (OTs) and an open line system (OLS). It has deployed Blue Planet's MDSO as the hierarchical SDTN controller in order to manage the multi-vendor optical network (three vendors and six different OT and OLS combinations). Telefónica chose Blue Planet as its vendor partner for this initial deployment because of its strong alignment with Telefónica's iFUSION vision, its commitment to open standards including T-API and its demonstration of a flexible and modular solution architecture.

Telefónica Germany has used Blue Planet's MDSO to implement five key use cases that enable network automation in a network that combines OTs and OLSs from different vendors. These use cases are automated network discovery, OT inventory discovery, service topology management, service management and alarms management avoiding manual configurations in a disaggregated network. Furthermore, Telefónica Germany has reduced the number of NBIs needed by more than 70% through the introduction of T-API as a single NBI.

2. Telefónica iFUSION initiative

One of the key tenets of Telefónica's SDN strategy is to evolve its transport network (consisting of optical, IP/MPLS and microwave technologies) to a disaggregated open architecture. Telefónica intends to use the iFUSION initiative to:

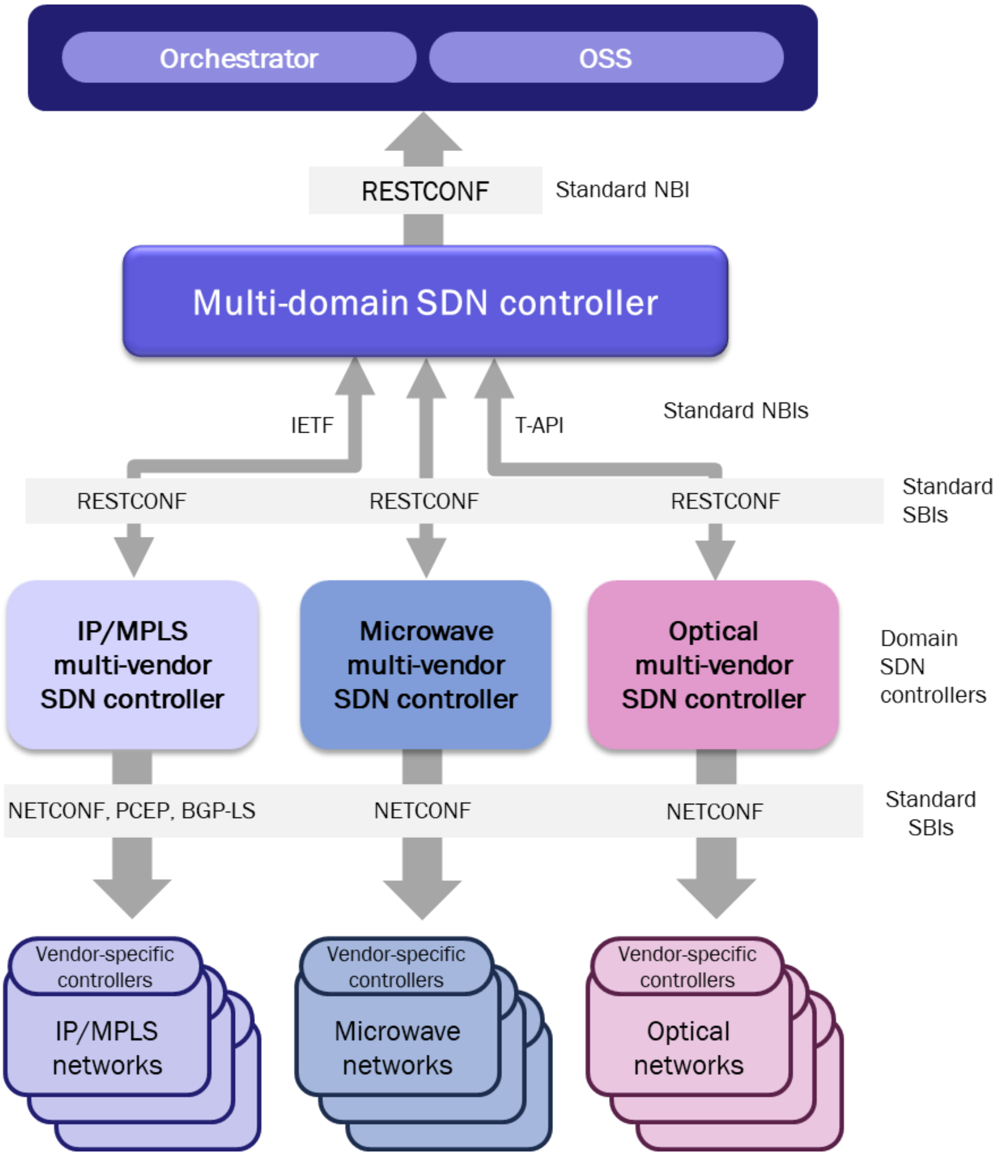
- enable the programmatic control of the transport network using software-driven traffic engineering and automated service provisioning processes
- embrace open standards and specifications, thereby giving architectural flexibility to replace vendors with minimum integration and increasing vendor competition
- simplify the higher-layer OSS and standardize its integration with the transport network based on clearly defined NBIs (one per transport technology); this will decouple the OSS and the network, thereby allowing each to evolve independently of the other
- enable 5G network slicing and lifecycle management through slice-based network resource allocation, monitoring and assurance.

The iFUSION SDN strategy is supported by the key pillars outlined below.

2.1 Hierarchical SDN controller architecture

Telefónica has adopted a hierarchical SDN architecture in which domain-specific, multi-vendor SDN controllers (SDN-Cs) replace traditional network management systems (NMSs). The domain-specific SDN-Cs will interface with an end-to-end multi-domain SDN controller through common, standardized NBIs. The multi-domain SDN controller will consolidate and abstract the control and management for all the transport network domains (optical, microwave and IP/MPLS), and will provide a clean interface up to the OSS through a RESTCONF/YANG interface. Similarly, the multi-domain SDN controller will take provisioning information from the service orchestrator and OSS to orchestrate the actions via the domain SDN-Cs (Figure 2.1).

Figure 2.1: Telefónica 's SDN reference architecture for transport



Source: Analysys Mason and Telefónica, 2020

2.2 Network abstraction to simplify integrations and enable OSS agility

One of the key aims of the iFUSION program is to create a network abstraction layer on top of the underlying transport network infrastructure. Telefónica currently maintains 100 vendor-specific northbound integrations across the three transport network domains, and introducing new capabilities and tools is highly complex. The existing northbound integrations have been introduced over the years as vendor-specific NMSs, device-type-specific EMSs and domain-specific interfaces that use a plethora of integration technologies such as CORBA, SNMP, MTOSI, XML, FTP, REST and even CLI.

The new network abstraction layer is intended to provide a vendor-agnostic and unified end-to-end view of the transport network to the upper-layer multi-domain SDN transport controller, and consequently, to the OSS and orchestration applications. This will be achieved through hierarchical SDN control architecture as depicted in Figure 2.1.

- At the lower layer, there will be three separate multi-vendor SDN controllers, one for each transport network domain. These will use standardized southbound interfaces and protocols to communicate with underlying, vendor-specific controllers. Telefónica will use Blue Planet's MDSO as the multi-vendor SDN controller for the optical domain. It will communicate with vendor-specific SDN controllers, initially using vendor-proprietary SBIs, but it will eventually use a standard SBI.

- The multi-vendor SDN controllers will communicate with the higher-layer multi-domain SDN controller using technology-appropriate standard NBIs (the IP/MPLS SDN controller will use IETF-based standard APIs, and the optical network SDN controller will use the T-API), which will provide further abstraction of the domain- and network-level complexity, thereby enabling Telefónica to decouple the OSS and orchestration layers from the network.

This hierarchical network abstraction approach greatly simplifies Telefónica's transport network management and will allow the operator to accelerate its OSS transformation independently of the pace of its network evolution.

2.3 Standards-based interfaces to enable vendor-agnostic implementation

Telefónica has also defined a strict functional boundary between the SDN layer and the OSS. It considers alarm correlation, path computation, traffic monitoring and engineering to be SDN functions, while network planning, performance management and inventory management belong to the OSS. The SDTN-C will provide multi-domain traffic engineering and optimisation across Telefónica's entire transport infrastructure, as well as being the single point of information exchange with OSS applications.

From a standardization perspective, the NBI in the optical domain will be based on ONF T-API 2.1/2.2 and its associated common information model. In the IP domain, the NBI will use IETF service models based on RETCONF/YANG and OpenConfig provisioning models. Telefónica will use an OpenConfig-based SBI for the IP domain and an ONF 5320-based SBI for the microwave domain using NETCONF/YANG models.

SBIs based on YANG device models will take longer to standardize than NBIs because of the current dependencies between NMSs and their equipment, the variability of vendor support for YANG models and the immaturity of OpenConfig-based models. Telefónica does not want to take risks with critical infrastructure by deploying SBIs too early. It expects that it will complete its modeling in 2021, at which point it can start tackling its next challenge: white-box disaggregation.

2.4 A use-case-based implementation roadmap

Telefónica is taking a highly practical approach to implementing the hierarchical SDN control architecture. It has built a pipeline of 89 use cases (at the time of writing this report), which were initially recommended by local technical operational teams, and has developed a solution for each use case through a series of agile process steps: use-case definition, standardization, technical validation, development and deployment. This design process then yields a specification document, which is released to vendors for implementation. Once developed, the solutions are further validated by Telefónica to ensure that they comply with the original use case specification, and are then released into production.

2.5 Cross-industry direction to standardize the open transport SDN architecture

Telefónica has joined forces with Deutsche Telekom, MTN, Orange, Telia Company and Vodafone to standardize the open transport SDN architecture and achieve vendor-agnostic network programmability. These CSPs are working together within the TIP's OOPT project group and have launched a new workstream titled Mandatory Use Case Requirements for SDN for Transport (MUST), which is aimed at developing technical specifications for the NBIs[1] and SBIs[2] for common use cases for all of the operators. The first deliverables for the IP and optical domains will cover use cases for network provisioning, inventory, resilience, and traffic engineering.

The workstream is now organised into three sub-groups: IP, optical and microware. Throughout 2021, the sub-groups will create use case specification documents focusing on key topics such as partial optical network disaggregation, IP and optical multi-domain and multi-layer co-ordination and network slicing. The working group has released a white paper titled *Open Transport SDN Architecture Whitepaper*, which provides an in-depth explanation of the hierarchical SDN control architecture discussed here.[3]

3. Telefónica is making good progress with its iFUSION optical network disaggregation

Telefónica is disaggregating its optical network to achieve two key goals, in line with the stated objectives of the iFUSION SDN strategy discussed in section 2:

- use standard interfaces to achieve interoperability among the disaggregated optical network components, thereby avoiding vendor lock-in and enabling vendor equipment to be swapped out with minimal or no disruption
- deploy a common SDN control plane based on standard information and service models to orchestrate services across a multi-vendor optical network.

3.1 Partial disaggregation of the optical network

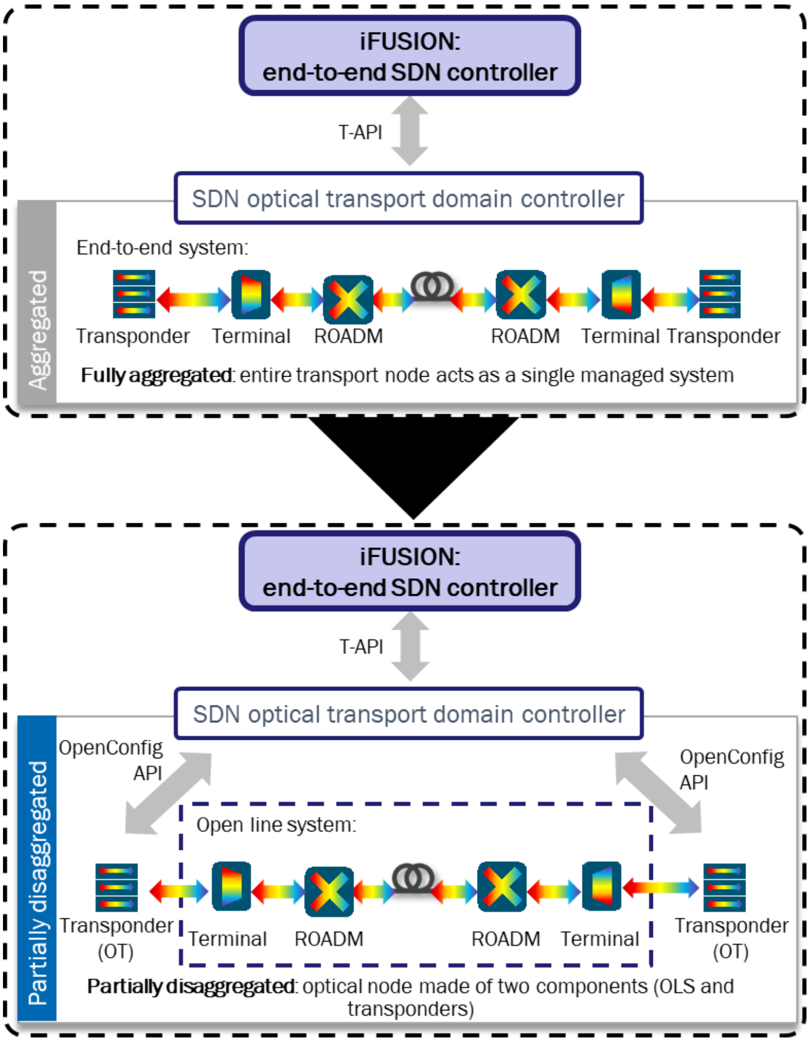
Telefónica is performing partial disaggregation of the optical network in the first stage of its iFUSION strategy (Figure 3.1). In the traditional deployment scenario, optical networks are supplied as an end-to-end closed solution, which then interfaces with the end-to-end SDN domain controller via T-API in order to automate provisioning, configuration and operation of the network domain.

1 T-API 2.1.3 for the optical domain and IETF service models for the IP domain.

2 NETCONF, YANG and OpenConfig for both the IP and optical domains.

3 Telecom Infra Project (2020), *Open Transport SDN Architecture Whitepaper*. Available at: https://cdn.brandfolder.io/D8DI15S7/at/jh6nnbb6bjvn7w7t5jbgm5n/OpenTransportArchitecture-Whitepaper_TIP_Final.pdf.

Figure 3.1: Telefónica's partial optical network disaggregation architecture



Source: Analysys Mason and Telefónica, 2020

However, in the desired partial disaggregated networks, the OTs (or transponders) are decoupled from the OLS, thereby enabling Telefónica to procure OTs and OLSs from different vendors and allowing the SDN domain controller to manage them separately. This will enable the standardization of the NBIs for OTs and OLSs independently of each other. The interface design and specifications for the partially disaggregated optical networks are as follows.

- The NBI specification for the SDN optical domain controller includes the topology abstraction and multi-layer connectivity service model requirements for T-API, the use case definitions (which include the high-level use case description), the workflow (which documents the RESTCONF API calls), the required parameters for T-API and example use cases.

- The SBI specification for managing the OTs includes the OpenConfig atomic operations on the OT (including the high-level description), the workflow (which documents the NETCONF API calls) and the parameters that are required for OpenConfig and for the operation code to be referenced. Additionally, the specifications include the NETCONF specifications and the OpenConfig modeling requirements for the platform and logical channels.

- The SDN controller specification includes the workflow description and the NBI–SBI model translation. It also includes references to the NBI and SBI specifications and the use cases for NBIs.

Telefónica is prioritizing the implementation of NBIs and the SDN optical transport domain controller; the SBI implementation will come later. The operator is operationalizing a highly curated set of T-API use cases that broadly belong to the following (non-exhaustive) categories:

- network and service discovery, and topology modelling
- provisioning across networking layers (for example, optical and dynamic service routing), taking the topology and service constraints into consideration
- hybrid inventory, including the correlation of the legacy inventory and the new inventory to drive T-API integration
- planning and maintenance, covering service modification and termination, and path computation
- alarms, notifications, and fault management based on the topology and T-API service models
- performance monitoring based on streaming telemetry.

3.2 Industry standardization of the NBI for the partially disaggregated optical network

As shown in Figure 2, Telefónica is using OpenConfig for the SBIs and T-API for the NBI. After the success of its initial implementation, Telefónica is rolling out the NBI specifications for the partially disaggregated optical network to the wider ecosystem in order to gain acceptance and achieve standardization. Telefónica is taking the following steps as part of this effort:

- release project documentation to all the relevant suppliers participating in the project
- provide input for open-source SDN controller development as part of the ONF ODTN project
- contribute to the technical specification for the OIF 2020 SDN API interoperability demo
- contribute to the TIP Disaggregated Optical Systems (DOS) as part of the specification of the management interface for RFI Phoenix.[4]

4. Telefónica Germany has deployed Blue Planet’s MDSO as the multi-vendor SDTN controller

Telefónica is deploying the hierarchical SDN architecture for its disaggregated optical network across its operational companies. This section provides details of the implementation at Telefónica Germany, and outlines the benefits achieved.

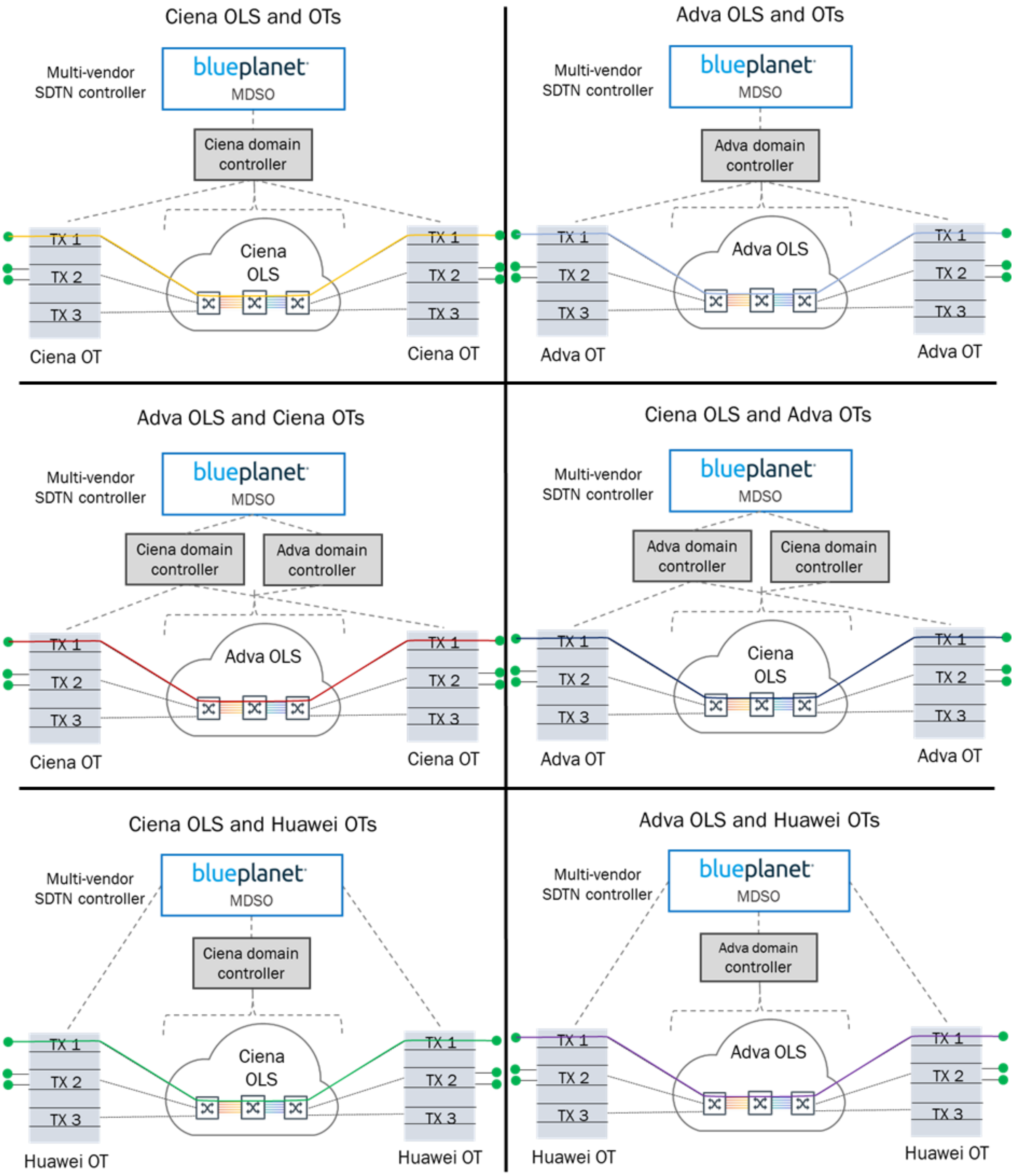
4.1 Telefónica Germany has deployed a unique architecture framework

Telefónica Germany has deployed ADVA and Ciena OLSs, and ADVA, Ciena and Huawei OTs. It has deployed Blue Planet’s MDSO as the hierarchical SDTN controller to automate the multi-vendor optical network with six different OT and OLS combinations, as depicted in Figure 4.1. Blue Planet’s MDSO uses

[4] Phoenix is on open white-box L0/L1 transponder that operators can deploy on top of/together with their existing line systems to increase the capacity of their optical networks.

standard APIs (REST, JMS, RESTCONF, NETCONF and SNMP) and network models (T-API 2.1.2 and OpenConfig) to manage the network and service lifecycle of the underlying network domains.

Figure 4.1: Telefónica Germany's deployment of Blue Planet's MDSO



Source: Telefónica, 2020

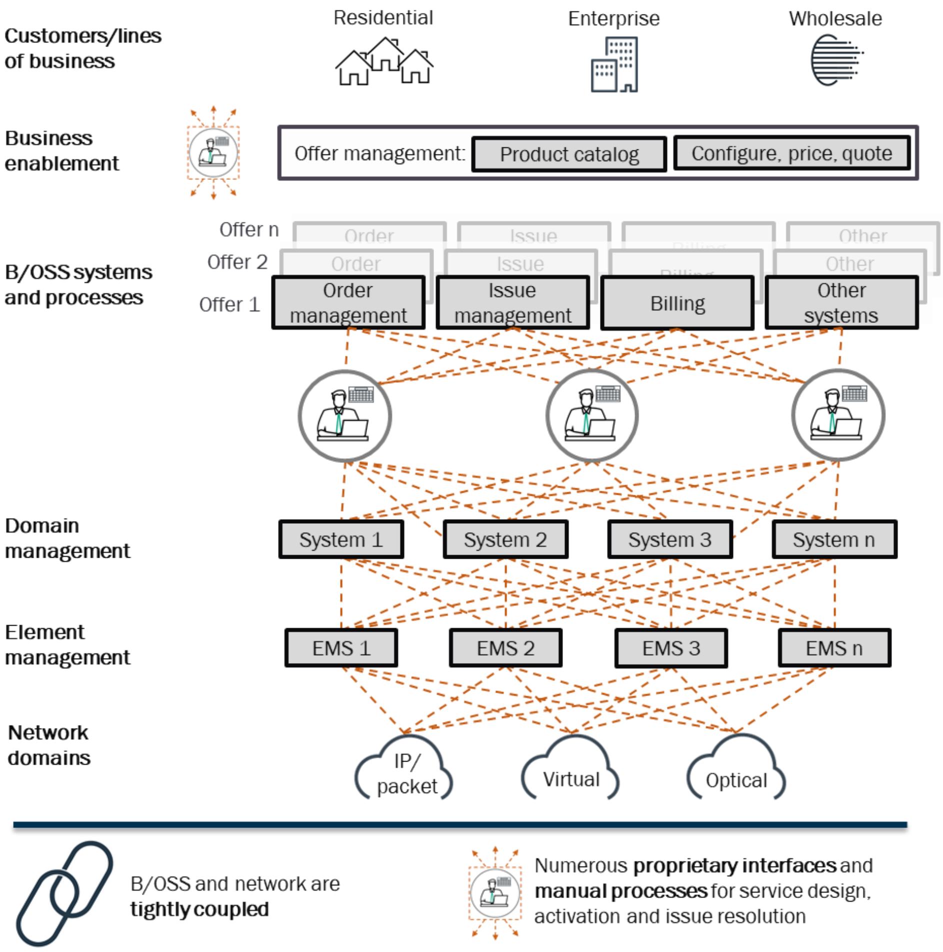
Telefónica chose to use Blue Planet's MDSO to automate the partially disaggregated multi-vendor optical network because:

- it aligned with Telefónica's vision of building SDN-enabled disaggregated networks
- it supports T-API for the NBI
- it supports open standards-based interfaces across the software stack
- it has a flexible, modular and standards-compliant solution architecture with minimal impact on the integration with higher-layer OSS and service orchestration systems
- Blue Planet won the competitive technical and commercial RFQ process.

4.2 The iFUSION deployment architecture aligns with Blue Planet's NaaS framework

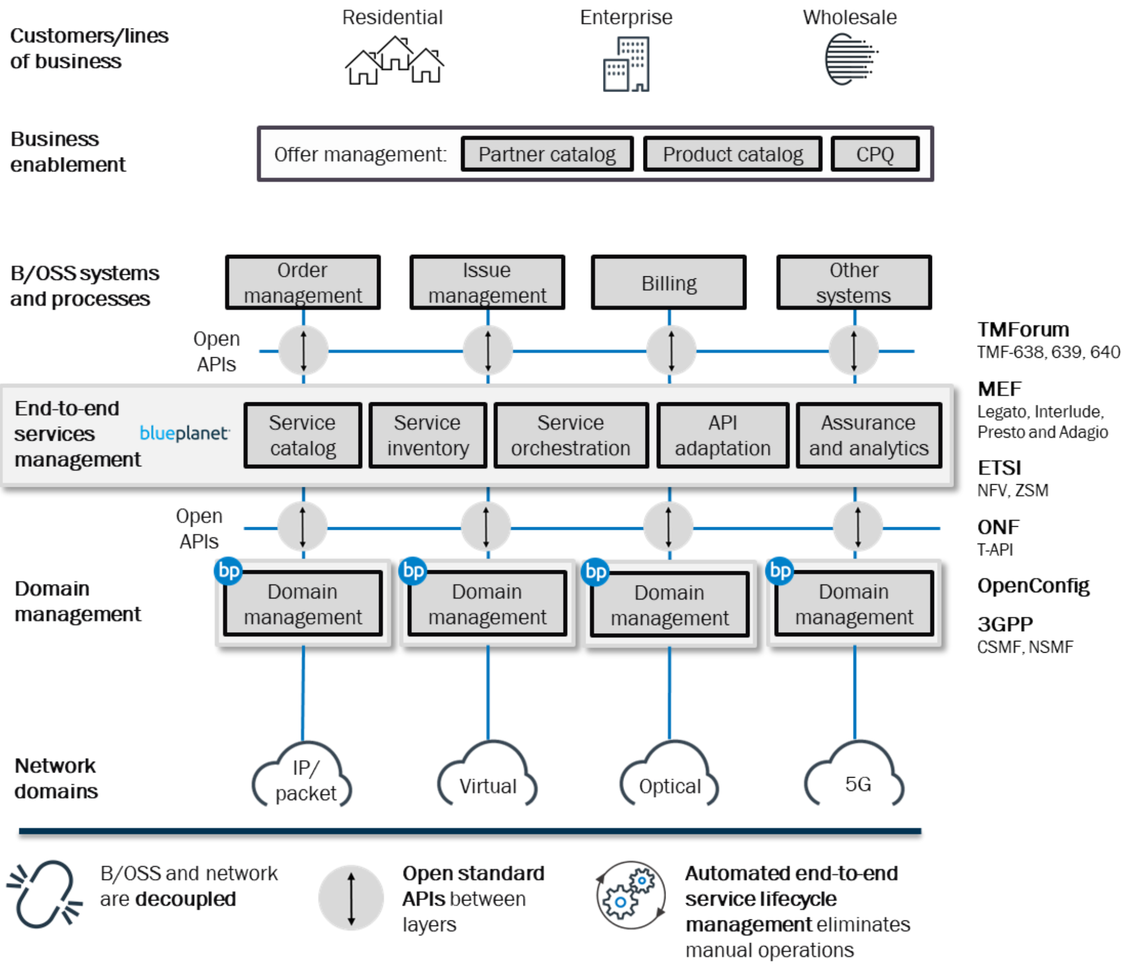
Telefónica's hierarchical SDN controller architecture (discussed in section 2.1) and the deployment architecture used at Telefónica Germany (explained in section 4.1) both align with Blue Planet's NaaS framework. Specifically, Telefónica's higher-layer multi-domain SDN controller maps to the end-to-end service management layer of Blue Planet's NaaS framework, and the multi-vendor SDN controllers of the optical, IP/MPLS and microwave domains map to Blue Planet's domain management layer, which interfaces with several lower-layer vendor-specific controllers. The NaaS framework also supports open APIs and industry standards for ease of integration and consistent communication between each layer, from the network right up to the business enablement layer. Figures 4.2 and 4.3 further illustrate the difference between the legacy operations approach and the NaaS-based approach.

Figure 4.2: Legacy operations approach with proprietary interfaces for a tightly coupled network and B/OSS



Source: Blue Planet, 2020

Figure 4.3: NaaS-based approach with an open, standards-based framework for the simplification of the OSS and network transformation



Source: Blue Planet, 2020

4.3 Telefónica Germany has used Blue Planet's MDSO in a number of use cases

Telefónica Germany prioritised five key use cases in its implementation of Blue Planet's MDSO; these are summarised in Figure 4.4. The use case prioritisation and implementation process discussed in section 2.4 was followed throughout. Telefónica is also working on technical specifications for additional use cases (such as alarm forwarding to an assurance system) that will be implemented in 2020–2021.

Figure 4.4: Blue Planet MDSO use cases

Use case	Description
Automated network discovery	Blue Planet's MDSO automatically discovers the physical and logical network resources, either through the domain-specific controllers or by connecting directly to the devices. To do this, the domain-specific controllers or the devices are first enrolled with Blue Planet's MDSO, and once enrolled, Blue Planet's MDSO uses resource adapters to perform periodic network synchronization to stay updated about the

Use case	Description
	network changes. The synchronization interval is configurable. Upon discovery, network resources are recorded within Blue Planet's MDSO on a per-domain basis. The inter-domain links are also recorded, which is used for the end-to-end service stitching functionality.
OT inventory discovery	Blue Planet's MDSO automatically discovers the OTs if the information is exposed through OpenConfig, the OTs have already been modeled in Blue Planet's MDSO and the OT has been enrolled into a domain. Blue Planet's MDSO records network element name, network element IP, card type, part number, port number and pluggable type.
Abstracted service topology management	The service topology provides the single truth of the end-to-end layer 0 and layer 1 services in the optical transport domain. The topology itself is automatically created using service stitching; this is the process of discovering and correlating individual service segments.
Service management	Blue Planet's MDSO maintains a fully up-to-date view of the end-to-end service, with the service-to-resource mapping in a dependency tree. This is performed using the automated network discovery capability when the service is created, modified or deleted. The dependency tree also provides an alarm overlay capability that is used for alarm management and troubleshooting.
Alarm management and forwarding	Blue Planet's MDSO discovers network alarms using standard APIs and displays them in the alarms and events UI. The alarm overlay on top of the topology allows the user to identify the affected services.

Source: Blue Planet and Analysys Mason, 2020

4.4 Telefónica Germany has achieved several benefits from using Blue Planet's MDSO

The iFUSION strategy and the implementation of SDN architecture for the transport network has enabled Telefónica Germany to:

- deploy and operationalize a cost-efficient and agile programmable optical transport network
- create a unified management and control plane for its multi-vendor optical network, thereby enabling network programmability and automation
- rationalize multiple bespoke NBIs from the optical vendor domains into a single standardized API and network model based on T-API
- decouple and abstract the underlying network from the higher-layer OSS and orchestration systems, thereby allowing it to simplify OSS integrations, increase OSS agility and accelerate automation
- create an implementation blueprint and best practices playbook based on the hierarchical SDN controller architecture, thereby allowing it to accelerate network disaggregation, network automation and service agility across its other operational companies
- take control of its destiny, increase vendor competition and drive vendor solutions to comply with the architecture and specifications defined by the operator
- drive cross-industry consensus and collaboration to standardize the open transport SDN architecture and associated APIs (such as TIP OOPT discussed in section 2.5).

Blue Planet's MDSO has been pivotal in enabling Telefónica to execute its transport SDN strategy, as evidenced by the successful implementation at Telefónica Germany for the partially disaggregated optical transport network. As a result of this implementation, Telefónica has been able to:

- implement key use cases to automate network discovery, topology management and service management, resulting in a reduced reliance on manual operations and fewer human errors
- introduce TAPI as single NBI and reduce the number of NBIs by more than 70% as a result.

5. About the author

Anil Rao (Principal Analyst) is the lead analyst on network and service automation research that includes the Network Automation and Orchestration, Automated Assurance and Service Design and Orchestration research programmes, covering a broad range of topics on the existing and new-age operational systems that will power operators' digital transformations. His main areas of focus include service creation, provisioning and service operations in NFV/SDN-based networks, 5G, IoT and edge clouds; the use of analytics, ML and AI to increase operations efficiency and agility; and the broader imperatives around operations automation and zero touch networks. Anil also works with clients on a range of consulting engagements such as strategy assessment and advisory, market sizing, competitive analysis and market positioning, and marketing support through thought leadership collateral.

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