WHITEPAPER

# The Ultimate Guide to Automated, Multi-Domain Service Orchestration

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# Table of Contents

# Executive Summary

At long last communications service providers (CSPs) are escaping the restraints that have impeded ARPU growth in an era of soaring capital and operations costs.

In growing numbers worldwide, network operators are discovering it's now possible to orchestrate accelerated development and delivery of virtually any type of consumer or business service across fixed and mobile infrastructures free of vendor lock-in or cookie-cutter conformity to pre-baked solutions. This is the new operations management environment enabled by the ground-breaking Xtreme multi-network orchestration platform introduced by DZS.

CSPs are leveraging Xtreme's standards-based network-element (NE) abstraction and workflow modeling architecture to support highly automated vendor-agnostic approaches to providing a new generation of carrier-grade services at far lower total costs of ownership (TCO) than once seemed possible. And they're offering these services with Xtreme support for logical integration of fixed and mobile facilities at far greater levels of reliability, quality, security, and personalized convenience than customers can get from cloud-based super-scalers.

This is a paradigm shift away from the long-standing trend in telecommunications where CSPs pour ever more capital into higher network capacity and advanced functionalities as their customers consume a potpourri of cloud-delivered third-party services with no revenue-bearing benefits to operators. For far too long, the scope and quality of user experiences have been at the mercy of DIY fragmentation fostered by app providers who have no control over network infrastructure.

Under those conditions, whatever CSPs gain from satisfying insatiable demand for more bandwidth is offset by the costs of supplying that bandwidth as they cope with customer dissatisfaction over quality-of-service issues that are beyond their control. The story of where this trend leads is well documented.

As the change-management firm Accenture notes in a recent report, the pressure on network operators "has never been greater. CAPEX & OPEX are on the rise even as traditional revenue streams only grow modestly."[i] The company cites a 27-country survey by researcher Analysis Mason that found the CSP average revenue per user (ARPU) dropped by 37% over the past ten years. Omdia, another research firm, projects that, without significant changes in business models, average ARPU across mobile and broadband services worldwide could fall by another 4.2% between 2022 and 2027.[ii]

Thankfully, there's no reason to expect this trend to continue now that CSPs can leverage advances in cloud technology introduced by DZS. Capitalizing on standards-based interoperability along with an innovative plug-in approach to integrations with proprietary systems, Xtreme has bridged the carrier and superscale domains to open an automated life-cycle management path to profitability.

## Key Take-Aways

- **CSPs Require Agile New Service Creation:** Despite rising CAPEX & OPEX due to investments in higher network capacity and the need to support cloud-delivered third-party services, CSPs are facing unprecedented challenges in rapidly introducing new services and raising ARPU.
- **DZS Xtreme Automation & Orchestration Accelerates the Launch of Lucrative New Services:** With automated, multi-domain life-cycle management, Xtreme enables zero-touch orchestration of service-specific aggregations of components and rapid new service creation that tap into multi-billion dollar global markets.
- **Proven Results with Tier 1 CSPs Globally:** Major CSPs in North America and Europe have leveraged Xtreme as an enabler for a Continuous Deployment approach to developing, launching, and managing virtualized services, reducing service delivery times from months to days and accelerating new features and services onboarding by 300%-400%.

The platform enables zero-touch orchestration of service-specific aggregations of components housed in transport, access, and mobile edge facilities by leveraging models of the workflows on which industry standards are based together with algorithmic abstractions of the NEs in every domain. In addition, the architecture supports standards-compliant approaches to using SDN technology whenever called for in consort with reliance on any functionalities that are assigned for activation through any combination of NFV technologies at any cloud location or hybrid mix of locations.

Critically, DZS has complemented this multi-domain flexibility in service management with innovations that provide internal and third-party developers the support they need to respond quickly to demand for new services. By lowering coding workloads with far less need for professional services assistance, Xtreme makes it possible to reduce time-to-market, cut OPEX, and expand revenues with services tailored to the specific needs of even the smallest user groups and individual customers.

As a result, CSPs of every description, from giant incumbents and regional independents to electric cooperatives and municipally run operations, are breaking out of the vendor-centric silos imposed by traditional approaches to operations. No matter where they're starting from on what promises to be a long-lasting journey, they are positioning themselves to holistically coordinate the use of best-of-breed network components end-to-end to satisfy consumer and business market demand wherever it leads.

This whitepaper is one of two DZS is providing to describe the full scope of the technical advances it is providing to strengthen CSP outcomes as the world transitions to new levels of persistent immersive engagement with network-delivered applications. Along with exploring how this transition is impacting multiple market sectors, the whitepaper titled "The Cloud-Orchestrated Path to CSP Ascendancy in the Emerging Metaverse" explains the roles the DZS Expresse and CloudCheck software solutions play in enabling CSPs to take a customer-centric approach to meeting quality-of-experience and other service performance requirements across all components of their external and on-premises infrastructures.

Here our focus is on the many aspects of the Xtreme multidomain orchestration and automation solution that allow CSPs to orchestrate service development and operations across all transport, cloud, mobile, and access edge points.
This marks the first time this level of virtualized service automation can be implemented in a mixed vendor environment.

## In this document:

- **Part 1** opens the discussion with a candid look at the market and telecom business trends that underlie the urgent need for a new vendor-agnostic approach to CSP operations.
- **Part 2** looks at the challenges that must be met and offers some examples of what could be accomplished with such an approach.
- **Part 3** concludes the discussion with an in-depth exploration of the Xtreme platform.

# Part 1 The Results-Driven CSP Change Agenda

The fundamental challenge every CSP faces is to do whatever is necessary to keep pace with market demand at this historic moment of transition in digital commerce. Amid an explosion in technological advances from artificial intelligence to extended reality to the core computing foundation that makes everything tick, the world is headed to a scale of engagement in network applications and services far beyond anything yet seen.

The stakes couldn't be higher for the providers of the conduits connecting everybody and everything in the digital world. As McKinsey & Co. notes in a recent telecom industry report, while CSPs have gone through many transformations in the past, "The next wave of change for operators is more fundamental in nature. The telco landscape of the next decade will be shaped by the extent to which today's leaders can recognize the magnitude of change that is already under way – and act with speed and conviction to truly reimagine how their organizations can thrive, front and center, in this new reality."[iii]

## The Long-Term Focus on Expanding Network Capacity and Reach

The telecom industry is already caught up in keeping pace with this transformation, as evidenced by an unprecedented level of spending on network advancement. In 2021, the industry's global CAPEX hit record levels, with estimates ranging somewhere between $304.2 billion, as registered by IDC,[iv] and the $326 billion reported by ResearchandMarkets.[v]

According to a recent ITU report, the telecommunications industry was able to accommodate a 30% increase in internet usage between 2020 and 2021.[vi] As of 2021, the ITU said, there were 4.9 billion internet users representing 63% of the world's population compared to 2.2 billion equating to 31% of the population ten years earlier.

Demand for ever more bandwidth has been a big driver behind this spending. Globally, the average fixed download rate hit 67.25 Mbps in 2022 while the mobile rate was calculated at 30.78 Mbps, according to Statista.[vii] These averages were up by margins of 46.5% and 133%, respectively, over the numbers registered four years earlier by Cisco Systems.[viii]

With the onset of 5G, mobile broadband rates are rapidly closing the gap with fixed broadband amid continued dominance of mobile as the primary mode of internet connectivity, now accounting for nearly 60% of internet traffic, according to Statcounter.[ix] However, mobile broadband performance is increasingly dependent upon a robust wireline infrastructure, and converged mobile and wireline experiences are becoming more commonplace. Additionally, fixed broadband speeds and capacity are on the rise driven by new technologies and unprecedented government broadband stimulus programs, and fixed wireless access (FWA) is also helping to bridge the digital divide

By 2030 the number of fixed broadband subscribers worldwide will total 1.6 billion, marking an 18% increase over the 1.35 million total registered in 2022, according to researcher Point Topic.[x] Currently, the share attributable to FWA is about 7% on its way to 11% by 2026, based on statistics reported by Deloitte.[xi]

Another perspective on what's in store over the next few years comes from Transforma Insights. The researcher projects the number of connected devices in use worldwide, including everything from connected IoT gadgets and smartphones to smart TVs, will increase at an annual rate of 12% to 29.4 billion by 2030 compared to 11.3 billion in 2021.[xii]

## The Market Shift to Unmanaged Network Services

The past decade of aggressive spending on network expansion has been accompanied by the historic market shift from network-managed to cloud-based internet services. The biggest and most immediate impact came from OTT video services as media players and dongles from the likes of Roku and Amazon followed by a new generation of smart connected TVs, opened the floodgates to a stampede of SVOD and AVOD providers. By all accounts this trend is here to stay (see Figure 1).

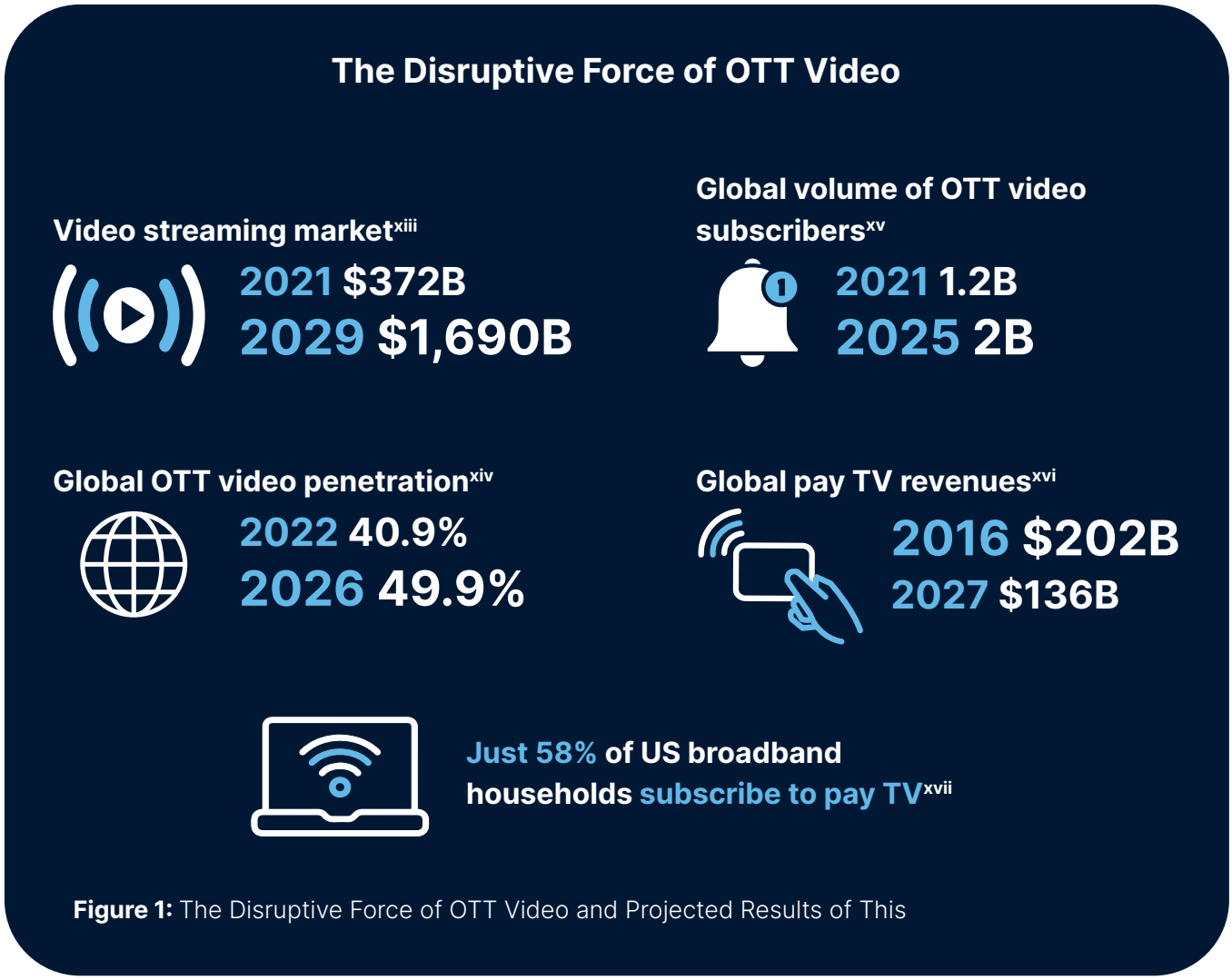



**Figure 1:** The Disruptive Force of OTT Video and Projected Results of This

Meanwhile, the anticipation in telecommunications industry circles that smart-home services would be a major opportunity for CSPs gave way to the smart home OTT revolution. The upshot has been a market enabled by CSPs' broadband networks and WiFi gateways that's driven by smart hubs and piecemeal retail purchases of smart-home elements such as smart locks, video doorbells, surveillance cameras, and appliances like smart washing machines and refrigerators.

More broadly, the cloud-based IoT solutions and services market encompassing industrial, health care, transport and other sectors as well as the consumer and small business markets has become a major source of revenue beyond the reach of CSPs. Precedence Research projects revenues flowing to super-scalers and other suppliers in this market will grow from $232.59 billion in 2022 to $748.57 billion in 2030.[xviii]

As reflected in this and other reports issued by Precedence Research, growth in both the Media & Entertainment (M&E) OTT and cloud IoT markets would far outstrip the rate of broadband revenue gains registered by CSPs under current market patterns (see Figure 2).

**Growth Rates in OTT, IoT & Broadband Access Markets**

| OTT Video[xix] | | | IoT All Market Segments | | | Broadband Services | | |
|---|---|---|---|---|---|---|---|---|
| 2022 | 2030 | CAGR | 2022 | 2030 | CAGR | 2022 | 2030 | CAGR[xx] |
| $190.3B | $1241.5B | 26.42% | $232.6B | $743.6B | 15.64% | $409.2B | $748.6B | 7.8% |

**Figure 2** Source: Precedence Research[xxviii, xxix, xxx]

## A Persistently Clouded ROI Outlook

Such outlooks explain why CSP business models that largely depend on ARPU from access fees are under scrutiny in the investment community. In a recent blog, the Kearny consultancy notes that CSPs' shareholder returns have underperformed industrial and other sectors by substantial margins over the past several years, averaging 20%-30% growth compared to 95% in the case of industrials.[xxi] Citing data produced by Capital IQ, Kearny says average return on capital investment (ROIC) in the telecom industry has actually dropped by more than 25% over the past ten years.

The current economic climate isn't helping. Bain & Co. recently issued an advisory projecting inflation would take three to five percentage points off telecom EBIDTA margins over the next two years.[xxii] As Bain notes, this trend can be mitigated to some extent by price increases, but inflation aside, the industry's larger challenge centers on what McKinsey in the previously referenced report calls "business model disruption."

"Over the past decade," McKinsey says, "telcos have been under continuous pressure as their traditional value pools have gradually eroded and new growth horizons have proven elusive, driving return on investment capital (ROIC) ever closer to weighted average cost of capital (WACC)."

McKinsey notes that business-model disruptions driven by technologies like AI, big data, video streaming, and IoT redefined service-delivery and value-capture models in favor of more adroit competitors. The result, as noted here in the Executive Summary, was a 37% drop in average CSP ARPU over the past ten years.

# Part 2 The Explosion in New Services & Business Models

The question now is, what can CSPs do to drive the ARPU increases that are essential to healthy returns on their investments? The good news is their network investments have brought them to a point where a much more expansive approach to ARPU growth is readily at hand.

That's because, along with spending on network capacity and wider reach, CSPs have invested heavily in the cloud and distributed edge technologies essential to supporting a new generation of services, especially when it comes to cellular facility upgrades to 5G. As noted in the previously cited ResearchAndMarkets report, 5G was a major contributor to a 10% jump in CAPEX between 2020 and 2021.

At the same time, the surge in capital spending has been complemented by major progress toward agreement on open standards designed to enable interoperability of network hardware, software and cloud virtualization technologies through initiatives backed by organizations like the Broadband Forum, IETF, TMF Forum, ETSI, 3GPP. GSMA, ONF, MEF, and the WiFi Alliance.

> **"5G was a major contributor to a 10% jump in CAPEX between 2020 and 2021."**

## Consensus on Eliminating Impediments to Transformation

But operators have been unable to transcend proprietary silos in order to leverage all this technology with the service-accelerated, cross-platform versatility essential to driving ARPU and lowering TCO. Even when there's support within these silos for more cost-effective use of products through automation, there's a substantial amount of coding and supplier assistance involved with implementation of automated processes. And, too often, the automation is built on a per-use case basis with little support for reusability.

Such limitations have set the stage for what must come next to enable CSPs to unleash the full potential of what's been achieved through intensive spending, innovation, and collaboration. The industry needs a solution that will enable orchestrated use of all network assets free of supplier lock-in with much faster use-case-specific responses to market demands. This must be done at lower total cost of ownership (TCO) while supporting services that meet quality-of-experience (QoE) expectations with five 9s consistency at all points of connectivity.

In other words, operators need to be able to deliver cloud-based services with the alacrity of hyper-scalers but at carrier-grade levels of performance. They need a vendor-neutral solution that supports simplicity of service design, integration, and deployment with design reusability across multiple use cases, infrastructures, and clouds. Every step in the service life cycle, from onboarding new equipment and new software, through testing and deployment, to operations, administration, and management, needs to be executed efficiently with a high degree of automation.

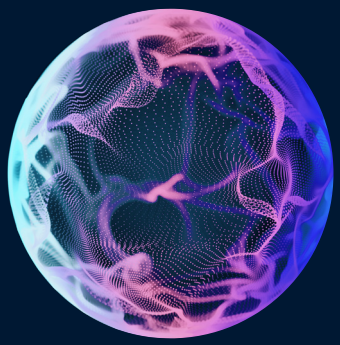
There's broad consensus on these goals. When CSP executives attending the annual DSP World Forum in 2022 were asked what they want most from an open-vendor system, two responses were chosen by 62% of respondents, one calling for reductions in TCO, the other citing accelerated time-to-market for new functions and services.

Other noteworthy responses included guaranteed interoperability (51%), greater choice of suppliers (44%), and a faster route from R&D to commercialization (40%). Taken together, these responses suggest the dominant goal to be realized from all that's been accomplished is to do a better, more cost-effective job of giving customers what they want.

And no wonder. At the end of the day, this is the key to the competitive successes that are essential to driving higher ROI.

## A World of New Opportunity

There's a lot less risk associated with aspiring to be the go-to source for any service than was once the case. In this new era, the opportunity isn't solely focused on go-it-alone approaches to mounting value-added services in competition with super-scalers and other cloud providers. It also entails capturing revenues in partnerships with such providers by supplying support for better user experiences than they can deliver on their own.



## Consumer Service Innovations & Partnerships

Consider, for example, the ARPU implications for CSPs who could ensure that subscribers to online multiplayer gaming services, now rivaling traditional entertainment in popularity, always have the QoE they're looking for no matter what devices they're using or where they are. Indeed, the flexibility to dynamically allocate more bandwidth and lower latencies on a per-subscriber basis would create a new environment for game developers to build competitive advantage where far more compelling levels of graphics richness and functionality would no longer be out of reach.

Moreover, with the flexibility to instantly combine multiple functionalities relevant to any particular use case, a CSP providing this kind of support with gaming services could also include a user-controlled option to implement parental controls over who has access to various kinds of games and when they can engage in game play. Such premium experience models can be applied to virtually any consumer service, not only in cases involving dynamic bandwidth and latency performance or application of parental controls but also with dynamic allocation of functionalities appropriate to any other approach to enhancing service value.

Just some of the possibilities include value-add initiatives benefiting potential partners as well as end users related to:

- Generating higher levels of service security.
- Fostering greater user engagement and better quality assurance through the sharing of data emanating from all end points.
- Improving addressable ad performance through more accurate and relevant placements in programmatic as well as sales.
- Coordinating the many functionalities across all network domains that are essential to fulfilling the mass-market aspirations of developers in the augmented-, virtual- and mixed-reality sectors.

## Examples of Possibilities in Other Market Sectors

The same types of ARPU-increasing possibilities apply when it comes to the vast range of services transforming operations across every other segment of the connected landscape, from SMBs and industrial enterprises to utilities, banks and financial centers, educational and research institutions, health care facilities, and government agencies involved in transportation, public safety, defense, and much else. There's no sector that won't benefit from more adroit CSP responses to market needs.

# Use-Case Specific Opportunities

There are boundless possibilities when it comes to development and cross-network domain distribution of services specific to the needs of each segment. With a service orchestration platform that can draw on virtualized and embedded functionalities wherever they're located regardless of the vendor source, CSPs can position themselves to participate in virtually any segment-specific service at granular levels of variation within each segment.

Consider, for example, the variations in data security functions that need to be applied in a collaborative energy grid management environment involving incumbent utilities and virtual power plants. In such cases, data pertaining to energy usage and generation must be parceled out on an authorized need-to-know basis among all participants in the dynamic grid operation down to each household contributor to the grid. A data security vendor partnering with a CSP would be able to deliver link-level security tailored for each use case. According to Data Bridge Market Research, the size of the Energy Security Market in 2022 was valued at nearly $17 billion and will reach nearly $31 billion by 2030, an 8% CAGR.

This is just one example of opportunities for CSPs to partner with vendors who are looking for ways to gain a competitive edge in an IoT space teeming with suppliers across multiple application arenas. Another example can be found in video security monitoring, a $55 billion market globally in 2022 according to Grand View research.

Here it would be possible to address the variations in surveillance requirements through services offering multiple data processing options that customers could select to fit the situations a vendor's security systems might be used for. Such a set-up could give the camera OEM a pricing advantage against systems purpose-built for each use case.

In this scenario a retailer buying cameras from a supplier partnered with a CSP would be able to order software applications delivered online that would provide the processing suited to interpreting and raising alarms from video feeds delivered by cameras monitoring for shoplifting, in contrast to the processes used with cameras monitoring for break-ins.

Similarly, a multi-faceted software layer used with cameras deployed in manufacturing operations might support different processing related to monitoring equipment, workers and building exteriors. And, of course, any surveillance use case would benefit from the allocation of "sliced" transport dedicated to transmitting alarm and other data to CSPs' security partners.

Moreover, it's important to note that in a multi-domain managed service environment, this or any of a multitude of other applications for 5G slicing could benefit from dedicated transport over fixed networks with use of new optical spectrum slicing technology. Just as dedicated 5G transmissions of security data can be extended to fixed networks in such scenarios, services like cell-site backhaul and VPNs typically delivered over opitcal links can be extended to remote locales over dedicated slices of mobile spectrum.

## A New Realm of Generic Service Enhancements

More generally and at a much higher level of prominence on CSPs' radar screens, there are many types of generic service enhancements that can be beneficial to customers and providers across multiple sectors. One example of much-needed service flexibility can be found in any instance where an operator has implemented a secured enterprise service with firewall intrusion detection system (IDS) or intrusion protection system (IPS) capabilities in conjunction with connectivity to fiber access networks. With a multi-domain orchestration system, the operator will be able to create a 5G slice that can extend availability of the secured enterprise service to remote locations not served by fiber.

Here it's important to note that when it comes to addressing current enterprise security needs, CSPs need to be able to apply their resources in ways that allow them to compete effectively against a phalanx of vendors who are leveraging cloud connectivity to compete with new approaches to providing security and other network services. A rapidly maturing trend centers on next-generation firewall services (NGFWs), which weave standard firewall and IDS or IPS capabilities together with the ability to analyze traffic and apply security policies at the individual application level, receive threat intelligence from external sources, and add new security features as necessary.

Similarly, CSPs have every reason to step up participation in the fast-growing SD-WAN market, which is projected by one researcher to increase at a 38.6% CAGR from its early days at $1.4 billion in 2019 to $43.0 billion in 2030.[xxiii] Currently, by another researcher's estimate, the telecom share of the SD-WAN market is only about 25%.[xxiv]

SD-WANs are a subset of the much larger traditional WAN market but are rapidly gaining ground owing to their compatibility with the enterprise shift to heavy reliance on cloud-based services. By applying a cloud-based management overlay supporting transport independence across MPLS, Ethernet, 4G/5G, and other modes of backbone and access transport, SD-WANs ensure there's ample network capacity to accommodate the dynamically fluctuating and often heavy loads of traffic that connect enterprise offices with cloud-processed software applications.

CSPs have long thrived on the supply of MPLS, Ethernet and other modes of connectivity in support of enterprise WANs, and that can be the case with SD-WANs as well. But for CSPs who don't want to concede the revenue-generating operational aspects of the SD-WAN market to competing suppliers, the opportunity lies with utilizing existing infrastructure to create high-value SD-WAN services of their own.

This dovetails with another growing trend, which is the pairing of NGFW services with SD-WANs to overcome security issues that have made many enterprises wary of commitment to the new approach to WAN operations. In the latest twist, pursuit of even tighter orchestration between WAN and security operations has spawned what is known as Secure Access Secure Edge (SASE), which, again, plays to the strengths of CSPs that can make full orchestrated use of all their assets.

# Part 3 Transformation via DZS Xtreme-Based Service Orchestration

There's no longer anything standing in the way of CSPs seeking to exploit opportunities like those discussed in Part 2. For the first time, telecoms have access to the operational framework they need to take the lead role in providing the services customers are looking for at this key moment of cloud transition across all market segments.

## Innovations Underlying Comprehensive Automation

With implementation of the unique capabilities embodied in the DZS Xtreme platform, operators can drive ARPU growth while keeping a tight rein on TCO by leveraging all their assets in a demand-driven approach to accelerated service development and distribution free of vendor lock-in. By employing a model-based architecture built on standards-defined workflows, Xtreme cuts through the complexities that have been ingrained in telecom operations through decades of incremental technological evolution in silos populated by incumbent suppliers. (See Addendum for list of standards used by Xtreme.)

The platform serves as an intent-driven network management system that enables automated, vendor-agnostic orchestration of functions and workflows within and across all operational end points in the transport, fixed access, and mobile domains, including SDN and virtualized cloud processes related to those domains. With reliance on workflows embodied in standardized Broadband Forum, ETSI, 3GPP, and TM Forum data models, Xtreme works automatically with any standards-based network element (NEs), and, in instances where CSPs' infrastructures include proprietary systems that aren't standards compliant, operators have recourse to plug-ins developed by DZS that can be used to import integrations with third-party IP.

The DZS Xtreme intent engine operates through a set of operator-designed policies which drive the resource selection process. Fields in standards-compliant templates such as a TM Forum Service Order or the GSMA NEST template are used to determine the best-fit resources to fulfil a particular service. Model-based workflow transitions are encoded, minimizing or even eliminating the need for custom scripts.

In the repeating series of life-cycle actions illustrated in Figure 3, the only manually executed steps occur in the planning phase. Everything else is triggered through drag-and-drop activation of wizard-driven task fulfillment on the multi-layered Xtreme UI (Figure 4).

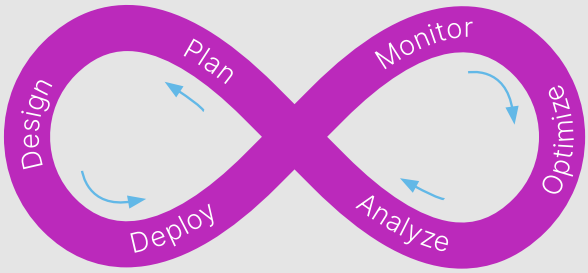



**Figure 3** Embrace Automation and Continuous Deployments

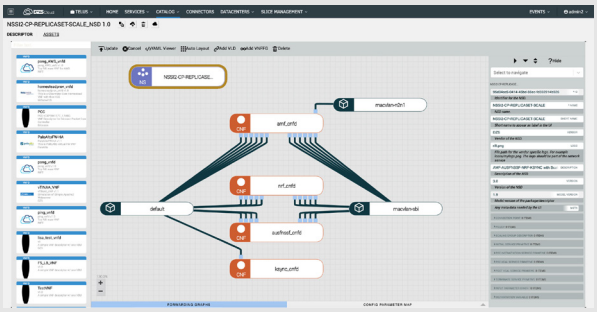


**Figure 4** Drag-and-Drop Activation

## Service Development at Unprecedented Speeds

This DIY self-sufficiency paradigm is key to ensuring the time consumed creating and commercializing services is reduced from months to days. And it allows product development, management, and marketing teams to avoid bloating their budgets with the costs of professional assistance from vendors or other third parties.

A major contributor to speed of development is the reduced coding burden resulting from the automated model-based approach to operations. Enabling the same designs to be replicated across multiple use cases, network infrastructures, and clouds is intrinsic to the Xtreme architecture, in contrast to vendor platforms that require a substantial amount of coding to enable automation.

Critically, automated activation of the standards-based workflow models works in tandem with object-based abstractions of NEs based on standards-defined functionalities. Xtreme is able to employ standardized or plug-in derived proprietary APIs to configure the use of NEs like Lego building blocks in the execution of whatever sets of functions are needed to deliver services mapped to customer-defined needs in any market segment.

Moreover, adherence to standards-based workflow models and interfaces means that, once the Xtreme platform has been integrated with a CSP's OSS, BSS, and specialized systems like CRMs and service assurance tools, interactions with those components remain stable as services, use cases and suppliers change. This eliminates the need for new northbound integrations.

This is the level of automation that the widely embraced IT concept of continuous deployment aspires to. Under Continuous Deployment (CD), once software artifacts are created, the entire delivery process is automated, starting with deployment of artifacts through staging and pre-production processes into the production environment and extending to execution of infrastructure and configuration changes and the monitoring and maintenance processes associated with deployment of the completed applications.

## Network Domain-Specific Approaches to Resource Orchestration

To systemize the application of workflow models with abstracted NEs, Xtreme employs modules architected to address the specific components and functionalities of each networking domain as well as the software domains associated with SDN and cloud virtualization technologies. In the latter two cases, of course, these modules interact as needed with NEs based on how the NEs are configured within their modules.

## The SDN and NFV Domains

The Xtreme SDN Management and Control module is designed in complete compliance with Broadband Forum and IETF standards suited to SDN execution of NE functionalities wherever SDN applications come into play. In the case of purpose-built hardware components where SDN technology isn't applicable to the abstraction process, the platform utilizes plug-ins to bring abstracted models of those components into the orchestration process.

The Xtreme NFV module provides the capability to manage virtualized NE functions and their respective domain workflows in any public, private or hybrid cloud environment regardless of whether operations are based on container or VM technology.

CSPs can deploy a service that relies on virtualized functionalities just about anywhere there's a virtual compute infrastructure available. The Xtreme NFV module is fully multi-vendor enabled with over 90 network functions from 50 different vendors catalogued in the system, including support for all the virtualized use cases documented for the consolidation of NFV with SDN technology through SDNFV. The module enables a self-service approach to adding more functions and vendors in a few days' time as needs arise.

## The Access, Transport, and Mobile Network Domains

The Xtreme modules architected for the access, transport and mobile domains are all designed to comply with the leading standards bodies' workflow specifications and their south- and northbound interfaces with the domain NEs' functionalities. And, as noted earlier, the platform utilizes the native southbound APIs provided with proprietary third-party systems in cases where the NEs don't work with standard APIs.

The Xtreme architecture opens possibilities for dynamic orchestration of NEs that go far beyond the norms of CSP operations. For example, in the orchestration of optical networking functionalities in the Access Domain, Xtreme workflows can interact with OLTs and their constituent CSM and ELM elements in the CO and ONUs at the access edge to execute service applications calling for adjustments in wavelength payload assignments, topological reconfigurations or activation of new wavelengths. See Figure 5 for diagram of a CO instantiation of Xtreme.

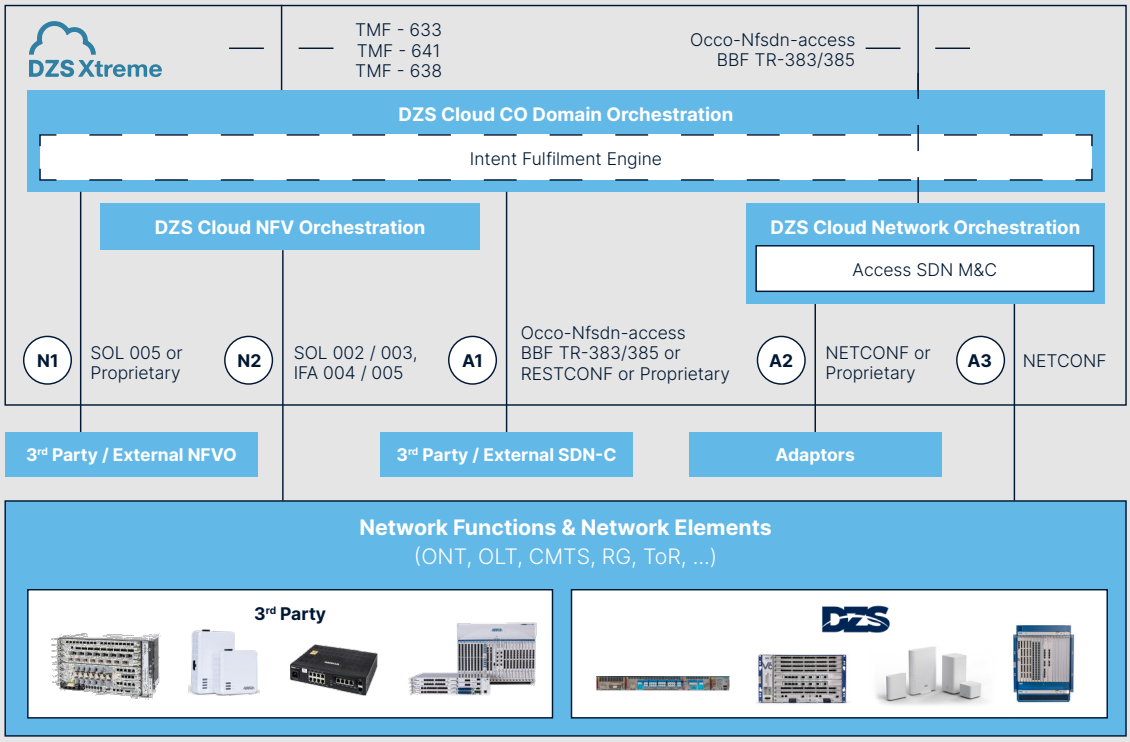
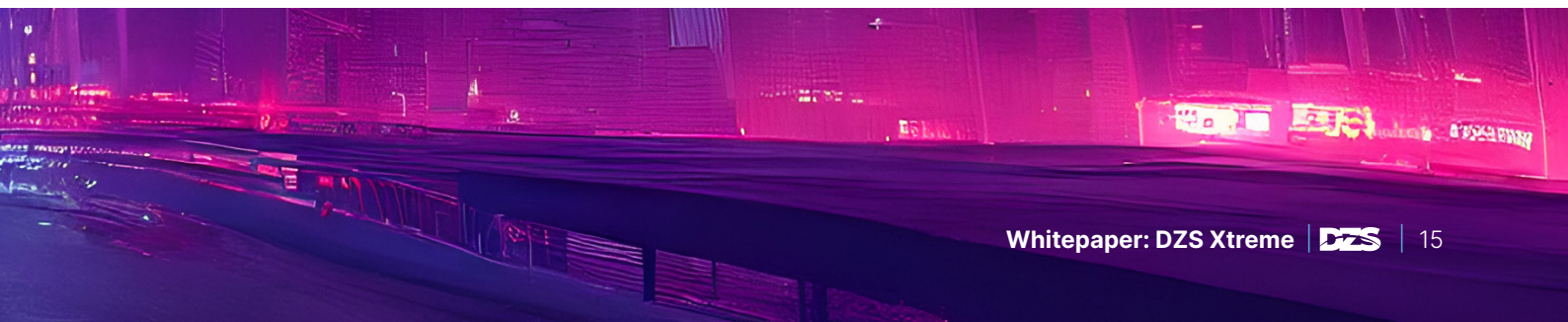



**Figure 5** DZS Xtreme Cloud CO Orchestration Deployment

Bandwidth can be assigned dynamically on a per-user basis to accommodate fluctuations in usage whether by service category, time of day or both. And the platform employs elastic optical network (EON) technology to manage optical spectrum within wavelengths for assignment of bandwidth segments to specific services in what amounts to a fixed-access analogy to 5G slicing. Moreover, wherever possible in FTTX scenarios involving last-segment distribution over xDSL, Xtreme interacts at the interfaces between ONUs and DSL modules to extend dynamic bandwidth and slicing capabilities over copper infrastructure.

It's important to note that Xtreme can be used in the context of operators' opportunity to drive optical access to record-breaking capacity with deployment of the DZS Velocity V6 OLT in conjunction with network designs targeting 20,000 to 20 million subscribers. The dynamics related to the use of OLT resources in Xtreme-managed service operations are greatly enhanced wherever V6 chasses are deployed, each of which supports up to 800 gigabits per second per slot of bi-directional throughput with capacity to serve up to 24,000 Gigabit PON (GPON) and 10 Gigabit PON (XGS-PON) subscribers.

In the transport domain, Xtreme maximizes dynamic versatility by managing the elements used in DWDM networks, including open ROADM transponders and switches (see Figure 5). Notably, as in the case of the Velocity V6 OLT, Xtreme enables automated management of the ground-breaking capabilities of the DZS Saber 4400 coherent optical transport platform, the widely deployed NE has redefined the economics of optical transport by incorporating unprecedented transport capacity at the network edge with up to 400 Gbps per wavelength along with new levels of flexibility and scalability in an environmentally hardened form factor.



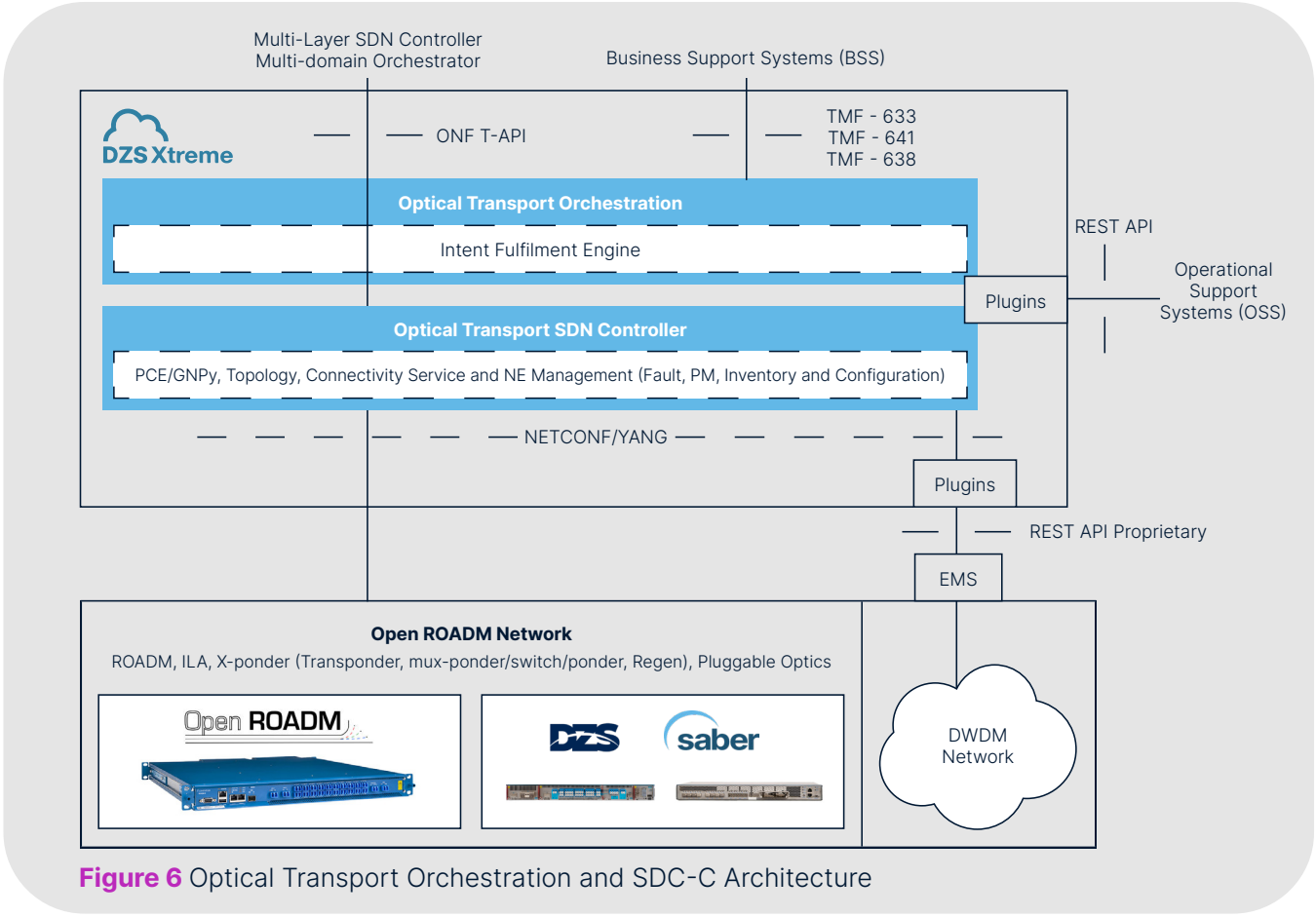



**Figure 6** Optical Transport Orchestration and SDC-C Architecture

Nothing is more important to CSP service acceleration and automated management versatility than the Xtreme Mobile Domain module and the ability to bring 5G services into the multi-domain service orchestration environment (see Figure 6). Here Xtreme incorporates the full complement of standards essential to maximizing the benefits of 5G NG and NSA deployments.

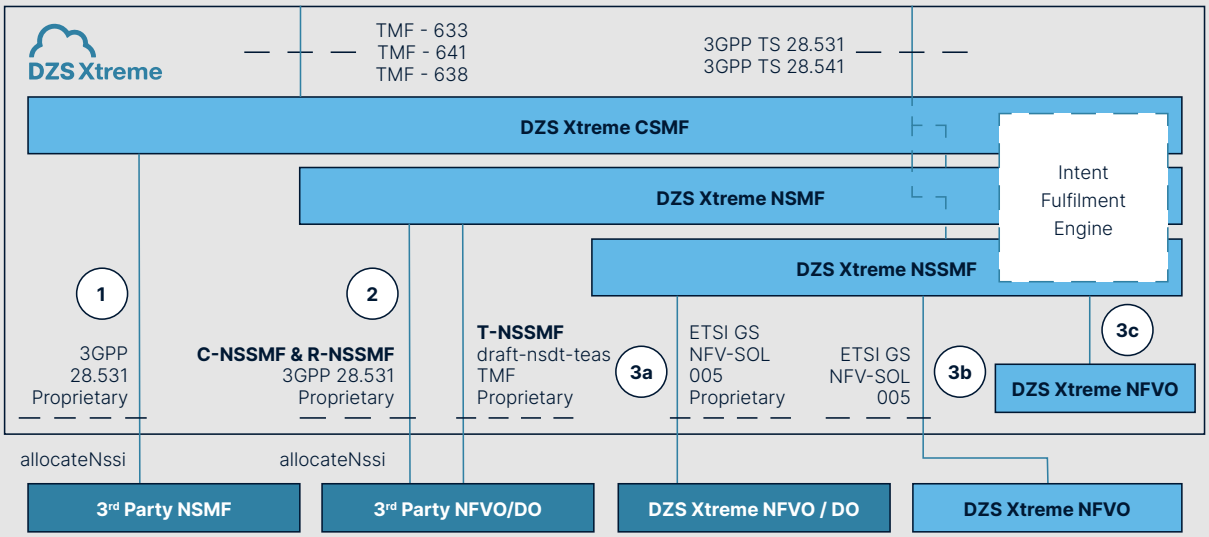



**Figure 7** DZS Xtreme Slice Orchestration Architecture

Xtreme integrates with any third-party southbound system such as Network Slice Management Function (NSMF), Network Slice Subnet Management Function (NSSMF) or NFV Orchestration (NFVO) using standard or proprietary APIs. The northbound interface uses TMF Open APIs and is designed in accord with 3GPP TS 28.805 and Broadband Forum TR-411 specifications. Xtreme also supports use of TMF 633, 641, and 638 NBIs for end-to-end control over services mapped to MEF Lifecycle Service Orchestration (LSO) “Legato” principles.

## Multi-Domain Orchestration

With all these modules in place in the context of the Xtreme approach to workflow modeling and NE abstraction, multi-domain distribution of services is a straight-forward extension of Xtreme operations. The same level of automation applies no matter how many domain modules are brought into play to support a service with drag-and-drop configurations of the NE building blocks and underlying workflows on the Xtreme UI.

No matter what the service might be or how it is differentiated from one domain to the next, Xtreme's ability to muster all the relevant NEs and workflows eliminates the traditional hassles entailed with instantiating services as separate building projects within each domain. Moreover, the platform makes it easy to embellish a given service with features suited to maximizing the user experience in accord with the devices and behavioral norms intrinsic to each networking environment.

For example, while the approaches to slicing differ within the access and mobile domains, Xtreme makes it possible for operators to consolidate the design and implementation of service verticals on a single platform. The potential impact on service diversity and business partnership opportunities is a game changer.

To take just one example of an emerging service category surging into prominence, the need for network support in the use of augmented reality (AR) technology is spreading across multiple sectors, including telemedicine, education, manufacturing, engineering, defense and many others as well as the mass consumer market as a whole. One researcher forecasts the global AR market will expand at a 31.5% CAGR from $31.97 billion in 2022 to $88.4 billion in 2026.[xxv]

There's not a lot of bandwidth required for these use cases since small data feeds rather than video payloads are the norm, so it's conceivable to dedicate multiple slices to AR based on variations in use-case requirements as opportunities take shape in each sector. For example, some might require ultra-low latency that can be implemented on an Ultra-Reliable Low Latency Connection (URLLC) 5G slice and on fixed networks through implementation of CDN services dedicated to low latency applications. Or, as more volumetric applications like holographic renderings enter the AR domain, there may be a need to dedicate higher bandwidth slices to the technology.

And, of course, if the vision of mass engagement in networked virtual reality (VR) services comes to fruition, there will be a need for dedicated VR bandwidth across all networking domains. Whatever technological innovation brings to the connected marketplace over time, CSPs using Xtreme will be able to allocate the dedicated capacity they need throughout their service areas.

# Cross-Domain Automation of Service Assurance

The ability to persistently ensure carrier-grade service delivery is also greatly enhanced through use of the Xtreme platform. Now quality assurance can be maintained across all domains through a single UI, eliminating the complexities and intensive manual workloads intrinsic to managing service assurance in diverse networking and service silos.

Xtreme automates multi-domain service assurance though use of automated Closed Control Loop (CCL) scaling and healing processes in the platform's model-driven workflows, ensuring issues impacting SLA performance are addressed in all instances (see Figure 7). Complementing CCL monitoring within specific domain workflows, the Xtreme architecture enables cross-domain service assurance through correlation of monitoring information hierarchies related to service components, segments, and topology.

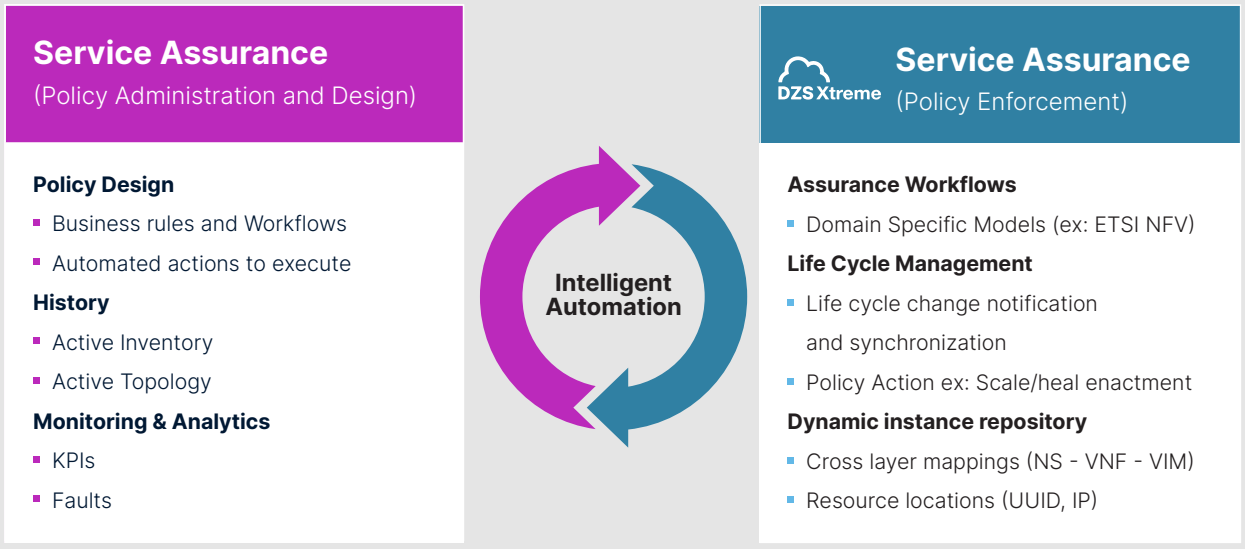



**Figure 8** Service Assurance Interaction

Through interfaces with NEs and network functions, CCL-based service assurance automates corrective action against detected anomalies and allows operators to monitor service- and application-level KPIs such as calls per second, TCP traffic rate, and packet-loss rates. KPIs retrieved in near real time can be aggregated in policies to drive automated actions such as service component healing through re-configuration, re-start, or re-instantiation and adjustments in network capacity in response to fluctuations in demand.

In addition, the DZS open-API approach to third-party integrations allows operators to implement advanced QA analytics and AI techniques from outside suppliers. In such instances, the external analytics system manages policy design and decisioning, while DZS Xtreme activates policy enforcement functions.

# Xtreme in Action

CSP deployments of Xtreme are underscoring the dramatic gains operators can expect when they put the platform into operation. All over the world, operators who have built aggressive service strategies on the strength of investments in 5G infrastructure are finding they can quickly and cost-effectively extend any new 5G services suited for wireline access across their fixed network footprints.

Likewise, they can readily bring services offered over wired infrastructure into their mobile and FWA domains. And they're discovering how much more they can gain with a cloud- and technology-neutral approach as they transition to ever greater reliance on NFV.

TELUS
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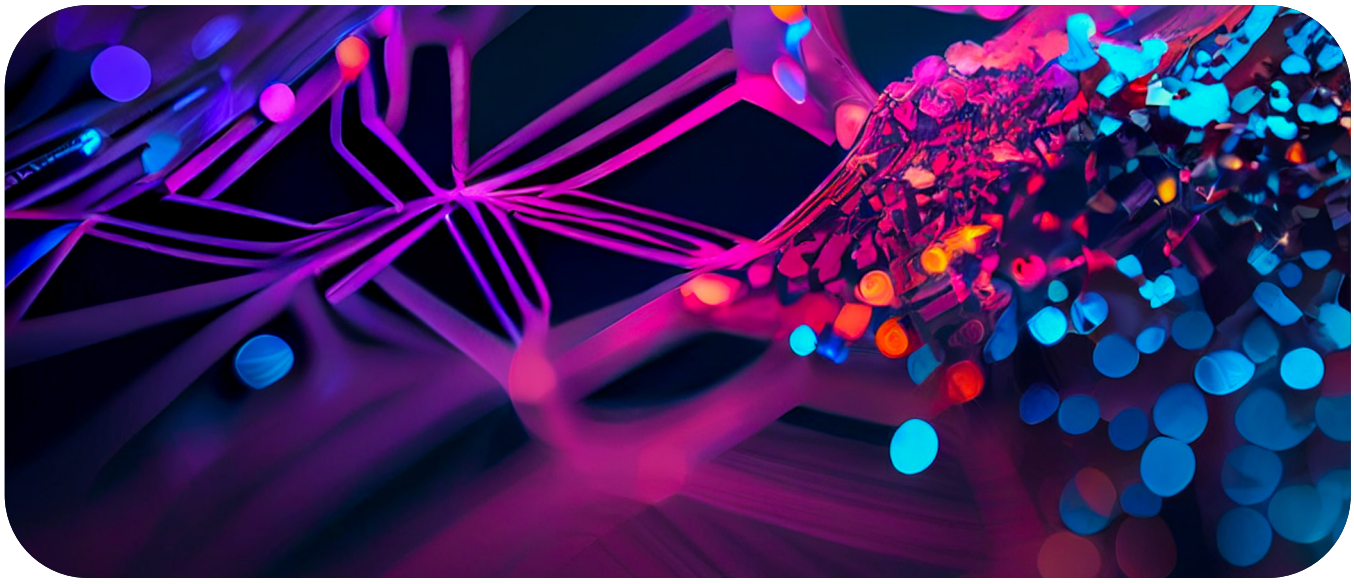
One CSP leveraging Xtreme to make much more aggressive use of NFV than it could previously is Canada's TELUS, a Tier 1 full-service provider in the midst of a major transition to cloud-based resource integration in the wake of launching 5G services. This phase of the TELUS journey began with complete replacement of an incumbent provider's NFV orchestration platform.

With Xtreme in operation, the company has been able to implement self-service automation in the management of its software-defined mobile network while expanding seamless orchestration of 4G, 5G, and related core services for IoT use cases across all its hybrid NFV resources. Delivery of new features and onboarding of new services have been accelerated by 300% to 400% according to TELUS CTO Ibrahim Gedeon.

"This is the right DNA for TELUS to succeed," Gedeon says. "The DZS team has been amazing to work with."

Similar experiences have been registered by one of the largest telecommunications providers in Europe. Asking for anonymity in the recounting of its experiences with Xtreme, this Fortune 100 company is benefitting from significant OPEX savings resulting from self-service automation across its virtualized mobile network systems. Like TELUS, it has achieved its goal of implementing the Continuous Deployment approach to developing, launching, and managing virtualized services.

> **"Delivery of new features and onboarding of new services have been accelerated by 300% to 400%."**
>
> Ibrahim Gedeon, CTO at TELUS



# Conclusion

The telecommunications industry has arrived at a crossroads where a brighter outlook for CSPs depends on a transformative shift away from reliance on transmission capacity as the primary revenue driver in conjunction with a manual-intensive approach to service management within each network domain. There's simply no way CSPs adhering to these traditional modes of operation can attain the much-needed improvements in bottom-line performance that are now at hand amid a technology-driven surge in the appeal of cloud-delivered services across all market segments.

What's required is a means by which network operators can build ROI by delivering far better user experiences than subscribers can expect from services distributed over unmanaged internet connections by super-scalers and other cloud providers. The way forward lies with a vendor-agnostic multi-domain service orchestration platform that operates at superscale speeds while delivering carrier-grade performance.

For the first time, CSPs can take this path to future success free of vendor lock-in by implementing the DZS Xtreme multi-domain service orchestration platform. Through an innovative combination of workflow modeling and NE abstractions tied to the data models on which a multitude of industry standards rest, Xtreme enables personnel engaging on the platform's UI to click on and pull together the resources from access, mobile, transport, software-defined, and virtualized cloud domains that are required to manage any given service or service attribute across all or any portion of their service areas.

A low- to no-coding approach to service development enabled by the replication of any existing template combined with integrations with OSS, BSS and other systems makes it possible to develop, test, and commercialize services on radically reduced timelines. And automation of operations extends into the service-assurance sphere through execution of monitoring and remedial measures within and across all workflows, including cases where Xtreme can be employed to carry out the actions ordered by integrated third-party QA analytics platforms.

Xtreme is part of the DZS Cloud solutions that include the DZS Expresse and DZS CloudCheck platforms, which can be deployed together to provide the full range of infrastructure and service management capabilities essential to maximizing CSP ARPU and minimizing TCO. With Expresse they can incorporate a powerful QA analytics platform in the access domains managed by Xtreme while, with CloudCheck, they can extend comprehensive QA and QoE management consistent with all services delivered across WiFi gateways and access points.

The prospects for CSPs are unlimited. As discussed in the Cloud Edge whitepaper complementing this one, operators now have an opportunity to assume the role of Experience Providers in support of a new era in network services that would be impossible without them.

# Addendum – Xtreme Standards List

## ETSI NFV MANO Specifications

### Stage 1 Specifications and Reports

- ETSI GR NFV 001 "Network Functions Virtualization (NFV); Use Cases"
- ETSI GR NFV-EVE 012 " Report on Network Slicing Support with ETSI NFV Architecture Framework"
- ETSI GS NFV-IFA 004 "Acceleration Technologies; Management Aspects Specification"

### Stage 2

- ETSI GS NFV-MAN 001 "Management and Orchestration"
- ETSI GS NFV-IFA 005 "Or-Vi"
- ETSI GS NFV-IFA 006 "Vi-Vnfm"
- ETSI GS NFV-IFA 007 "Or-Vnfm"
- ETSI GS NFV-IFA 008 "Ve-Vnfm"
- ETSI GS NFV-IFA 010 "Management and Orchestration Functional Requirements"
- ETSI GS NFV-IFA 011 "VNF Packaging"
- ETSI GS NFV-IFA 013 "Os-Ma-nfvo"
- ETSI GS NFV-IFA 014 "Network Service Templates"
- ETSI GS NFV-IFA 019 "ETSI GS NFV-IFA 014 "Network Service Templates"
- ETIS GS NFV-IFA 029 "Enhancements of the NFV architecture towards "Cloud-native" and "PaaS"

### Stage 3

- ETSI GS NFV-SOL 001 "NFV descriptors based on TOSCA"
- ETSI GS NFV-SOL 002 "Ve-Vnfm"
- ETSI GS NFV-SOL 003 "Or-Vnfm"
- ETSI GS NFV-SOL 004 "VNF Package"
- ETSI GS NFV-SOL 005 "Os-Ma-nfvo"
- ETSI GS NFV-SOL 007 "Network Service Descriptor File Structure"

### Access Domain Specifications

- TMF633 Service Catalog API
- TMF638 Service Inventory Management API
- TMF641 Service Ordering Management API
- TMF653 Service Test Management API
- TMF635 Usage Management API
- Broadband Forum TR-411 Definition of interfaces between CloudCO Functional Modules
- Broadband Forum TR-383 Common YANG Modules for Access Networks
- Broadband Forum TR-385 ITU-T PON YANG Modules

### Transport Domain Specifications

- TMF633 Service Catalog API
- TMF638 Service Inventory Management API
- TMF641 Service Ordering Management API
- IETF Traffic Engineering Architecture and Signaling (TEAS)
- IETF Abstraction and Control of Traffic Engineered Networks (ACTN)
- IETF L2 and L3 Topology
- ONF T-API
- Open ROADM API
- Transport Infra Project Open Optical & Transport (TIP OOPT)
- OPEN ROADM MSA
- OpenConfig

### Mobile Domain Specifications

- 3GPP TS 28.525 "Life Cycle Management (LCM) for mobile networks that include virtualized network functions; Requirements"
- 3GPP TS 28.526 "Life Cycle Management (LCM) for mobile networks that include virtualized network functions; Procedures"
- 3GPP TS 28.531 "Management and orchestration; Provisioning"
- 3GPP TS 28.533 "Management and orchestration; Architecture framework"
- 3GPP TS 28.541 "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3"

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