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Multi-Vendor Automation for Established IP Networks:
A Telefónica Case Study

A custom Heavy Reading report produced for Cisco Systems

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1. INTRODUCTION

Telefónica is the one of the leading telecom operators by revenue and customers. Like its global peers, Telefónica faces tremendous challenges adapting its IP networks for the future of the internet. The next-generation internet will be characterized by rapid traffic growth, the agility requirements of cloud computing, and unprecedented performance demands set by revolutionary new applications enabled by 5G, artificial intelligence, and other major 21st century advances. For network operators like Telefónica, automation will be fundamental for survival.

This Heavy Reading report presents a case study of how Telefónica is automating its IP network to improve network robustness and reliability and automate its disaster recovery. The telecom operator calls the automation initiative R³ (R Cubed), and its ultimate goal is an automated, intent-based IP network. While Telefónica uses several IP router suppliers, the operator selected the Cisco Crosswork Network Automation software family as the R³ foundation. This report details the reasoning behind Telefónica's choices and the benefits that the operator expects to achieve through this automation initiative.

2. TELEFÓNICA FUSION IP OVERVIEW

Telefónica launched its Fusion IP transport network modernization initiative in 2016. The project's goal was to converge Telefónica's multiple service-specific transport networks into a common IP and optical network that reduces complexity, increases operational agility with network automation, and enables the operator to design new services for its customers. The common IP network covers mobile, corporate, and residential services and thus represents a truly converged infrastructure. Key Fusion IP attributes include the following:

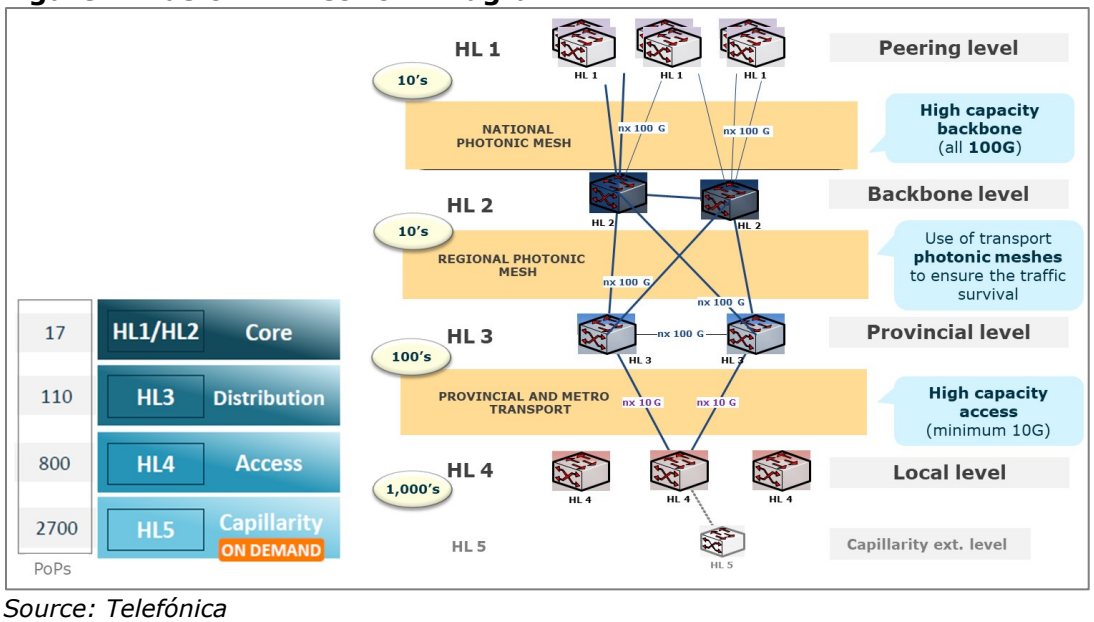
- An end-to-end Multiprotocol Label Switching (MPLS) network that extends from the access to the core.
- All IP functions collapsed in multi-service platforms, as opposed to dedicated platforms per function.
- Highly distributed design with the IP edge functions running in the IP layer.

Fusion IP was designed with the capacity growth requirements of the next 10 years in mind. Telefónica developed the network to be flexible and capable of incorporating 5G requirements for telemetry, synchronization, and advanced data plane technologies for 5G, such as network slicing.

The Fusion IP architecture collapses the IP network into four layers (termed HL [Hierarchical Layer] by the operator), as well as a fifth one for small populations, covering the core/ backbone network and extending down through the access layer. It also represents a complete redesign of the IP network, as Telefónica migrated from legacy platforms to the new network elements provided by new vendors. Following a request for proposal (RFP) process, two IP routing suppliers were selected for Spain's next-generation IP network: Juniper and Nokia.

Figure 1 provides a high level overview of the Fusion IP network.

Figure 1: Fusion IP Network Diagram



Source: Telefónica

Fusion IP was initially rolled out in Telefónica's home country of Spain. Due to its success, the architecture has been exported to other Telefónica regions. Most recently, in October 2019, the operator announced completion of the first phase of services to the Telefónica UK Fusion IP Network. It is also deploying the model in Brazil, in its International Network, and throughout its Latin American region (Colombia, Chile, Argentina, Peru, and recently, Ecuador).

3. AUTOMATING IP WITH R³

Even with a highly scalable Fusion IP network, human touchpoints in provisioning, monitoring, and maintaining the IP network became the pain points, according to Telefónica executives. Human involvement in processes slows them down and, by definition, breaks the chain of automation. But equally significant (or perhaps even more significant), human touchpoints inevitably lead to mistakes, and these mistakes can lead to significant network shutdowns. Thus, minimizing human interaction with the network is critical for improving network reliability and resiliency.

Telefónica recently set about the next phase of its IP evolution, focusing on creating an autonomous network that can collect telemetry at scale, adapt to network conditions in real time, and make many decisions without human intervention. Automation within a multi-vendor IP environment was also critical. These automation goals center on improving network robustness, reliability, and automated disaster recovery; therefore, Telefónica named the new initiative R³ (R Cubed).

R³ is built around a set of five major automation functions (called "functional blocks" in Telefónica terminology), each with its own set of potential use cases and enabling technologies. **Figure 2** provides an overview of the major R³ functions.

Figure 2: Functional Blocks, Use Cases, and Enabling Technologies

Functional Block Description	Potential Use Cases	Technologies
(BF1) Configuration abstraction and orchestration	• Secure configuration in non-automated environments • Abstract northbound interfaces to third-party applications • Transactional configuration toward network elements • Audit of provisioned configurations • Inventory of provisioned configurations	NETCONF/YANG
(BF2) Data collection	• Network management with pseudo real-time granularity • Inventory of network elements	Open-source tools for telemetry
(BF3) Planning tools	• Real-time traffic matrix (VPN incl.) • "What if" traffic simulations • Real-time capacity management • Verification of service status after network configurations • Logical resource monitoring	NetFlow, BGP-LS, FOS telemetry, SNMP, show commands (NETCONF), configuration analysis

Functional Block Description	Potential Use Cases	Technologies
(BF4) PCE server	• Real-time monitoring of routing status; status change alarms and anomaly detection • Postmortem analysis of routing incidents • Monitoring and service alarms based on the characterization of service flows (service-mapping, flow mapping) • Network management based on service flow characterization	BGP-LS, PCEP, SRv6/EVPN
(BF5) Advanced performance and fault monitoring	• Use cases to be determined	Open-source multi-layer frameworks such as TensorFlow (Google), Deep Scalable Sparse Tensor Network Engine (Amazon)

Source: Telefónica

While Telefónica's long-term goal is an intent-based, closed-loop automated IP network, the operator is introducing automation in phases. The short-term goal focuses on inventory and telemetry. In order to make the network assured and resilient, a single, complete, and accurate inventory and network data repository is essential. Telefónica seeks to create an accurate view of inventory with data pulled directly from network elements in real time or near real time. The operator also aims to make that inventory and operational data available for the higher order automation functions such as predictive analytics, proactive health alerts and remediation, and automated provisioning or restoration. An accurate and unified inventory and data collection system is the foundation on which the rest of the IP network automation strategy rests.

Telefónica plans to complete the first phase in 2020. After some internal debate as to the best way forward, the operator has decided to use Cisco's Network Services Orchestrator (NSO) as the unified physical and logical assets inventory system. It will also use Cisco's Crosswork Data Gateway for consistent telemetry across all of its IP network applications. Telefónica executives recognize that NSO was not designed to fulfill the role of traditional inventory systems but have concluded that the orchestrator meets their requirements of providing an accurate and unified view of the network. NSO provides a single platform for managing the entire life cycle of service and configuration operations toward the network. As such, it offers a real-time view of the actual state of the network, including an inventory of all provisioned service instances.

Cisco's Crosswork Data Gateway solves a foundational requirement to consistently collect data across the large IP network. The ability to collect real-time data from multi-vendor equipment and offload telemetry for increased scale is critical.

Beyond the inventory and telemetry consolidation, Telefónica is currently developing use cases for each of the functional blocks (as detailed in **Figure 2**). Work is at various stages across use cases, with some having begun in 2019, some scheduled for 2020, and others planned for 2021.

3.1 Multi-Vendor Automation Challenges

Telefónica has faced several challenges along the way. Some of them have been resolved, but others remain as the operator continues to work on this project. Below are the primary technical challenges cited by the operator:

- **Automation of a multi-vendor network:** The Fusion IP network has two main router suppliers, Juniper and Nokia, so orchestrating and managing across them all was a difficult task. Although Cisco was not one its chosen hardware suppliers, in the end, Telefónica selected the vendor for its software expertise, confident that NSO and Crosswork can handle the multi-vendor network.
- **Common feature sets:** This point also relates to the Fusion IP multi-vendor environment. To have a unified network, the operator requires a common set of features across its routing hardware. Yet, different vendors offer different features, and new feature releases do not coincide. Today, commonality across Resource Reservation Protocol for traffic engineering (RSVP-TE) functions is required. As Telefónica adopts segment routing (SR), commonality across SR features will be required. This is an ongoing challenge.
- **Increased reliance on the software innovation pace:** The Fusion IP router network is multi-vendor, but the orchestration and automation functions are based on Cisco. Thus, Telefónica's automation strategy will ultimately evolve at the same pace as Cisco's releases. Innovations in cloud-based automation applications will help increase the pace.
- **Complementary orchestration functions:** NSO provides many orchestration functions for automating the multi-vendor network, but it does not come with all the capabilities required by Telefónica. One such function is a workflow manager for operational processes and data enrichment. NSO can be integrated with different workflow management systems, and Telefónica's team is working to complement NSO to fulfill the workflow automation requirements.

Beyond technical challenges, Telefónica cites two important organizational challenges in automation:

- **Impacts on workforce:** The team is conscious that automation affects workforce deeply, including headcount. In choosing where to apply automation, the operator needs to ensure that it selects the areas that will produce the greatest benefits and yield the highest savings. Automating tasks for the sake of automation must be avoided. The increasing scale of IP networks and the new mandates for speed and agility mean that certain tasks will be possible only with the new software tools.
- **Changing skill sets:** Like most Tier 1 network operators, staff is dominated by network engineering roles. Automation requires new skills in software, including Python, data analytics, and DevOps. Telefónica is working to train staff on the new skills but notes that employees must be open to new methods and new technologies for reskilling to be effective. Hiring outside software experts is also an option, but outside hires may not have the required networking expertise.

4. CISCO CROSSWORK NETWORK AUTOMATION

The R³ RFP process began in late 2018 and Telefónica awarded the work to Cisco as the sole supplier in 1Q 2019. The key products include the Cisco Crosswork Network Automation family of software products aimed at network automation, multi-vendor orchestration, data collection, machine learning, network insights and health, and closed-loop actions. The Crosswork family consists of a modular architecture and provides several distinct products (cutting across a number of Cisco software acquisitions, as well as internal development) that solve for specific use cases that can also be integrated to achieve closed-loop automation. Below are descriptions of the Crosswork products that are most significant to Telefónica across the entire operational life cycle. Cisco continues to grow Crosswork, both on-premises and in the cloud as new use cases are defined:

- **Network Services Orchestrator (NSO):** NSO came to Cisco through the 2014 acquisition of multi-vendor orchestration pioneer Tail-f Systems. NSO is a YANG model-driven platform for automating provisioning, monitoring, and managing applications and services across multi-vendor networks. It accomplishes this goal by abstracting the services from the underlying physical and virtual network and uses northbound APIs (governing interaction between NSO and the operations and business support systems above) and southbound APIs (governing interactions between NSO and network elements below) to automate commands and processes. Thus, NSO provides a bridge between automation and orchestration frameworks and the underlying physical and virtual infrastructure. Cisco has developed network element drivers to mediate access to both Cisco and more than 170 non-Cisco operating systems.
- **Crosswork Data Gateway:** This product is a model-driven data collection software that enables coordinated and optimized real-time data collection from multiprotocol capable devices. The Data Gateway enables service providers to quickly deploy collectors without imposing unnecessary strain on network elements. It also provides consistent, central northbound interface through a data bus architecture to applications consuming the network data for various analytics functions, such as health, performance, or fault monitoring. Southbound collectors include command-line interface (CLI), Simple Network Management Protocol (SNMP), and model-driven telemetry.
- **WAN Automation Engine (WAE):** Cisco WAE is a planning tool that provides a cross-sectional view of traffic, topology, and equipment state across vendors. It takes advantage of a predictive model that performs "what if" analyses of failure impacts. WAE Planning evolved from the Cisco MATE software suite, which has been used in service provider networks for more than 10 years. Cisco WAE Automation builds on top of WAE Planning. It combines data collection, modeling, and predictive analytics into an extensible API-based configuration platform.
- **Crosswork Health Insights:** This is a network health application that performs real-time monitoring, alerting, and troubleshooting based on key performance indicators (KPIs) defined by the operator. The application enables programmable monitoring and analytics, allowing for service providers to proactively address changes and events in the network. For operations teams, this alerting can drastically reduce time and cost caused by network conditions that may be planned or unplanned.

- **Crosswork Optimization Engine:** This product enables operators to define and deploy transport software-defined networking (SDN) capabilities such as path computation and optimization using their own metrics or policies. Optimization Engine will deploy the defined network policy or intent and continuously monitor, track, and react to maintain the original intent. Key functions include topology auto-discovery, closed-loop feedback, dynamic service-level agreement (SLA) management, real-time network visibility, and SR policy life cycle management. Optimization Engine is tightly coupled with Cisco's SR-Path Computation Element (SR-PCE) and SR technologies.
- **Crosswork Change Automation:** This application is integrated with other components of the architecture, such as Health Insights and NSO, and provides an open programmable environment to automate closed-loop network changes for remediation or optimization of the network. This can include performing network status checks, triggering changes in device configurations or service configurations, or performing a defined set of maintenance window work orders.
- **Crosswork Network Insights:** This cloud-based application provides analysis, visualization, and alerting on events in the Border Gateway Protocol (BGP) network. It works by aggregating global and local routing information and rapidly identifies the source of network anomalies based on a consensus of the routing databases. The cause could be configuration errors or malicious intent, which can bring down entire networks. Network Insights is the first cloud-based product of many for service providers as part of Cisco's Crosswork Cloud to deliver automation outcomes faster.
- **Crosswork Situation Manager:** Supported by machine learning, this application effectively filters out noise from redundant events generated by the network into a manageable set. It correlates these events from multiple sources into situations and offers proactive insights so operation teams can focus on the high priority issues. Furthermore, Situation Manager initiates cross-team collaboration to resolve incidents using knowledge capture-and-reuse algorithms.

Figure 3 maps the specific Cisco Crosswork products to Telefónica's R³ functional blocks.

Figure 3: Cisco Products for Telefónica R³ Functional Blocks

Relevant Cisco Crosswork Products	Telefónica R³ Functional Block
Network Services Orchestrator (NSO)	Configuration abstraction and orchestration
Crosswork Data Gateway	Data collection
WAN Automation Engine	Planning tools
SR-PCE and Crosswork Optimization Engine	PCE server
Crosswork Health Insights, Change Automation, Network Insights, Situation Manager	Advanced performance and fault monitoring

Sources: Telefónica, Cisco

5. FUTURE DIRECTIONS

Priority number one is addressing network disruption through automated IP network resiliency, reliability, and disaster recovery. Telefónica is heading toward a self-healing and auto-diagnosis network. Although it will take time, steps are being taken to define new use cases that will be refined and introduced over the project's multi-year span. Opex savings also represent an important goal and a natural fit for automation. Avoiding and reducing network outages eliminates the operational costs associated with technician dispatches to fix them. Eliminating manual functions anywhere in the network also eliminates the operational costs associated with those functions – whether it is provisioning, troubleshooting, monitoring, or remediating. (Freed from these tasks, employees can focus time elsewhere.) Telefónica will continue to look for automation use cases that deliver the greatest opex benefits.

The promise of automation, however, extends beyond greater network reliability and increased opex savings to include revenue generation. For Telefónica, automation technologies will prove an important tool for driving growth, but the specific use cases must still be developed.

Global expansion is another future direction for Fusion IP and automation. Telefónica has a global program for IP and optical networks control plane transformation that is being deployed in Fusion IP-like projects. The goal is to improve the automation and flexibility of connectivity services, with a multi-domain and multi-layer approach via standardized northbound and southbound interfaces.

Telefónica Spain is one of the leading operations for IP automation. The successes and best practices that come from the Spain project will be introduced into other regions and Telefónica groups over time, just as the operator has done with the Fusion IP network. Additionally, the operator believes that the flexibility of the Cisco tools will permit a smooth transition toward new vendor-agnostic standard interfaces in the future.

Lastly, Cisco's planning tools cover both IP and optical layers. Telefónica can use these tools to develop additional and more sophisticated use cases, such as multi-layer coordination – provided that ROI requirements are met.

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