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WHITEPAPER

The Cloud-Orchestrated Path to CSP Ascendancy in the Emerging Metaverse

A Virtualized, Vendor-Neutral Approach to QoE Management Positions Operators for New Opportunities as Experience Providers

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Executive Summary

Communications service providers (CSPs) have an unprecedented opportunity to reposition themselves as Experience Providers who can support the quality, convenience, and breadth of internet engagement that customers will require as the Metaverse era in connectivity unfolds.

In a fast-evolving market driven by consumers' freedom to tap the internet for whatever entertainment, smart home, and other services they need, there are significant upsides for network operators who can expand monetization beyond compensation for ever higher fixed and mobile access speeds. The key lies in their ability to leverage managed fixed and mobile broadband access networks together with cloud-based Wi-Fi connectivity in the home to set a new standard for quality of experience (QoE) in cyberspace.

This new approach to driving customer loyalty and monetization rests on a multi-vendor friendly combination of automated network orchestration, service delivery and assurance and Wi-Fi experience management embodied in the Cloud Edge software platform developed by DZS. For the first time, CSPs have access to the tools they need to reposition themselves as XPs (Experience Providers) in stride with established network evolution strategies free of major forklift outlays and vendor lock-ins.

Overcoming the Dumb Pipe Syndrome

Until now, from a purely financial perspective, the "dumb-pipe" approach to unleashing the forces of internet development has outweighed any setbacks to CSPs' revenue potential stemming from the disruptions caused by OTT video service providers, smart TV OEMs, and superscaling cloud invaders. Understandably, as network operators pour billions of dollars into fixed and mobile network capacity expansion worldwide, they have been resistant to spending on high-cost equipment and BSS/OSS changeouts in hopes of improving cash flow margins with support for better QoE and new self-branded services.

But CSPs can no longer afford to ignore the red-ink side of ledgers fueled by mounting operating costs stemming from customer dissatisfaction with subpar service performance. They're taking the hit even though the problems are often caused by retail-purchased third-party Wi-Fi access points and boosters and glitches in cloud services over which operators have no control. The need to eliminate that cost drain grows ever more urgent in light of the far greater vulnerabilities to performance malfunctions taking shape as the world transitions to what has become widely known as the Metaverse era.

It's now possible to neutralize those vulnerabilities with DZS's Cloud Edge-enabled quality assurance that matches service performance to consumer expectations. Moreover, Cloud Edge intelligence running on software-defined networks allows operators to support accelerated development and delivery of their own branded services in rapid response to shifting market demands.

Critically, Cloud Edge enables a customer-first approach to the XP role at a time when market demand is the core driver behind the Metaverse transition. By unleashing the network functionality and flexibility that's essential to following market demand wherever it leads, Cloud Edge allows CSPs to go far beyond the capacity-expanding measures that brought to life the current wealth of internet services and applications.

The Metaverse Is Real

Many definitions of the Metaverse have flooded the blogosphere over the past three years. Operators are justifiably skeptical that concepts often associated with the term will have the earth-shattering impact predicted by proponents.

But, beyond the hype, it's important to recognize that whatever one chooses to call the emerging immersive approach to cyber engagement, it will far transcend activities of avatars populating 360° bubbles. VR and the augmented and mixed reality (AR/MR) iterations of extended reality (XR) will be just one way to experience the Metaverse, albeit with a growing presence over time.

Fundamentally, judging by the spate of technological advances moving rapidly to commercialization, it looks like we're on the verge of a major break with the two-dimensional on-screen broadband experience that began changing the world following the invention of the World Wide Web. That applies whether users will be using traditional or autostereoscopic 3D displays to go about their routine online activities or availing themselves of a forthcoming potpourri of eyewear far better suited to everyday use than the current crop of head-mounted devices (HMDs).

Users will be able to navigate webpages and videos on flat screens without encountering the usual rendering boundaries, a phenomenon already in play with 360° viewing of sports and other live events. And they'll have touch-free control over what they're seeing using gestures, verbal commands and even eye movements.

With or without eyewear, users will be able to bring others into what they're doing instantly. Computerized network support for group interactions around any type of display surface, from AR hologram lenses and VR HMDs to phones, PCs, TVs and even walls, will become pervasive.

But, ultimately, it's not just about how things are viewed or shared. Equally, if not more important, it's about how data is used with ubiquitous compute support in real-time to make a new realm of immersive Wi-Fi in-home and on-the-go 5G/6G- and, soon, 7G-powered experiences available on all devices.

Trends in consumer behavior are already building the demand foundation for Metaverse-caliber network performance, some related to VR, some not. Casual group social activity is flourishing, much of it with video-infused interactivity tied to video conferencing, sharing user-generated content, and sports, esports and other live-event watch parties. Young people are now regularly donning VR headgear for social interactions. And cloud-supported multiplayer gaming has taken off as mainstream entertainment with ever more activity occurring in VR spaces.

Beyond entertainment and casual social interactions, people are working and learning at home full or part-time at scales never seen before. In ever greater numbers, they're availing themselves of network-delivered healthcare. And cloud-supported home automation is spurring a proliferation of internet-connected security cameras, voice-activated smart speakers, thermostats, appliances, and myriad other gadgets.

The Industry's First Vendor-Neutral Cloud Solution to End-to-End QoE Management

The basic axiom guiding the CSP-to-XP transition in all market segments is, customers are defining the services, and service providers' successes will depend on their ability to deliver what customers want. This is the principle that has guided DZS's development of Cloud Edge and its wide range of Software-as-a-Service (SaaS) offerings as the common software-defined network (SDN) framework for all the intelligent functionalities that will carry operators into the future.

While DZS is a leading network platform and software vendor working at the cutting edge of development in the supply of broadband access, optical and mobile (5G OpenRAN) edge and subscriber edge infrastructure (i.e. Wi-Fi access points and experience management software), the company recognizes that CSPs must be able to pursue a best-of-breed approach in their transition to operations as XPs. By virtue of its expertise in these technologies and its adherence to standards and open-source initiatives across the fixed and mobile ecosystems, DZS has been able to develop Cloud Edge as the first vendor-agnostic carrier-grade platform to provide operators the comprehensive, highly scalable support for end-to-end network orchestration, automation, visibility, service assurance and Wi-Fi experience management they need.

Moreover, by taking advantage of the increasing commonalities between the technologies underlying fixed and mobile access migration, Cloud Edge makes it possible for CSPs using virtualized and cloudnative network functions to manage services across all edge infrastructures. As a result of these efforts, Cloud Edge is interoperable with existing access, mobile and optical edge infrastructure and more than 150 unique residential gateways and Wi-Fi devices supplied by a vast array of vendors.

Making things easier still, that interoperability is facilitated by open API access to the OSS/BSS systems associated with those vendors' products. Leveraging a wizard-driven drag-and-drop designer UI, operations personnel can employ single-click, zero-touch SaaS templates to gain end-to-end visibility into all aspects of service development and operations.

Uses of Cloud Edge extends in complementary ways across three solution pillars.

When it comes to service deployment and access network operations, DZS Xtreme allows operators to rapidly design, deploy, and orchestrate network services and applications for delivery over logically independent virtual networks on the shared fixed, optical and 5G access management platform. Critically, DevOps teams can leverage the model-driven Cloud Edge architecture to rapidly create and automate the life cycles of new services, reusing models to avoid the lengthy delays required to set up resource allocation and create custom code on a per-service basis.

On the QoE front, our primary focus is on the role two other Cloud Edge elements, Expresse and CloudCheck, play in providing operators the ability to automate a customer-centric approach to meeting service performance requirements across all components of their broadband access and onpremises Wi-Fi infrastructures. As shall be seen, Expresse and CloudCheck deliver benefits that give CSPs a tremendous advantage over OTT providers in efforts to drive customer loyalty and higher ARPU. And we'll explain how the ARPU potential increases to unprecedented levels when the network slicing capabilities of Cloud Edge are brought into play with the QoE management capabilities of the Expresse and CloudCheck solutions.

Data collection and AI-assisted analytics employed by Expresse are used to manage performance over GPON and DSL access networks while CloudCheck uses iterations of those mechanisms across Wi-Fi gateways and access points (APs). Together they enable holistic hands-off orchestration of whatever adjustments are needed end to end to ensure QoE is always the best it can be.

At the same time, the automated processes and intuitive user interfaces accelerate technicians' ability to get to root causes in proactive manual interventions aimed at minimizing the impact of performance issues over time. Additional CloudCheck capabilities include a home network security suite, family controls and reporting for government broadband programs that provide incentives to address the digital divide.

Results tabulated across the more than 100 million households worldwide now benefitting from CSPs' implementation of DZS solutions attest to what the XP role can mean to operators.

In the aggregate these uses have:

- Increased customer retention by 20%.
- Decreased customer calls by 35%.
- Increased network QoE by 35%.
- Decreased field dispatches by 16%.
- Increase ARPU with new services by 2 – 4 x.

As emphasized by Michael Philpott, Research Director, Service Provider Consumer, at Omdia, CSPs' ability to make the leap to operations as XPs is now mission critical. "Broadband marketing has shifted from focusing on top-line speed to overall customer experience, and this requires not only investment in access and core networks, but also in the Wi-Fi connected home," Philpott said in response to the 2021 DZS acquisition of ASSIA, the original developer of the Expresse and CloudCheck solutions.

"Making the connected home a top priority for investment is therefore now essential for future broadband service success in addressing the needs of the 1 billion broadband connected homes globally," he added. "To achieve this, service providers need to move to a single, cloud-based, software management layer across the entire footprint that can dynamically optimize the performance of the home broadband gateway."

Now they can.

Part 1

Forces Reshaping CSPs' Consumer Market Opportunities

From every angle, the statistics tell the same story: the emergence of a cloud-based ecosystem of OTT providers and connected devices has carried the world to once-unimaginable heights of internet engagement across multiple consumer service categories. As a result, the opportunities unfolding for CSPs who leverage their managed networks to deliver what consumers are looking for from life in cyberspace are unprecedented.

Accelerating Bandwidth Consumption

One route into this vast field of dreams lies along the well-traveled path of bandwidth expansion over access and premises networks, where the opportunities are richer than ever for CSPs who can orchestrate ever-higher levels of throughput end to end with far greater efficiency, flexibility, granularity, and speed than ever before. With video streaming to ever more devices in the home and an XR-rich Metaverse taking shape on the near horizon, there's every reason to expect the volume of traffic entering and traversing through consumers' homes will continue soaring with even greater intensity than it has over the past few years.

The ITU recently reported that total bandwidth usage worldwide increased by 30% in 2021 over 2020. Surprisingly, that matched the previous year-to-year rate of increase when the Covid 19 pandemic first drove everyone to far greater dependence on internet access than ever before.[i]

Currently, fixed broadband access speeds are on a six-year 20% CAGR growth path that will take the global per-household average past 100 Mbps in 2023, according to Cisco's most recent Annual Internet Report.[ii] (Figure 1). Average mobile access rates are increasing even faster at a five-year CAGR of 27% on course to hit 43.9 Mbps in 2023.

Figure 1

Average Mobile & Fixed Access Speeds (Mbps)

Mobile (Global CAGR 27%)

Markets	2018	2019	2020	2021	2022	2023
Global	13.2	17.7	23.5	29.4	35.9	43.9
North America	21.6	27.0	34.9	42.4	50.6	58.4
Western Europe	23.6	31.2	40.1	48.2	54.4	62.4
Asia Pacific	14.3	18.0	24.7	32.4	39.0	45.7
Central/ Eastern Europe	12.9	15.7	21.3	30.3	36.1	43.0
Latin America	8.0	11.2	15.7	21.1	24.8	28.8
ME & Africa	6.9	9.4	13.3	17.6	20.3	24.8

Fixed (Global CAGR 20%)

Markets	2018	2019	2020	2021	2022	2023
Global	45.9	52.9	61.2	77.4	97.8	110.4
North America	56.6	70.1	92.7	106.8	126.0	141.8
Western Europe	45.6	53.2	72.3	87.4	105.6	123.0
Asia Pacific	62.8	74.9	91.8	117.1	137.4	157.1
Central/ Eastern Europe	35.0	37.2	57.0	65.6	77.8	87.7
Latin America	15.7	19.7	34.5	41.2	51.5	59.3
ME & Africa	9.7	11.7	25.0	29.0	34.9	41.2

Average Mobile & Fixed Access Speeds (Mbps)

Over 25 Mbps

2018	2019	2020	2021	2022	2023
51%	60%	63%	74%	80%	88%

Over 100 Mbps

2018	2019	2020	2021	2022	2023
11%	20%	24%	29%	34%	39%

Source: Cisco Systems [ii]

The Smart-Home Perspective on Today's Residential Services Market

But CSPs' opportunities now extend far beyond the demand for more bandwidth or once-promising opportunities to become multichannel video programming distributors (MVPDs). From a CSP perspective, video services are now best understood as part of a larger realm of market activity centered on all the experiences embodied in the term "smart home." This is the context CSPs will be operating in when it comes to forging a stronger role in subscriber experiences.

The smart home OTT revolution is part of a global IoT market for hardware, software solutions, and services extending across homes, businesses and institutions that was valued by MarketsandMarkets at $300.3 billion in 2021.[iii] The researcher projects the market will grow at a 16.7% CAGR to reach $650.5 billion in 2026.

Estimates vary as to the size of the residential segment of the global IoT market. Grand View Research, in a 2020 report, pegged the residential market at $42.05 billion in 2021 on a 14.1% CAGR growth path to $92.79 billion by 2026, which is just 14.3% of MarketandMarket's projection for the total market.[iv] Reflecting more recent analysis, Statista in a 2022 report says global residential IoT revenues are much higher, hitting $126.1 billion in 2022 on the way to $207.8 billion by 2026.[v]

Whatever the actual numbers might be, as Grand View noted in its 2020 report, much of the market so far has been driven by piecemeal retail purchases of smart security systems such as smart locks, smart video doorbells, and smart cameras; smart washing machines, refrigerators, and other appliances, and, most dominantly, smart hubs like Google Nest (formerly Google Home), Amazon Echo, and Samsung SmartThings Hub. While Grand View predicted hubs will be primary drivers behind market growth in the years immediately ahead, the Statista research shows a significant percentage of households in several countries, led by the U.K. and the U.S., are now relying on more comprehensive home automation systems for integrated control over smart devices (Figure 2).

Figure 2

The Global Smart Home Market

2022	2026
$126.1B	$207.8B

Smart Home Automated Systems Penetration Rates 2022

Markets	Rates
UK	33%
US	30.6%
Germany	20.5%
Australia	19.8%
S. Korea	19.6%
Canada	15.9%
Netherlands	10.8%

Markets	Rates
Sweden	10%
France	9.2%
Japan	8.8%
China	6.4%
Mexico	4.8%
India	3.3%
Brazil	2.9%
Russia	1.7%

Source: Statista [v]

As discussed in telecommunications industry circles in past years, network-based smart home automation once represented a major opportunity for CSPs, which some acted on. But superscalers became the dominant suppliers by turning their popular hubs into smart-home management centers that, with simple voice commands, could be connected to operate a limited collection of IoT devices that support open APIs. Some, like Google's Nest, went farther with cloud-based whole-home automation.

Apple, too, is upping its game after stumbling in efforts to make the iPhone the smart home control device via its HomeKit app. In June 2022, the company announced it has rebuilt the app from the ground up for use with the forthcoming iOS 16 to make it easier to find, organize and control multiple household accessories.[vi] And other OEMs are vying for a stake in whole-home automation with the marketing of smart, vendor-neutral devices like LG Electronics' Smart Security home automation hubvii and the Samsung SmartThings hub, now augmented with launch of its cloud-based SmartThings Home Life service.[viii]

Clearly, the IoT horse as envisioned five or ten years ago has left the barn. But the story doesn't end there.

The Onset of Metaverse Transformation

A new, much vaster opportunity for CSPs to take charge of User Experience (UX) is materializing with the emergence of more immersive user engagements that blur the boundaries between virtual and real experiences. If, as seems inevitable, the Metaverse label is going to be routinely applied to this new era, CSPs' perspective on what's in store should not be distorted by the restrictive meanings often ascribed to the term.

There's certainly no reason to doubt that, as proponents like Meta CEO Mark Zuckerberg claim, virtual reality (VR), augmented reality (AR), mixed reality (MR), and interactions with freestanding holograms will play a major role. But the most fundamental transformation, whether or not extended reality (XR) technology is involved, will stem from how AI-infused processing of massive data resources and cloud-based network functionalities can be combined instantaneously at any time in any place to support far more immersive personal and social engagements in a boundless array of services and applications.

As noted in a blog co-authored by Mark Rolston and Jared Ficklin, senior executives at the global design consultancy Argodesign, "The meta in metaverse refers to a universe built out of pure data," which means it "won't be realized in a closed-garden VR space. Instead, it will emerge as our digital lifestyles begin to join us in the physical world."[ix]

That will take shape across "different business models, content types, and classes of experiences," they add. "Individuals will orchestrate the interfaces for these into workflows that bring productivity, entertainment, or socialization in the manner they want. The common thread is that all of these applications will amplify the capabilities of the individual users."

Another common, if not always essential, thread will be spun out of the role video is already playing beyond the passive entertainment domain. Interactive video communications now infuse daily life, from calls with family and friends to casual engagement on social media platforms, from live-event watch parties to remote participation in game shows, from online sessions with doctors and teachers to work-at-home collaborations with colleagues, from identifying who's ringing the doorbell to spotting intruders.

Currently, all these use case categories are evolving independently, as are the use cases involving XR technology. The opportunity for CSPs centers on the fact that Metaverse-caliber seamless fluidity of immersive user engagement across all these activities won't happen without an overarching experience management layer operating in conjunction with massive amounts of bandwidth, network support for distributed intelligence, ultra-low latency, dynamic configurations of how network functions are allocated to specific service categories, and the means to maintain a consistent QoE across all devices engaged with any given service.

In other words, CSPs are in the catbird seat when it comes to anchoring the Metaverse. But in order to avoid ceding the opportunity to super-scalers and cloud-based instantiations of essential networking capabilities under control of CDN operators and other third parties, CSPs need to act immediately to secure their place as the go-to experience providers (XPs) consumers, developers and technology suppliers can depend on as the transition to life in the Metaverse accelerates.

The urgency behind the need to act now can be seen in how fast the many strands of nextgeneration internet engagement are taking hold at massive scales. Before exploring how CSPs can become the next-generation XPs the market needs faster, more cost effectively, and more comprehensively than ever before, it's useful to review how far market demand has moved the world into the early stages of the Metaverse era.

One way to think about this proto-Metaverse phase is embodied in the term "hybrid life." The Internet-based blending of remote and in-person participation in our daily routines and interactions with others has been taking shape in various categories of activity at varying levels of intensity for a long time. But, thanks to how the world has reacted to the Covid 19 pandemic, the trendlines have rapidly come together to a point where the norms of living are heavily skewed toward hybrid mixes of virtual and real experiences. Most significantly, the shift to hybrid approaches to work and education has become the center of gravity in this transformation.

The Hybrid Work Trend

By all accounts, remote work is here to stay, in some cases involving no in-office presence but in most following hybrid models with time roughly split between home and office. In a 2021 report looking at conditions most favorable to remote working in China, France, Germany, India, Japan, Spain, the United Kingdom, and the United States, McKinsey found that 20%-25% of the work forces in those countries could work from home three to five days per week in situations where work can be done remotely without loss of productivity.[x] McKinsey found that such strategies would lead to an average 30% reduction in companies' and other entities' office space requirements.

Gartner's 2021 analysis of how remote work was unfolding going into 2022 tracked closely with the McKinsey and other assessments (Figure 3). In the knowledge worker category, including writers, accountants, designers and engineers, Gartner says 51% of the global workforce will be working remotely in 2022.

Figure 3

Percentage of Employees Working Remotely at Least 1 Day/Week

By Country in 2022

Markets	Percentage
US	53%
UK	52%
Germany	37%
France	33%
India	30%
China	27%

Worldwide

2019	2022
17%	32%

Source: Gartner[xi]

In the U.S. it appears that close to half the 53% of employees Gartner describes as engaged in remote work at least one day per week are likely to be working remotely full time. In an article titled "How Remote Work Is Reshaping America's Urban Geography," The Wall Street Journal noted, "While surveys differ, as much as a quarter of the 160-million-strong U.S. labor force is expected to stay fully remote in the long term, and many more are likely to work remotely a significant part of the time."[xi]

Such predictions are being borne out as ever more companies announce hybrid work plans. A partial list of big firms making news about recently adopted long-term hybrid work plans includes Adobe, Allstate, Amazon, American Express, Apple, BP, British Airways, Capital One, Facebook, Ford, Google, JPMorgan Chase, Lincoln Financial Group, Microsoft, Nationwide Insurance, SalesForce, SAP, Siemens, State Farm, Stellantis (Fiat Chrysler), Twitter, and Verizon.

But it remains to be seen whether businesses and their employees will have access to the tools and infrastructure that are essential to getting full value out of operating in this new environment. Notwithstanding the inroads super-scalers and other outside suppliers have made in smart-home operations amid widescale use of Zoom and other videoconferencing systems, support for efficient cost-effective adoption of hybrid work strategies is still in a rudimentary stage of development.

A hybrid approach to workforce operations represents a paradigm shift that can't be accommodated by adding bells and whistles to existing platforms. What's needed is a hybrid business operations framework that can integrate all realms of activity into the everyday workflow with the same level of seamless normality that characterizes a purely on-premises work environment.

In other words, developers require support from network operations that allows them to build remote-working platforms from the ground up with no limits on scalability, quality, or functionality. For example, such platforms should make it possible for companies to:

- Scale real-time interactive video communications to include all personnel, no matter how large and far flung their workforces might be.
- Expand those interactive video connections for use by externally facing units like call centers, sales departments, and front offices to reach any number of customers, supply chain partners, investors, press people or other targeted parties.
- Integrate video communications into the flow of daily business life to a level of seamless, instantaneous engagement that does away with impediments like usage pricing tiers, virtual room licensing, formalistic scheduling requirements for every type of interaction, and manually administered join authorizations.
- Avoid the current hassles related to cobbling together whatever collaboration, recordkeeping, graphics-sharing, unified communications, and other tools companies may need to meet their hybrid operational requirements.
- Maintain A/V quality support while leveraging current and new formats to the fullest extent, starting with 1080p HD and extending to 4K and, eventually, 8K, as well as VR, wall-size displays, and holographics.

Sustaining a Hybrid Approach to Education

Similar capabilities will be required to meet the requirements of an education environment that heavily depends on remote participation. Multiple market projections portray a fast-growing global remote-learning marketplace where workers' and students' ongoing reliance on internetdelivered instruction will fuel an ever more technologically sophisticated ecosystem populated by tools, platforms and turnkey providers serving every need.

For example, ResearchAndMarkets predicts revenue generated by all these products and services worldwide will grow from $187.88 billion in 2019 to $319.17 billion in 2025.[xiii] A report from Syngene Research closely tracks with these numbers, predicting that the market will top $336 billion by 2026.[xiv]

One of the more comprehensive post-pandemic studies of the hybrid trend in education was issued by RAND Corp.[xv] In a survey of more than 375 K-12 public school districts and charter management groups, RAND's American School District Panel found that 37% were planning to make remote learning either a full-time optional alternative to in-class teaching or part of a hybrid program on an ongoing basis.

Use of remote learning in higher education, especially as it applies to providing specialized training as a supplement to more generalized subjects, is widely recognized as a permanent feature of career preparation at all types of institutions. In this environment video, including interactive communications between instructors and students, has emerged as the essential educational medium and a major force in the evolution of the remote-learning ecosystem.

On the enterprise side, ongoing training through online education tools has become a routine aspect of operations everywhere, reflecting global recognition that there's simply no other way to cost-effectively address the increasing frequency of essential knowledge updates across an expanding range of topics. The remote-learning workload now encompasses new product introductions, skill-level certifications, updated company policies on production processes and safety procedures, HR issues like sexual harassment, health protocols and ethnic diversity, and much else.

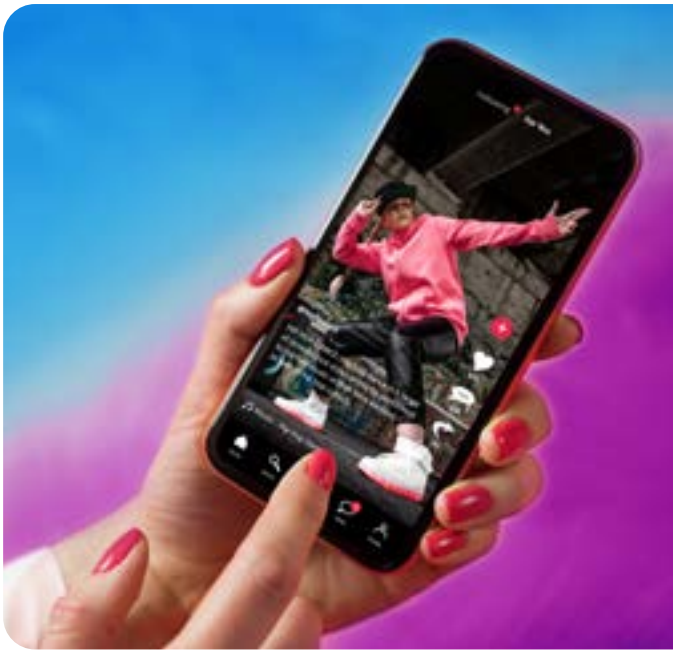
A recent global survey conducted by cloud video processing vendor Kaltura found that 91% of respondents work for companies that are using at least some video for learning and development, 64% have employers who are using virtual classrooms for live learning via video, and 69% would prefer to learn a new skill from video rather than a written document.[xvi]

As noted by Deloitte in a recent study focused on "hybrid campus" strategies, educators want to move beyond enabling basic hybrid instructional modes to blended, immersive student experiences that fuse the online and physical worlds campus wide.[xvii] This requires infrastructure support for virtual interactions, including "collaboration tools for video, text chat, discussion boards, simulations, and virtual private network connections," Deloitte says.

Hybrid Trends in Consumer Leisure Time Activity

As the trends in career and learning pursuits establish support for hybrid living as the top priority in internet infrastructure evolution, there's a parallel transition to the Metaverse occurring with consumer activities unrelated to work and education.

Social Media and Watch Parties



Ever more of the time people spend with social media, now averaging well over two hours daily,[xviii] involves video communications. For example, a big growth category is centered on community engagement with user-generated content (UGC) on outlets like Facebook Live, Instagram Live and TikTok, which allow people to register comments on received video and to respond with their own content.

An even greater force behind video-rich interactive engagement stems from the surging role of watch parties in social media and other settings for shared viewing of live sports, esports and concerts. According to a study conducted by market research firm Maru/Matchbox, one fifth of U.S. adults and a third of people in the 18-34 age bracket have participated in watch parties.[xix]

Since the onset of the pandemic major players like Facebook, Amazon, Hulu, HBO Max, and Sling TV have launched watch-party platforms supporting video chat. There's also a new crop of startups like Netflix Party, Kast and Metastream dedicated to feature-rich watch-party experiences. And video-chat-enabled watch parties are now offered in direct-to-consumer streamed productions from the NFL, NBA, soccer leagues and other sports organizations.

But, whether they're designed for watch parties or other types of video interactions on social media, most of these endeavors are encumbered by poor video and audio quality on the interactive streams. Moreover, live-event watch parties are limited by out-of-sync viewing experiences with the primary content caused by differences in per-stream latency performance. When people's comments about what they just saw are irrelevant to those who haven't seen it yet, the watch party becomes a spreader of the dreaded spoiler effect.

Livestream Shopping

Other realms of intensifying interactive engagement include livestream shopping, gambling and auctions.

Livestream shopping is a fast-growing segment of consumer product marketing that resembles traditional TV shopping on channels like QVC and HSN but with the added benefit of direct interactivity between presenters and viewers. In these new venues, pitches delivered by salespeople or celebrity hosts are streamed on platforms that support direct in-video purchasing options and chat links that presenters can respond to live as part of the webcast.

Initially popularized in China, livestream shopping took off worldwide during the pandemic as brand advertisers and retail outlets sought to overcome the decline of in-person shopping. Major players, including Amazon Live, Facebook Shops, and Google Shoploop are competing with startups like Popshop Live, Whatnot, TalkShopLive, Packagd, Very Very Shopping Network, and many more who are pursuing a wide range of innovative approaches, often with a funloving, youth-oriented slant.

The existence of these platforms and the fact that sellers and buyers are acclimating to livestream shopping as a supplement to traditional advertising, e-commerce and retail shopping in the postlockdown period appear to ensure the new trend will endure and grow. As Maira Genovese, founder of the global marketing agency MG Empower, put it in a recent blog, “Livestream shopping is changing the relationship between consumers and brands... The future of eCommerce is live.”[xx]

But livestream shopping as it is supported by most platforms today still has a long way to go to better emulate the in-store shopping experience. Interactivity with viewers is limited to text chat, and their experience of what’s happening live is bounded by streaming latencies that can vary from a few seconds to half a minute or more. The obvious next step is to enable a synchronized real-time viewing experience on the part of shoppers in conjunction with support for real-time video communications from audience members, no matter how many might be watching.

Gambling

Online gambling, too, is starting to incorporate in-stream interactive engagement. Casino-type gambling involves remotely located players that need to interact with dealers in real time. Sports betting takes on new dimensions, known as micro-betting, when people watching an event unfold in real time can all bet in advance on what might happen next.

Deregulation has unleashed a flood of casino gaming and sports betting services worldwide, driving mass market participation with betting handles reaching $74.4 billion in 2021, according to a research report from Visual Capitalist.[xxi] IMARC Group, reporting similar levels of current activity, predicts the global take will hit $131.4 billion in 2027.[xxii]

But the field is crowded with betting services, prompting market leaders and newcomers alike to find new ways to more users. For example, DraftKings, a leader in sports betting, recently introduced socialization features it characterized as “industry-first” innovations.[xxiii] Other providers, including market leaders like 888 Holdings, GVC Holdings and DraftKings, have teamed up with software developers in virtual reality (VR) technology to bring VR casinos to market.

Moreover, there’s widespread micro-betting is the wave of the future in online sports and esports bookmaking. In 2021 JPMorgan issued an advisory telling clients that micro-betting will be a major driver behind projected increases in sport betting handles.[xxiv]

But there are significant drawbacks to micro-betting strategies under current networking conditions. One has to do with the need to rely on users’ access to TV broadcasts of live content rather than enabling a holistic connected experience where they can watch the competition and bet through the same user interface (UI). And variable multi-second lag times between action on the field and remote reception gives an untenable advantage to bettors talking to someone viewing the action at the venue.

The Hybrid Approach to Healthcare

Another trend accelerated by the pandemic is growing consumer reliance on live interactions with healthcare providers as part of the vast array of in-home services offered through telehealth technology. In a July 2021 report McKinsey noted that the U.S. per-household rate of telehealth engagement had stabilized to a range of 13%-17% across all specialties.[xxv] This represented a 38x increase over the pre-pandemic norm, lending credibility to McKinsey's prediction in 2020 that $250 billion, or about 6.5% of the total U.S. healthcare spend, could shift to virtually enabled care.

This tracks with Fortune Business Insights' research offering the global perspective on market growth shown in Figure 4.

Figure 4

Global Telehealth Market

Year	(Billion USD)
2020	$144.38
2021	$173.79
2022	$209.19
2023	$251.80
2024	$303.09
2025	$364.83
2026	$439.15
2027	$528.60
2028	$636.38

Source: Fortune Business Insights[xxvi]

Telehealth devices now comprise a significant component of the IoT device market. At the end of 2021, Parks Associates reported U.S. broadband household adoption of connected medical devices such as smart thermometers, connected blood-pressure cuffs, and wireless CPAP (continuous positive airway pressure) machines had increased from 15% in 2020 to 25%. Looking at a more expansive range of connected health devices that includes smart watches, pedometers, pulse oximeters and other wearable monitors, Parks said the adoption rate was 55%.

The Growing Significance of XR Use Cases in the Consumer Market

VR, augmented reality (AR) and, longer term, mixed reality (MR) and immersive interactivity with holographic imaging will be bringing new dimensions to the Metaverse transition across multiple spheres of these and other activities. Research calculations show that, globally, adoption of AR and VR use cases across all industrial, institutional and consumer segments has taken off at very high CAGRs.

For example, Statista predicts global spending for XR content, equipment and services across all market segments will grow at a 36.72% CAGR from $28 billion in 2021 to $250 billion in 2028.[xxvii] In a report focused on the VR segment of the global XR market, Grand View Research predicted the VR market, valued at $15.81 billion in 2020, will grow at 18% CAGR to reach $59.43 billion in 2028.[xxviii]

Looking at the consumer side, a ResearchAndMarkets report offers an even more aggressive picture of market growth, predicting global spending would go from $18.3 billion in 2018 to $94.63 billion in 2023.[xxix] By this researcher's calculations, AR has had an edge on VR in the early going with the 2023 projection for the AR market at $60.55 billion versus $34.08 billion for VR.

The trendlines surrounding VR are especially significant for CSPs. While network-delivered support for AR delivered with content from the cloud is a fast-growing aspect to use of the technology, most AR apps employ local processing in smartphones to produce the effects appearing on screens with other content, including video or photos captured by phone cameras. In addition to playing games like Pokemon Go, consumers are putting AR apps to use for prepurchase looks at themselves wearing new makeup or clothes, for redesigning homes and arranging furniture, and much else.

As for VR, after years of struggle with technology issues that disappointed expectations, suppliers have turned a corner with currently implemented as well as forthcoming advances that have opened a much faster track to adoption. Mordor Intelligence recently reported the global volume of VR device shipments went from 13.48 million in 2020 to 18.04 million in 2021 on a projected course to hit 112.62 million by 2026.[xxx]

According to eMarketer, the number of active VR headset users in the U.S. jumped from 20.8 million in 2020 to 28.3 million in 2021 and will hit 32.7 million in 2023.[xxxi] The researchers said the number of U.S. consumers accessing VR at least once monthly reached 58.9 million in 2021 and would hit 65.9 million by the end of 2023.

Solving XR Head Gear Issues

Metaverse naysayers often claim that widespread public aversion to donning specialized headgear will prevent XR usage from gaining the universal traction foreseen by proponents. But it remains to be seen whether market resistance to early bulky versions of HMDs and AR eyewear like Google Glass will persist as form factors shrink.

A major force driving improvements in form factors comes from advances in systems-on-chips (SoCs) that have freed users from connecting to PCs or smartphones for compute power. Dense combinations of CPU, GPU and AI processing enable capabilities approaching those of high-end tethered HMDs, which, as evidenced by booming sales of the tetherless Oculus Quest, has resonated with consumers.

For example, Qualcomm's Snapdragon XR2 SDK, used with the recently released Quest 2, supports 4K video resolution at 120 frames per second (fps), 6K at 90 fps and 8K at 60 fps.[xxxii] The chipset offers 11 times the AI processing power of the XR1 and interacts with multiple graphics APIs to enable hardware-accelerated composition, dual-display functionality and 3D overlays.

Another contribution to reductions in AR, MR and VR headgear form factors comes from breakthroughs in display technology. For example, startups DigiLens and WaveOptics have developed eyeglass-size lenses that support fields of vision (FOVs) appropriate to XR headgear using waveguides based on the principles of light ray refraction employed in holographic systems. Facebook, too, is now developing the technology, according to Venture Beat.[xxxiii]

Made of thin transparent material, the embedded waveguides project light from micro-LEDs or other miniaturized light sources to form an image on the users' eyes in contrast to the image forming process that occurs when illuminated pixels are arrayed across a screen. For VR purposes a waveguide is paired with a liquid crystal blackout layer that blocks out external light.

Other approaches to miniaturizing XR displays are underway as well. Fraunhofer, a German developer of micro displays with high pixel densities, is a case in point, according to another Venture Beat report.[xxxiv] The company says the combination of two one-inch-square displays per eye delivers a high-resolution, 100+^{0} wide FOV, resulting in viewing experiences comparable to VR displays with headgear that is half the weight and a quarter the size of typical HMDs.

Qualcomm, in a post assessing future trends, describes the types of "sleek and stylish XR glasses" people might one day happily wear to engage with all categories of XR experience.[xxxv] The company predicts such glasses will feature multi-functional, semi-transparent lenses supporting display surfaces and telescopic viewing. Rims and earpieces will be embedded with multiple dot-size devices, including tracking and recording cameras; motion health, ambient light and thermal imaging sensors; directional speakers and microphones; image projectors, and haptic devices conveying a sense of touch in user interactions with virtual elements.

How close we are to such eyewear is reflected in the smart glasses produced by Ray-Ban for use with Facebook View.[xxxvi] This is not an XR app, but the glasses, running on Qualcomm processors, are a big step in the direction envisioned in Qualcomm's post. Billed as designercaliber eyewear, they allow people to make phone-free mobile calls, take photos, record video, and listen to music via touch and verbal commands.

Enabling Live-Streamed VR Experiences

The networking possibilities made possible by bandwidth-reducing innovations in distribution and progress on compression, rendering techniques and latency reduction are enabling fully immersive participation in multiplayer gaming and less immersive approaches to viewing sports, concerts, and other live events. In the realm of multiplayer participation, producers are seeing significant consumer engagement in everything from high-action competitions to social environments where players in avatar mode interact in virtual sports bars to play darts, paintball, laser tag and other popular games.[xxxvii]

At the same time, 360° (and 180°) VR experiences replicating in-person attendance at sports and other live events are emerging at the cutting edge of applications that are widely expected to comprise the massively interactive live event (MILE) component of the Metaverse. As an article published by The Verge put it, live VR video has become "the gateway drug between what most people watch today and the immersive era of virtual reality that is just getting underway."[xxxviii]

After some early stumbles with less-than-compelling UX, the VR 360 trend is taking hold at an accelerating pace, driven by producers' understanding that there's a real market for these services when UX meets consumer expectations.

According to results from a global survey conducted by Deloitte, well over a third of sports fans described as casual viewers and about half of those categorized as fanatics in five major sports categories said they would be more likely to watch a game if they had access to "VR front-row seats."[xxxix]

IBB Consulting, in another survey, found that a third of respondents said they would watch live sports on VR all the time if they were given the option.[xl] In both surveys, these sentiments held even though the vast majority of respondents weren't VR users.

Today services are only offered with three degrees of freedom (3DoF), which means users in any of multiple stationary virtual positions can panoramically watch and zoom in on anything in the field of play. Experts say 6DoF enabling viewers to walk around in the virtual space while taking everything in probably won't kick in until later in this decade.

But, clearly, the threshold for providing gripping VR 360 UX has been reached, as was evident in the gains achieved by NBCU with its Olympics coverage in the short span between the pandemic-delayed 2020 Summer Olympics staged in Tokyo in 2021 and the Beijing Winter Olympics in February 2022. In Beijing NBCU's VR by Xfinity app delivered 360 VR UX across over 150 hours of on-demand and live content with what was described as unprecedented clarity and immersive engagement.[xli]

One of the most significant advances involved the use of 8K UHD cameras to capture the action with resolution at 7,680 x 3,840 pixels for the VR360 feed and 7,680 x 4,320 for the VR180 signal, equating to about an eight-fold increase in pixel density over comparable 4K camera feeds. This created a high-resolution viewing experience that did away with the "screen-door" pixelation effect that occurs when content is rendered at 4K resolution on headset displays close to viewers' eyes.

Use of 8K is made possible within current bandwidth limitations by the streaming technique known as "tiling," an innovation that was used in the summer Olympics as well. Tiledmedia's ClearVR platform, utilizing an evolved version of MPEG's Omnidirectional Media Format (OMAF), breaks an equirectangular cube map encoding of the camera feeds, which is analogous to the flattening of spherical surfaces used in 2D global maps, into segments or tiles.

These are combined to create an immersive experience using only the content needed to fill the user's screen or viewport with each shift of view. Tiles are compressed and delivered at varying degrees of resolution in tandem with how the eye registers different parts of the immediate field of view (FOV) in real life so that only a portion of the stream is delivered at the highest resolution.

As a result, the Olympics 8K VR transmissions operated at just 25 Mbps using High Efficiency Video Coding (HEVC), which is less than half the bitrate required for 8K transmissions to TV sets. The 8K streams could be decoded by any device capable of decoding 4K.

Remarkably, the renderings of changes in the user's FOV happen so fast against a low-resolution backdrop of the complete 180° or 360° viewscape that there's barely any noticeable loss in quality, even at global transmission distances. This is abetted by the fact that the aggregated VR camera feeds are replicated at local CDN nodes worldwide.

BT, too, has adopted the 8K/tiling approach to delivering the expanding VR 360 portfolio in BT Sports, which soon will be incorporated with Eurosport as part of a 50-50 joint venture with the recently created Warner Bros. Discovery conglomerate. BT is also working with EE, its 5G mobile service unit, to develop new XR applications for BT Sport on the mobile side.[xlii] Along with bringing VR 360 soccer to 5G, the company is experimenting with AR overlays to conventional viewing of rugby and car racing. And it has tested standalone holographic renderings of boxing matches for viewing on tabletops in the home.

Many VR 360 initiatives have also come together on the Meta Horizon Worlds platform, which was recently introduced as part of the realignment of Oculus, Facebook, Horizon Venues, and other brands with its metaverse strategy.[xliii] Some VR sports offerings are tied exclusively to Oculus headsets, while others can be used with multiple brands.

One of the leading VR 360 options promoted by Horizon Venues was the NBA's 2021-2022 season package of 26 games. Major League Baseball's lineup of live VR and on-demand highlights have been featured as well. Other recent live VR viewing options included highprofile boxing matches from Fox Sports, Breeder's Cup horse races, several Women's NBA games, esports competitions from VR Master League, and championship squash broadcast from the Middle East.

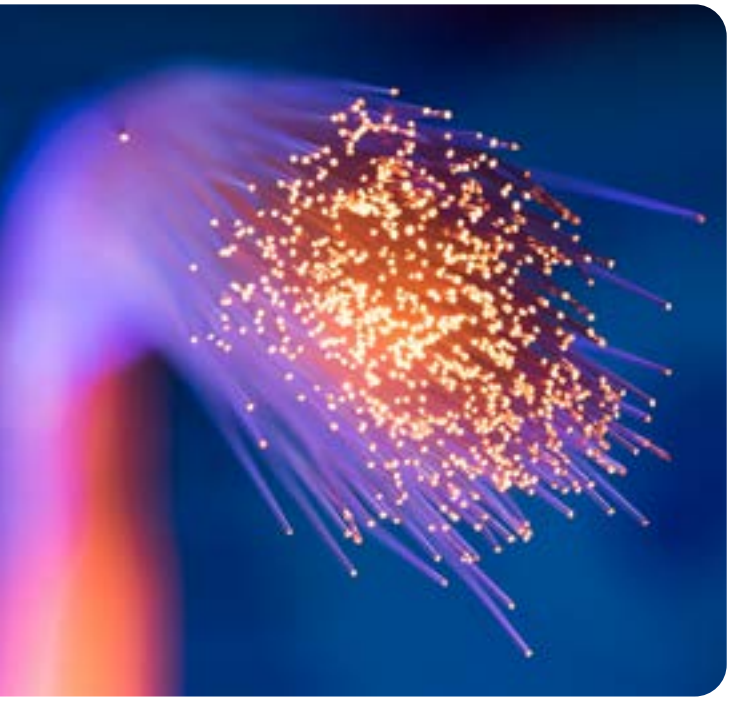
These advances leave no doubt that the path to commercialization of live VR service applications is now open. But there's every reason to expect it will take much more in the way of network performance to drive XR to the pervasive scale of adoption envisioned for the Metaverse era. In other words, complex, hard-to-implement functionalities enabling delivery of immersive experiences at 3DoF won't cut it.

This poses a real problem for expectations that it will be possible to ubiquitously enable instant entry into the compute-intensive, high-bandwidth-consuming world of 6DoF experiences over the open internet and unmanaged broadband links. Internet engineers have made great progress toward lowering end-to-end latency with highly scalable WebRTC-platforms now operating commercially in support of end-to-end latencies in the sub-500ms range. And there are deepedge strategies afoot that can bring latencies at a regional level of transport distances into the 50ms range.

But even if all the money it would take to make such network infrastructure available to everyone everywhere were to be spent on these solutions, they would still fall short of enabling the instantaneous flow of voluminous amounts of content that must be executed with each shift in a user's gaze across the 360° volumetric space. Multiple studies have reached similar conclusions as to what it will take in terms of reduced latency and bidirectional throughput to support Metaverse-caliber experiences with VR.

One of the latest assessments, posted by Meta in early 2022, asserts "[W]here graphics will have to be rendered on screen in response to where someone is focusing their eyes, things will need to move from single to low double digit ms."[xliv] Similarly, a widely cited paper produced by telecom experts from Vodafone and Huawei asserted superior VR experiences would lower the latency bar to 10ms.[xlv]

Meta didn't postulate a bandwidth estimate other than to say the level would far exceed today's broadband norms. The telecom team put the bandwidth requirements so superior quality VR viewing experiences in the range of 1-2.35 Gbps. On a whole-home level, these estimates mean Metaverse era households will be consuming symmetrical bandwidth loads running as high as 5 Gbps.



Adding to the networking challenge is the fact that the miniaturization of headset form factors will require reliance on a combination of device and remote CPU/GPU processing to handle the volumetric rendering load. Or as Meta puts it, "Enabling remote rendering will require both fixed and mobile networks to be rearchitected to create compute resources at a continuum of distances to end users." Of course, a key aspect of this involves greater deployment closer to the end user at the edge of the network (access edge) and all the way into the subscriber edge in the home.

Seen in this light, there won't be a Metaverse without CSPs taking the lead role in establishing a networking foundation suited to these requirements. As shall be seen, the network virtualization, telco cloud and orchestration tools CSPs need to provide that foundation are readily at hand.

Part 2

CSPs' Indispensable Role as Experience Providers

The sweeping scope and accelerating pace of developments highlighted in Part 1 make clear CSPs have entered a new era of opportunity where they can take the lead in delivering whatever services customers want with a quality of experience (QoE) fully tuned to their expectations.

The Urgent Need for End-to-End CSP Control Over QoE

The state of internet engagement we've reached at this stage of transition to Metaverse-caliber experiences has made QoE support the cornerstone to CSPs opportunities as XPs. Simply put, the more consumers want from internet services and applications, the lower their tolerance for subpar performance, even as their usage patterns intensify the chances that things will go wrong.

Consumer Intolerance for Poor OTT Video Performance

Many studies point to how little tolerance consumers have for poor streamed video quality. For example, research performed by video performance tracker Conviva found that 75% of online video viewers will stop watching a video within 4 minutes of encountering a poor experience, with 33% leaving the site to look for video elsewhere.[xlvi] A study produced by academic researchers reviewing behavior of 625,626 users in nine U.S. cities found that average daily viewing time decreased from more than 210 minutes for users who experience little or no buffering to less than 30 minutes for users experiencing frequent buffering.[xlvii]

Similarly, looking at over 100 billion plays across 150 video services, NPAW found the completion rate was 68% when the buffering ratio was virtually unnoticeable at just 0.2% of total playing time. At 2% buffering ratios, the completion rate dropped to 51%, which represents a 52% increase in the drop rate.[xlviii]

Another approach to gauging the impact of poor performance on subscribers was taken in a study conducted by CDN operator Akamai and Sensum, a biometric research firm.[xlix] They used tools like galvanic skin response monitors and facial coding software to compare reactions of more than 500 people exposed to one instance of rebuffering in a key scene to the reactions of an equal number who experienced no rebuffering with the same clip.

Researchers reported rebuffering caused a 16% increase in negative emotions, 9% increase in disgust, 7% increase in sadness, and 8% decrease in focus. Asked how they would react if rebuffering occurred several times, 76% of participants said they would stop using a service responsible for such experiences.

Delayed starts are a big problem as well. Online usage tracker Conviva reported delayed starts produced a 12.8% rate of complete abandonment with streamed video in 2019.[l] Consumer reactions to latency, too, have become a major issue listed as a top concern among service providers and other video professionals, as illustrated in Figure 5.

Figure 5

Top Concerns Most Commonly Cited by Video Professionals

Latency	Content Playback	CDNs
55%	50%	36%

Latency Preferences for Live Streaming

5 seconds or less	Less than 1 second
53%	30%

Source: Cisco Systems [ii], MarketsandMarkets [iii]

One study showed live-sports streaming service vulnerabilities to negative reactions are especially high by virtue of the massive numbers of simultaneous users pressuring available bandwidth. (Figure 6). Of course, it's reasonable to assume higher levels of vulnerability to customer dissatisfaction will increase as live VR streaming comes into play.

Figure 6

Subscriber Discontent with Sports Streaming Experience

Expect Bad Service Experience	Reluctant to Subscribe or Re-Subscribe
72%	63%

Types of Problems

Buffering	Start-Up Delays	Pure Picture Quality	Loss of Service
64%	42%	32%	30%

Source: Streaming Media [liii]

Clearly, there's a lot at stake for OTT video providers when they fail to meet consumer expectations, given how easy it is for consumers to switch services. Their readiness to jump to other providers, whatever the source of dissatisfaction might be, is reflected in the churn rates registered by OTT services.

The six-month OTT video service churn rate is running at 37% in the U.S. and over 30% in some other countries in Europe, Asia and Latin America, according to Deloitte's 2022 Digital Media Trends report.[liv] Parks Associates pegged the U.S. OTT churn even higher at 44% in late 2021, about nine times that of Pay TV.[lv]

High Rates of Problems with IoT Applications

There's also a great deal of customer dissatisfaction surrounding the performance of IoT services. One study conducted by Parks Associates found that over 30% of households reported problems with networked security cameras and programmable thermostats.[lvi] Even higher percentages said they had problems with smart door locks and water leak detectors.

Overall, according to another Parks study, 25% of U.S. broadband households with smart home devices experience problems on a monthly basis.[lvii] This study found that 57% of consumers with an IP security camera and 58% using smart electronic door locks or thermostats would welcome tech support services for those solutions.

The challenge is especially acute in the IoT domain, where the Wi-Fi-centric architecture must also accommodate operators' growing reliance on secondary and tertiary wireless connectivity over ZigBee, Z-Wave and Bluetooth links. Operators will need to be able to deploy gateways, Wi-Fi extenders, STBs and even remote controls that are equipped to support short-range wireless connectivity that allows for easy onboarding of any CSP-supplied or consumerpurchased IoT device, from simple sensors to complex appliances.

As hacking and the prevalence of malware become ever greater concerns in the public consciousness, security is becoming another problem for consumers in the IoT space. And for good reason. In one of many recent reports attesting to high levels of vulnerability, HP's Fortify on Demand unit says tests of ten leading retail home security systems found all of them to be woefully lacking in basic protections against hackers.[lviii]

This study followed another more general HP report that looked at ten devices across multiple IoT product types. In that research the firm found an average of 20 vulnerabilities per system, spanning TVs, thermostats, home automation hubs, alarm systems, etc. The researchers saw credentials being sent over clear text, network ports listening with root shells without a password and private data leakage as well as vulnerabilities common to Web and mobile usage in general.

Leveraging the Full Power of Wi-Fi

Wi-Fi reigns supreme as the wireless environment shaping consumers' internet experiences at home. CSPs who make that experience all it can be will be positioned to ensure consumers always have fault-free access to all the bandwidth they need going into the Metaverse era and beyond.

Wi-Fi 6 and 6E, the latest iterations to go into commercial deployment, provide plenty of reasons to be confident this is the case. And not far behind is Wi-Fi 7, on course for finalization as the next Wi-Fi Alliance standard by 2023.

Wi-Fi 6, technically designated 802.11ax, makes use of orthogonal division frequency multiplexing (OFDM) to support up to 40% higher peak data rates per client device compared to 802.11ac while improving average per-user throughput in highly congested environments by a factor of four or more. In addition, the standard expands the number of simultaneous connections on upstream and downstream links to eight, compared to one upstream and four downstream for 802.11ac, and significantly expands coverage while improving quality of performance by as much as four times at the maximum range of an access point (AP).

Critically, Wi-Fi 6 makes it possible to get closer to meeting the requirements of a new generation of M&E and IoT services. This includes a sub-channelization capability that supports dedication of spectrum segments to specific applications as well as support for implementation of service-specific iterations of user experience within the premises gateway.

Wi-Fi 6E adds the use of a third spectrum tier in the unlicensed 6 GHz band, which, in the U.S., opens a new 1.2 GHz bandwidth lane offering compatible devices about twice the capacity of the 5 GHz Wi-Fi spectrum with far less congestion to slow connectivity, Other countries allocating 6E spectrum include Brazil, Chile, the European Union, Japan, Mexico, South Korea, Taiwan, the United Arab Emirates, and the United Kingdom.

While, unlike Wi-Fi 6, 6E is not backward compatible with 802.11ac or earlier generations, the pace in production of 6E-compatible devices has set the stage for rapid uptake. There are now over 200 Wi-Fi 6E router and other products available at retail, according to the Wi-Fi Alliance.[lix]

With seven 160 MHz channels to work with, aggregate throughput available to these devices appears to be in the 4-5 Gbps range, based on real-world tests measuring per-channel data rates at close to 700 Mbps.[lx] Critically, 6E makes use of 160 MHz channels practical through spectral power density mechanisms that allow the power limits to increase with wider channels. This overcomes the doubling in noise that comes with doubling channel width, which has prevented effective use of the widest 5 GHz channel options with 802.11ac and Wi-Fi 6.

Wi-Fi 7 with initial product support anticipated in the second half of 2023 provides the bandwidth and performance support that CSPs will need to deliver Metaverse-caliber experiences throughout the home. With channel widths at the 6 GHz tier expanded to 320 MHz and introduction of a new, denser quadrature amplitude modulation (QAM) technology known as 4K QAM, peak per-channel data rates are expected to hit 5 Gbps.

For the first time, Wi-Fi 7 is bringing multi-link operation (MLO) into play on Wi-Fi, which means that rather than locking each device into a single channel, MLO can combine several frequencies across bands into a single connection. CSPs will thus be able to set up multi-band Wi-Fi channels dedicated to immersive interactive use cases requiring extraordinary amounts of bandwidth.

The Wi-Fi Conundrum

These are exciting prospects for the use of Wi-Fi to support in-home delivery of a new generation of CSP services. But there's an underlying problem with reliance on Wi-Fi that CSPs have ever more reason to address as the complexities of Wi-Fi technology and the services it's meant to support intensify.

Simply put, much of what's behind the points of customer dissatisfaction enumerated above is attributable to Wi-Fi performance issues. More than 40% of U.S. broadband households using Wi-Fi report problems with slow starts, interrupted stream flows, coverage gaps and other issues, according to a report issued by Parks Associates in 2021 (Figure 7).[lxi] Data amassed from DZS's global customer base paint an even more troublesome picture showing that the share of CSP customer calls attributable to Wi-Fi issues averages out to 70%. Elsewhere, a global survey assessing residential Wi-Fi experiences found that while full-home coverage was a top priority for 72% of respondents, only 46% reported they are getting the coverage they need.[lxii]

Figure 7

Wi-Fi Technical Issues Cited by U.S. Broadband Household

Percentage of Households Reporting:

Report	Percentage
Some Type of Problem	40+%
Wi-Fi Network Seems Slow	30%
Wi-Fi Frequently Stops Working	22%

Percentage of Households Reporting:

Report	Percentage
Coverage Gaps	18%
Hard to Connect to Internet	9%
Hard to Connect Devices to Each other	5%

Source: Parks Associates [lxi]

Other surveys point up additional aspects to consumers' experiences with residential Wi-Fi. One found that poor access point (AP) placement is the main cause of problems, however they are manifested.[lxiii] Another reported 63% of respondents with Wi-Fi problems said they called their broadband service providers for help.[lxiv] Advanced Television reported findings showing 55% of all ISP service calls are Wi-Fi related.[lxv]

All of this points to a no-win situation for CSPs when Wi-Fi networks are beyond their control. Getting blamed for such problems and having to cover the costs of handling the complaints not only impacts cash flow; it contributes to the general state of customer dissatisfaction that has left network operators at the bottom of multi-industry satisfaction rankings for years. In just one example of the trends, ISPs once again registered the lowest rating among 41 industry sectors covered in the latest compilation of consumer survey results for the American Customer Satisfaction Index.[lxvi]

In the case of Wi-Fi problem-induced calls to CSPs' customer care centers, customer dissatisfaction is intensified by poor experiences on the calls. Long delays answering calls in help centers often lead to high abandoned call rates. And, once calls are answered, more delays as CSRs try to get answers to customers' questions make matters worse, increasing dissatisfaction as well as the cost-per-call averages that contribute to excessive OpEx.

As the Wi-Fi connected device counts and video-related bandwidth consumption rates rise, these issues will only grow more damaging to CSPs without corrective action. The problem is compounded by the fact that most of the surging levels of video traffic flowing to and from mobile phones when users are at home is offloaded to premises Wi-Fi networks.

The upstream video traffic emanating from mobile phones is increasing even faster than the downstream load. With billions of smartphones, tablets, and PCs equipped with high resolution cameras and the ability to transmit at speeds exceeding 100 Mbps, social network transmission of video and photos and uploads to cloud storage are consuming ever more bandwidth, which, in the home, means Wi-Fi bandwidth.

Requirements Underlying the XP Mandate and How to Meet Them

While taking charge of end-to-end QoE is, as mentioned, the linchpin to the XP opportunity, there are many other aspects to the role that need to be brought into play through fulfillment of all the bandwidth and network functionality requirements intrinsic to keeping pace with market demand. In doing so, CSPs will gain a tremendous advantage over super-scaler and other OTT competitors as well as less nimble broadband providers in the pursuit of customer loyalty and increased ARPU.

To achieve these goals expeditiously at costs tuned to budgetary reality, CSPs must be able to:

- Exploit open-source policies and standards across every aspect of network expansion and operations end-to-end across outside and indoor facilities to ensure ongoing access to best-of-breed solutions.
- Implement network migration strategies that enable them to keep pace with advances in opto-electronic, 5G, and Wi-Fi technologies that maximize the flexibility and minimize the costs of expanding access and premises network bandwidth on an ongoing basis.
- Introduce technology that surmounts the latency limitations of unmanaged IP networks with support for ultra-low bidirectional latency that meets the requirements of the most demanding volumetric payloads.
- Take advantage of the most efficient iterations of network virtualization and cloud technology with every response to evolving needs to maximize the scalability, shared hardware usage, and other cost-saving benefits of software solutions running on commodity appliances.
- Flexibly dedicate bandwidth to specific service categories in fixed network as well as 5G slicing operations to facilitate optimal allocation of network and back-office resources within each category.
- Execute NFV instantiations and operational responsibilities across all fixed and wireless access facilities from a unified cloud-based network management layer.
- Implement distribution of computer processing across core, edge, and premises locations in ways that optimally deliver intelligence essential to each type of service as requirements evolve.
- Support accelerated DevOps in the creation, testing, launch, and modification of services.
- Orchestrate UIs to maximize customer convenience in the use of whatever services they choose with navigational support provided by the latest advances in voice, gesture, and other remote-control mechanisms.
- Implement cloud-based execution of tightly orchestrated end-to-end quality management across all fixed and wireless access and Wi-Fi premises networks with the ability to make automated adjustments wherever necessary to overcome degradations in performance levels set for each type of service or, where manual intervention is necessary, to provide technicians analysis essential to quickly identifying and remedying root causes.
- Provide robust end-to-end security across the home network and all interactions with cloud-based functionalities.

In a new first for the telecommunications industry, CSPs now have recourse to an integrated set of solutions that can satisfy every requirement defining this XP mandate for the current digital communications environment and beyond. DZS has made this possible by leveraging its expertise as a leading supplier of open-source and standards-based links, gateways and other components of fixed/mobile access and Wi-Fi infrastructure in conjunction with a suite of market-leading cloud-based software platforms that are designed to exploit the full power of NFV technology.

Figures 8 and 9 provide contrasting views of how access and premises networks, services and quality assurance are managed in today's siloed approach to operating multiple access networks and how all of this can be unified under DZS's Cloud Edge management. What this means to CSPs in terms of costs of network migration and operations management, speed and variety of customer-driven service development, and end-to-end quality assurance is nothing less than the difference between maintaining the traditional broadband transport provider role and becoming XPs at the center of the Metaverse transition.

Figure 8

How Silos Affect Transformation

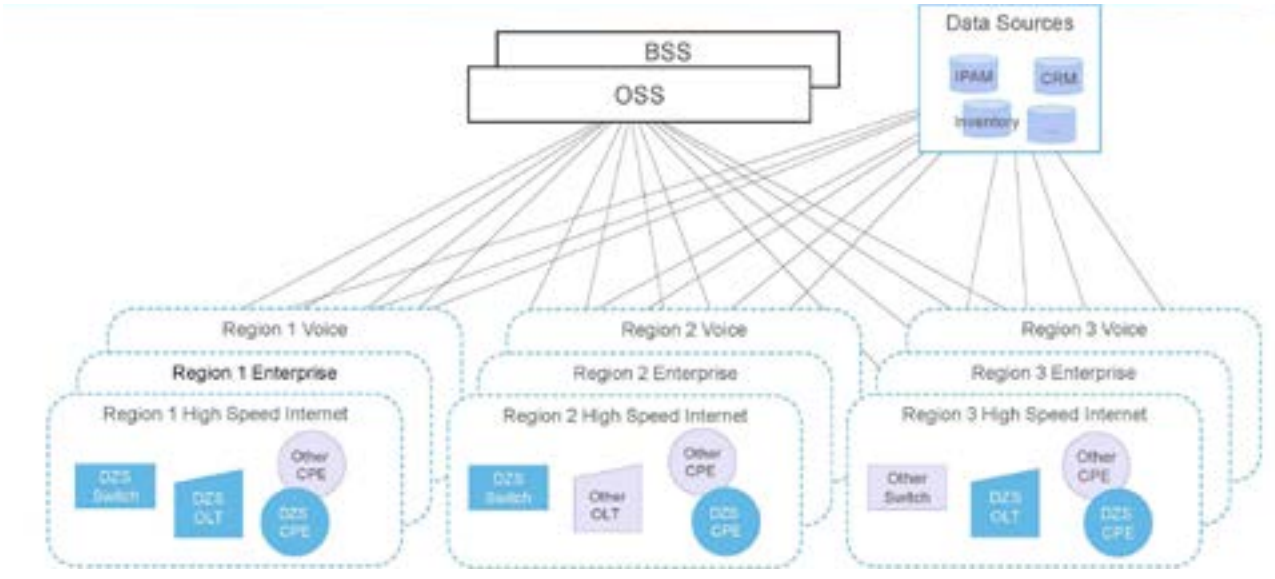
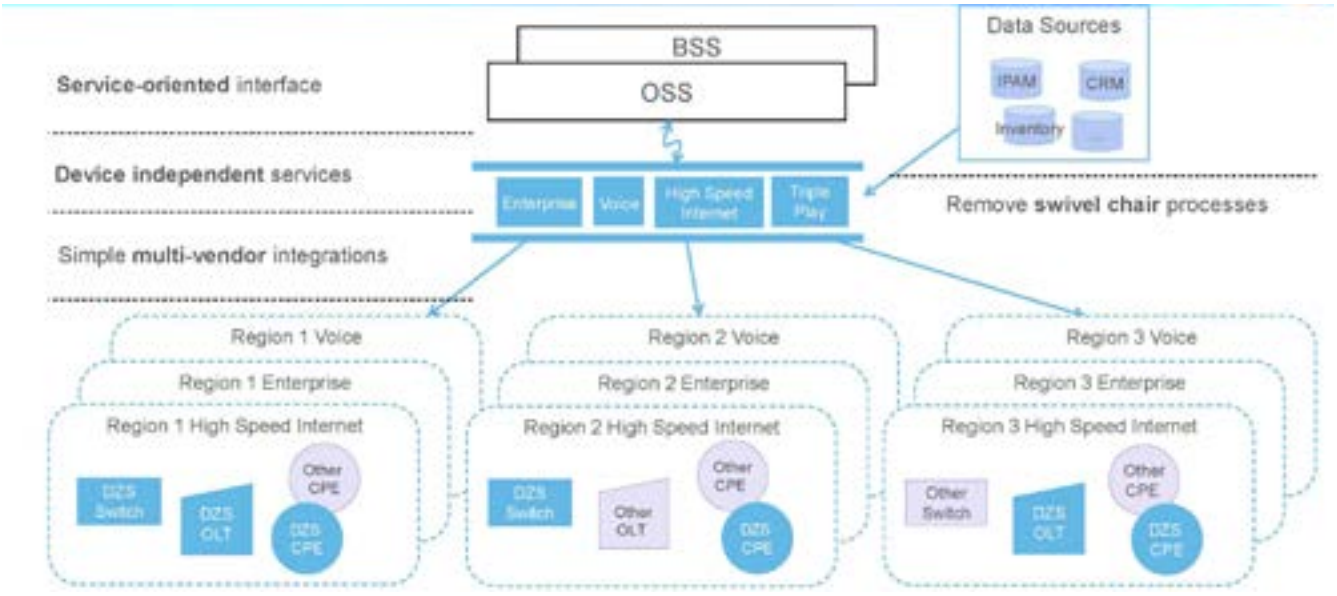


Figure 9

Service Provider Business Transformation Simplified



DZS's Cloud Edge is the first carrier-grade operations management platform to leverage standards and open-source initiatives in support of a vendor-agnostic approach to executing network and service migration with end-to-end control over QoE. The expanding roster of vendor products that can be brought under Cloud Edge management includes leading solutions competing with DZS for supply of PON and other optical infrastructure equipment, 5G platforms compliant with Open-RAN policy, and more than 150 brands of residential gateways and Wi-Fi devices. Open API-enabled integrations of DZS Cloud components with third party back-office systems make it possible for DZS customers to continue relying on OSS/BSS platforms commonly used with these network products.

Every software solution offered through Cloud Edge relies on the shared resource and scalability efficiencies of the various approaches to datacenter virtualization, including the highly flexible resource usage enabled by the Kubernetes cluster management system employed with Docker and other modular containerized approaches to assigning functionalities to hardware. This ensures that network migration as well as ongoing operations can be built on the cost-saving principles of NFV.

AI-assisted real-time collection, processing, analysis, and intelligent optimization of data is central to all aspects of Cloud Edge-managed operations (Figure 10). Customer personnel can employ single-click, zero-touch UIs using drag-and-drop access to engage with whatever management and data elements are relevant to any CloudEdge use case.

Figure 10

It's also important to note at the physical network layer, DZS is enabling the ultra-low latency and ultra-high bandwidth capabilities essential to Metaverse applications, as discussed above. The latest DZS platform release in this regard supports non-blocking throughput at 10-50 Gbps per subscriber with up to 24,000 subscribers per chassis with the option to dedicate links operating at latencies in the 10-20ms range.

Part 3

The Path to Achieving XP-Caliber QoE Management Goals

Cloud Edge solutions are divided into two broad categories that can be employed independently or together to support a tightly coupled approach to execution in their respective domains (Figure 11). NFV-based network migration together with service development, deployment, and orchestration are supported through DZS Xtreme. In addition, DZS Expresse and CloudCheck enable a highly automated AI-assisted customer-centric approach to meeting service performance requirements across all components in the access network and on-premises Wi-Fi infrastructures.

Figure 11

In future publications, we'll delve more deeply into how all the aspects to Xtreme's software solution contribute to enabling fixed and mobile network migration matched to market segment needs. Here we are drilling down on the all-important quality management capabilities provided through Expresse and CloudCheck software. But we do want to underscore a major contribution from DZS Xtreme that provides CSPs a way to incorporate multiple bespoke service streams into the data flow under QoE management implemented through Expresse and CloudCheck.

The Benefits of Bringing Slicing into the Fixed Access Domain

When CSPs take advantage of the opportunity to implement orchestrated use of Cloud Edge solutions, they can set their QoE mechanisms to accommodate the nuances of the multiple service verticals enabled by the transport partitioning mechanisms implemented through Xtreme. Basically, DZS has designed Xtreme to expand the benefits of 5G-like slicing to all fixed broadband access infrastructures.

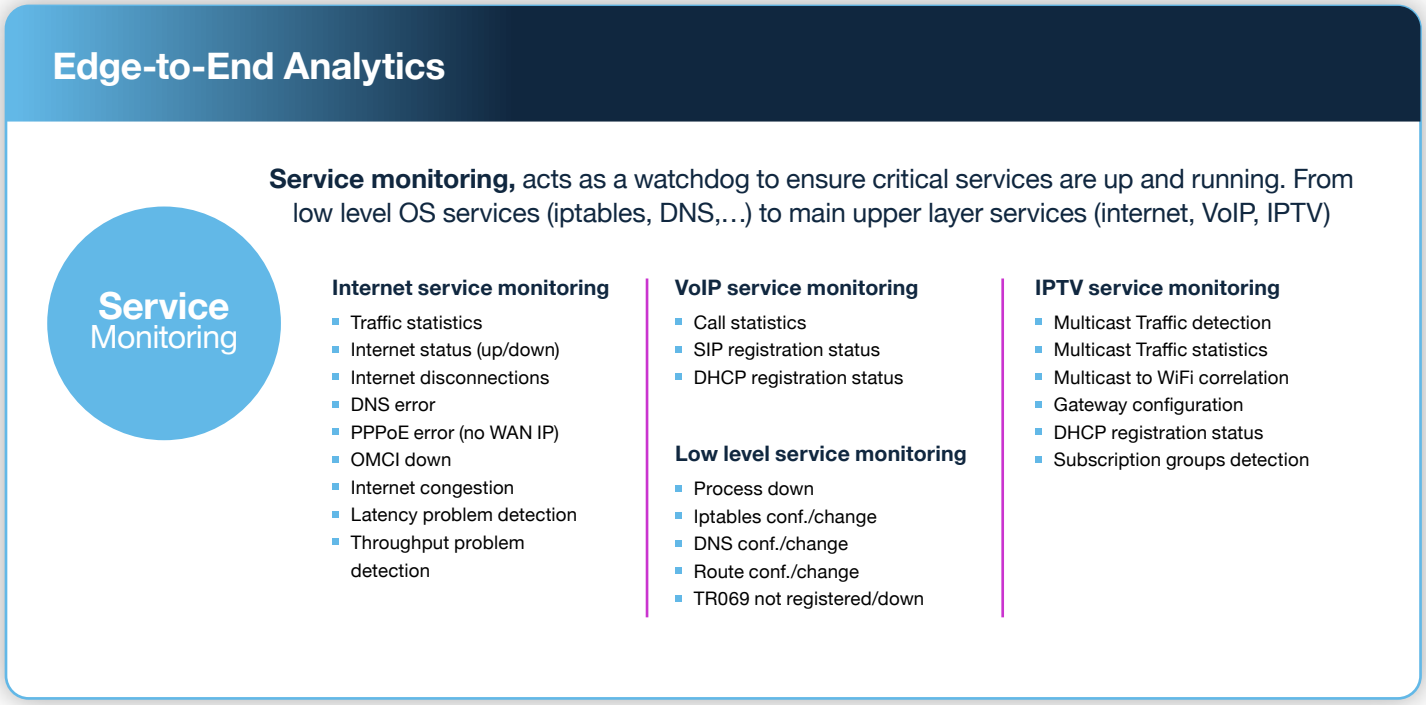
Slicing as executed through 5G NG specifications utilizes frequency, time, or code space partitioning to create logically independent virtual conduits supporting all the functionalities specific to each service category. In contrast, Xtreme applies bandwidth spectrum slicing to create similarly dedicated logical flows over fixed networks.

While the approaches to slicing differ within the respective fixed and mobile domains, Xtreme makes it possible for operators to consolidate the design and implementation of service verticals on a single platform. With access to the specific performance requirements of each vertical through the interface with Xtreme, Expresse and CloudCheck are able to gauge their monitoring, analytics and mitigation capabilities to ensure optimal QoE across all verticals. This is fundamental step in CSPs' ability to step into the XP role with far greater flexibility to build ARPU through their own branded service offerings than they've ever had.

The Vendor-Agnostic Approach to Maximizing QoE End to End

Whatever mix of services is in play, Expresse and CloudCheck software provide CSPs a holistic automated approach to ensuring QoE end to end across all service categories, including all types of internet applications and services as well as managed digital voice and IPTV. Figure 12 lists a sampling of the results aggregated from the end-to-end analysis.

Figure 12



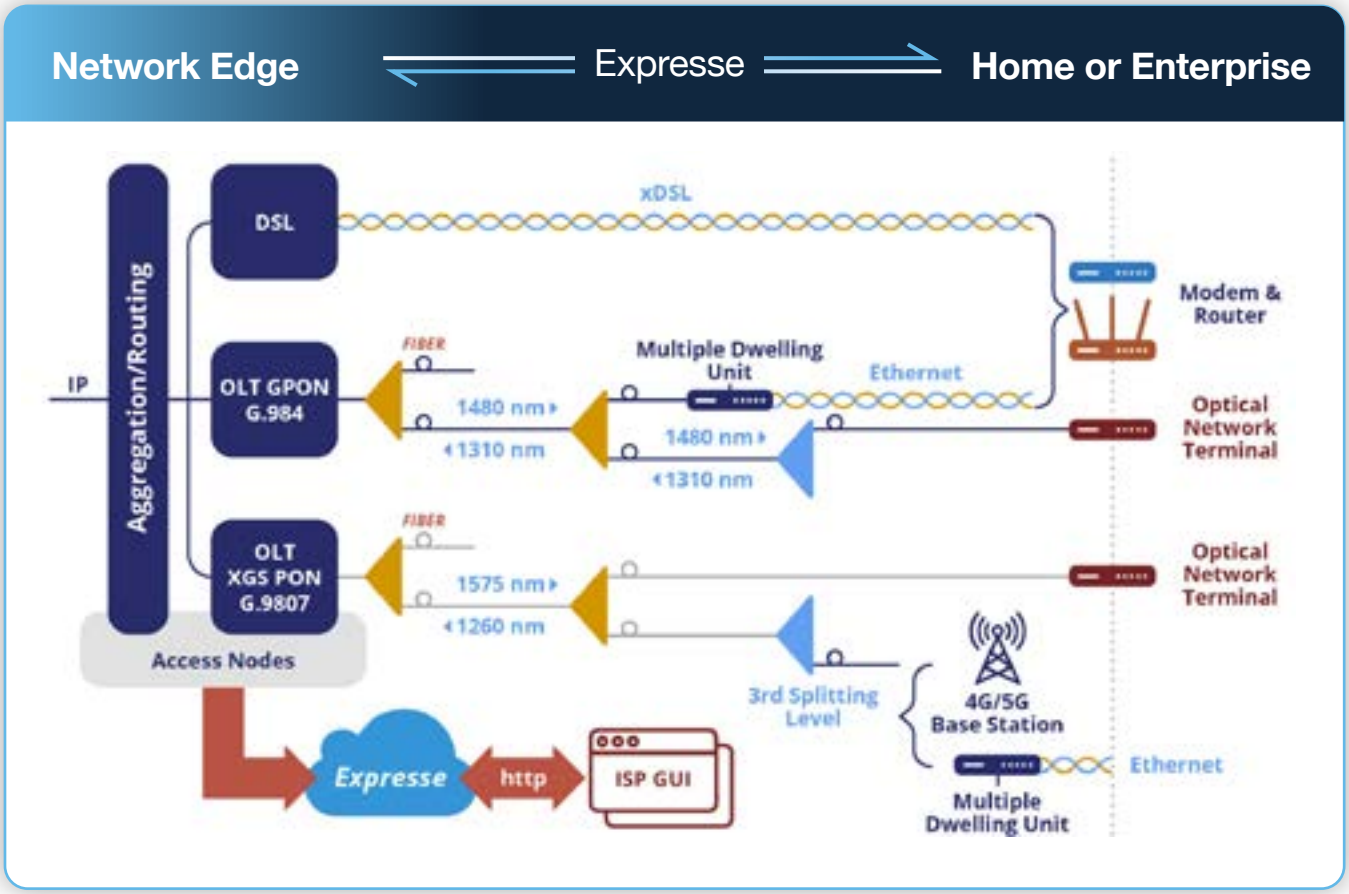
Drawing on data from all monitoring points Expresse and CloudCheck instantly analyze the way issues at any point are contributing to subpar end user experiences and automatically apply the remedies that are best suited to mitigating the problem. At the same time, AI-assisted analysis of the monitoring data facilitates technicians' ability to take proactive measures before emerging problems have a noticeable impact on users' QoE.

Unified QoE Management Across all Access Networks

Expresse executes quality assurance uniformly over all broadband access infrastructures, including xDSL, xDSL+fiber, GPON and XGS-PON. The platform has been breaking new ground in virtualized open-network territory since 2010 when former owner ASSIA introduced vendor-neutral DSLAM Dynamic Spectrum Management (DSM) software as the industry's first commercial instance of what became known as NFV.

Today Expresse optimizes QoE with real-time monitoring, diagnosis, and resolution of the many types of impairments to performance occurring across the primary connections in multi-vendor access networks (Figure 13). With DZS's commitment to advancing Expresse in tandem with new generations of access technology, CSPs can be assured they'll be able to sustain comprehensive unified control over quality management across all facilities no matter what migration paths they choose to pursue.

Figure 13



The Ideal Approach to Achieving Whole-Home QoE Management

As described in Part 2, Wi-Fi poses an especially stiff challenge as well as a big opportunity for CSPs. Often the issues stem from the fact that consumers purchase some or all of their Wi-Fi gear from retailers, in which case CSPs who implement a managed Wi-Fi service will likely benefit, even if they charge for the service. Research conducted by Qualtrics found that 78% of surveyed U.S. and U.K. consumers prefer receiving their Wi-Fi equipment from their ISPs and 77% would be willing to pay an extra monthly fee for a managed Wi-Fi service.[lxvii]

But the fact that the CSP provides the Wi-Fi equipment doesn't necessarily lead to the sustained QoE consumers expect. That can only happen when the provider has a way to execute automated control over whole-home performance, which is best accomplished through implementation of CloudCheck. CSPs can employ CloudCheck with any vendor's Wi-Fi gateways and APs as long as they comport with the prplMesh Foundation's open-source, carrier-grade and certifiable implementation of the Wi-Fi Alliance's Multi-AP EasyMesh specifications.

The Drawbacks to Reliance on P2P Wi-Fi Architectures

The carrier-grade implementation of EasyMesh capitalizes on all the features that have made mesh architecture the superior choice over P2P architectures, including daisy-chained configurations of gateways and off-the-shelf extenders as well as newer hub-and-spoke topologies.

While the latter leverage gateway intelligence to gain more control over whole-home performance through direct communications between each AP and the hub, they retain many of the vulnerabilities of older systems that rely on 802.11 repeater technology known as Wireless Distribution System (WDS). WDS allows the extenders to boost the gateway-generated signals but at the cost of reducing overall network throughput.

Like mesh systems, managed hub-spoke systems are designed to orchestrate link communications to the benefit of the whole, which means they have the intelligence to shift devices or, in Wi-Fi parlance, stations to better AP connections if the closest one is overloaded with traffic. For example, to avoid the drain on throughput caused by reliance on WDS with extenders, the newer systems rely on extenders operating as full-fledged APs that can regenerate rather than just boost the signal, which means the extenders must read client addresses as stations come into range.

This poses a problem in the case of most smartphones, which secure the addresses from outside access. Moving them to a different AP terminates and delays resumption of the data flow until the phone app reconnects the device with the Wi-Fi network.

Moreover, in cases where stations are shifted from the first point of connection to a closer AP as they are moved around the home, it's often not a seamless process, which results in an interruption in the signal flow for a few seconds as the transfer to the new AP is consummated. Similarly, hub-and-spoke systems have the intelligence to shift stations to better AP connections if the closest one is overloaded with traffic. But the systems' reaction times are delayed by the need to aggregate and analyze what's happening at each end point between AP and station before executing decisions affecting each link.

A big issue left unaddressed by most of these Wi-Fi platforms is interference from neighbors' APs in dense dwelling environments and from microwaves and other non-communications devices that operate in the 2.4 GHz spectrum range. This is even a problem when dual-band stations or, in the case of Wi-Fi G6, three-band stations are in play, because, if left alone, a dualband station running at 2.4 GHz will stay there.

The drain on throughput caused by "bad apple" stations is another headache for Wi-Fi infrastructure with limited intelligence. These older devices aren't designed to shift to the closest AP and, therefore, continue pulling their bandwidth from the point of initial connection, which uses ever more AP radio power at the expense of throughput to other stations as the offending device moves farther away.

Another cause for inefficient use of resources is the freedom of multi-band stations to choose which band to connect to, 2.4 GHz,5 GHz or, with 6G, 6GHz. Sensing activity on the higher band and none on the lower, they often choose the latter, even though there's plenty of space for them at 5 GHz, which serves to cut off space for single-band stations operating at 2.4 GHz.

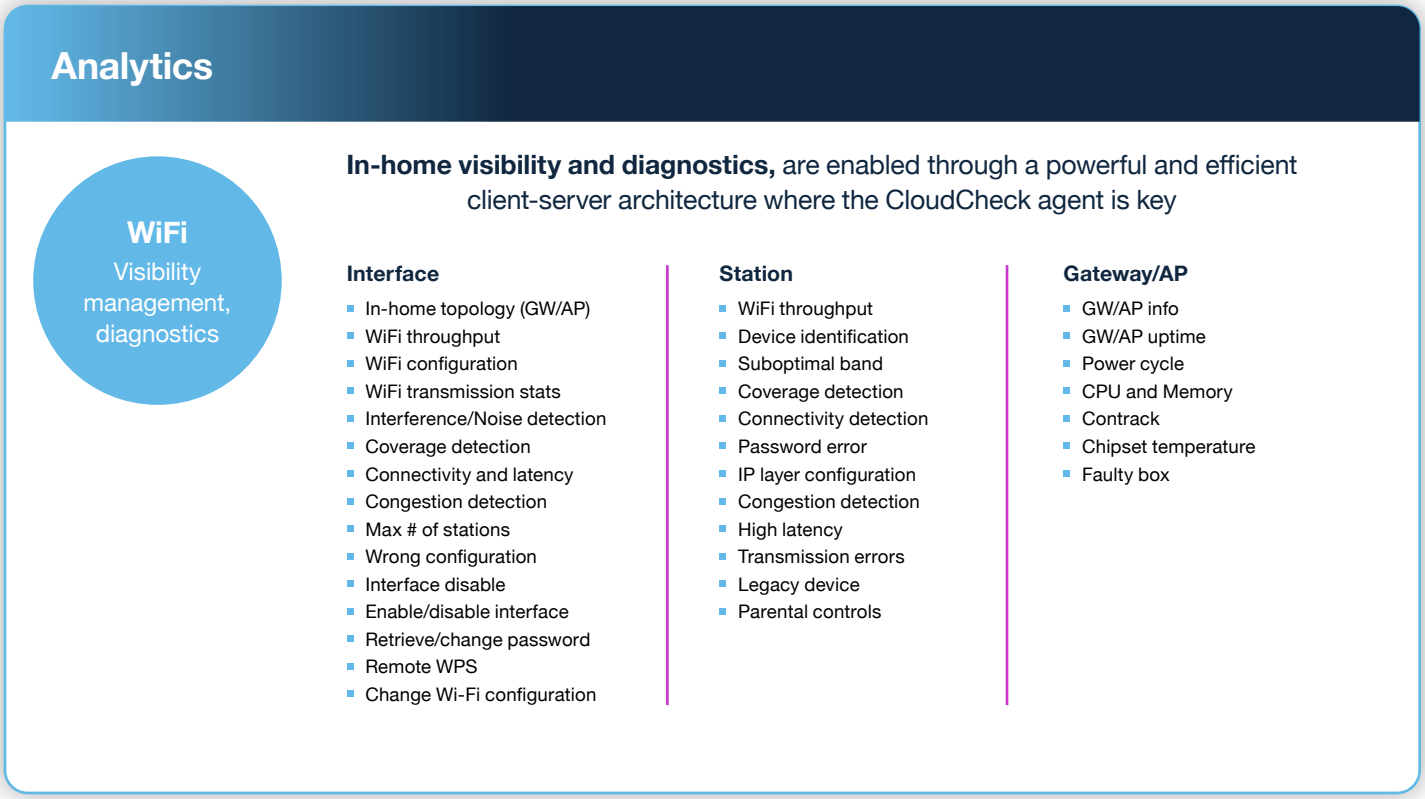
The New Level of Performance over prplMesh Coupled with CloudCheck

A prplMesh-compliant Wi-Fi network makes it easier to reduce the QoE threats posed by these issues. Software links the gateway and all other APs together for holistic execution of all the functionalities that go into ensuring optimal connectivity of all stations everywhere in and around the home. Data critical to optimizing connectivity is directly shared among APs for processing by the system controller without requiring handoffs to and from the gateway.

Moreover, the standardized approach to orchestrating any-to-any AP connectivity in a prplMesh network creates an environment ideal for maintaining quality control through a cloud-based monitoring and management platform. prplMesh, like everything else relevant to the Cloud Edge solutions, supports open-network interfaces, including a high-level API enabling external quality management control over the prplMesh software stack. The specifications also support interoperability across a wide variety of Linux-based router OSs as well as Intel, Qualcomm, and other hardware platforms.

CSPs will need what only CloudCheck can provide in a vendor-neutral context to maintain QoE adequate to the needs of the emerging Metaverse household. The platform provides an unparalleled scope of analysis to the data generated from the CloudCheck agent's monitoring of CSP subscribers' prplMesh networks (Figure 14). This applies to all generations of currently deployed Wi-Fi technology, including 6 and 6E. And CloudCheck will evolve as needed to work equally well with Wi-Fi 7 and succeeding generations.

Figure 14



When a prplMesh-compliant Wi-Fi network is deployed with CloudCheck, the CloudCheck agent monitors the shifting demands for broadband, VoIP, and IPTV streams across all active stations. Analysis performed by CloudCheck in real-time determines which primary frequency band and which in-band frequency channel should be used with each transmission so that individual link performance is always optimized in the context of achieving optimal performance across all active links.

As stations are moved around the premises, the system ensures they automatically and seamlessly change AP connections accordingly. Any time a new AP is added, the map is automatically adjusted to ensure the benefits to overall network performance are fully realized.

A major contribution to optimal resource usage stems from how CloudCheck performs perstation band steering based on proximity to APs. When a station is close to the AP, it is steered to the 5 GHz interface to maximize throughput; when relatively far from the AP, the station is steered to the 2.4 GHz interface to improve coverage.

Stations are switched to clear channels whenever there is interference, which is especially important to consistent performance in MDU and other environments where there is heavy Wi-Fi usage nearby. And in the case of bad apple devices, the software orchestration of devices on the mesh network makes it possible to force the bad apple to connect to the nearest AP.

There are many ways CSPs can adjust policies governing use of CloudCheck to meet their goals. As listed in Figure 15, these many policy-setting options provide CSPs the flexibility essential to keeping pace with evolving household needs and device characteristics.

Figure 15

WiFi Policy Optimization

WiFi
Optimization for single-AP, multi-AP and MDU

WiFi and service optimization, are designed to automatically improve customer QoE. A set of ML algorithms that decide next best action in real-time.

Wi-Fi single household

Single AP - Interface
- Channel optimization
- WiFi driver restart
- Station or SSID prioritization (ATF based)
- Device/service prioritization based on relevance

Single AP - Stations
- Band steering
- Station de-authentication
- Block/unblock station

Single AP – Gateway
- Router reboot
- PPPOE restart
- TR restart
- SIP restart

Multi AP – Interface
- Topology optimization
- Configuration propagation
- Coordinated channel change

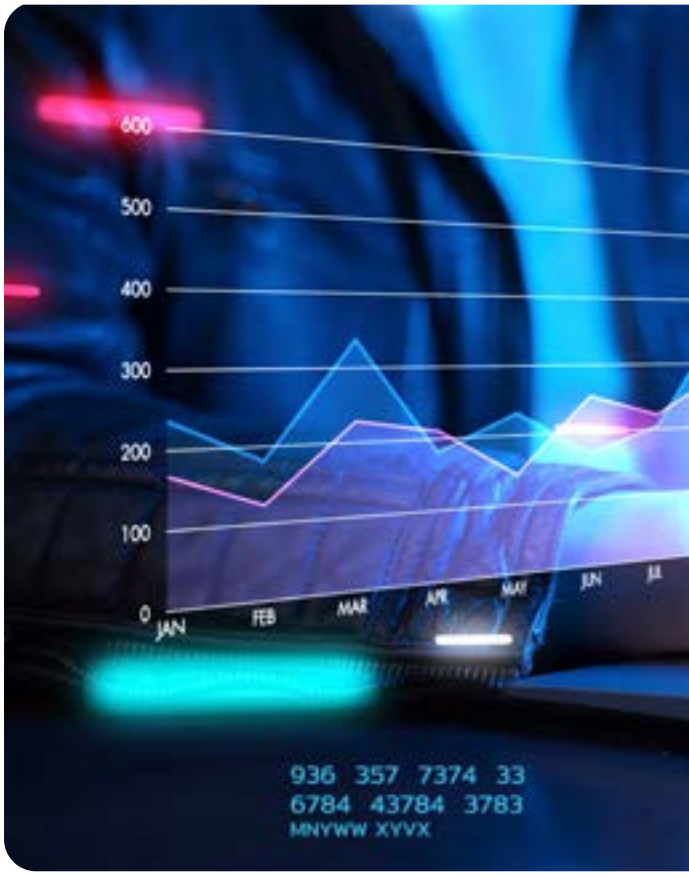
Multi AP – Stations
- AP roaming

Multi AP – Gateway
- Onboarding
- Auto-grouping

Wi-Fi MDU - multiple household

Single or Multi AP
- Coordinated Channel optimization
- Beacon and package rate management
- Transmitted power
- Auto-grouping

Complementing the automated functionalities orchestrated by CloudCheck, the platform also employs its AI-assisted intelligence to generate actionable insights into key performance indicators (KPIs) via a set of standard reports designed for specific teams and business functions. Customer care teams, starting with CSRs and extending to all technical troubleshooting tiers, use the information generated by diagnostic algorithms performing real-time analysis of data generated by premises equipment as well as any data generated from outside plant via Expresse.



Call agents can troubleshoot connectivity issues with either the CloudCheck Wi-Fi GUI or by pulling data into their own operator monitoring tools via a northbound API. With guided flows, agents can also assist subscribers to troubleshoot issues themselves. If field technicians are required, they can use the CloudCheck Wi-Fi GUI for verification during install or service validation on repair calls.

Reporting also enables operators to take action to improve the subscriber experience before issues generate complaint calls. Operators can put programs in place to contact the subscriber proactively and/or utilize the information provided in the complaint.

The impact of these recommendations can be reported based on data gathered from tracking calls/dispatches, net promoter scores (NPS), and customer churn. Reporting can also be used to inform upsell strategies by identifying and ranking subscribers who would benefit from faster service speeds and, in the aftermath of upsell initiatives, by providing insights on effectiveness.

CloudCheck can be used to generate many other types of reports as well. These and other additional benefits gained from use of CloudCheck are detailed in this white paper.

Conclusion

The world's progress toward a seamless flow between consumers' engagement in real and increasingly immersive virtual activities has reached a point where the scale, pace, and coherence of what comes next heavily depends on whether CSPs take the lead delivering the experiences everyone is looking for.

The accelerating transition to what's commonly known as the Metaverse era is already pockmarked by skyscraper-high silos driving consumer dissatisfaction to new heights. The intensifying disarray is fueled by legions of cloud-based entities who, lacking any anchor in network facilities, are nonetheless competing to produce the advances in network intelligence, consolidated smart-home service management, and persistent quality of experience that can be readily achieved by CSPs who are prepared to take on the mantel of Experience Providers.

Until now, CSPs have been largely content to ride the revenue tide driven by insatiable market demand for ever more bandwidth. Any thoughts of taking on a more aggressive role as providers of value-added services have been dampened by the daunting costs and uncertain prospects of battling OTT competitors against the backdrop of what they've already lost in the premium video turf wars.

However, there's a new perspective on what CSPs can accomplish with regard to both the costs and the likelihood of success beyond the boundaries of "dumb pipe" operations. Bandwidth, of course, remains the indispensable cyberlife stream that only CSPs can deliver. But now they can assume the role of indispensable Experience Providers by creating a customer-driven service environment that Metaverse activities can thrive in.

Prospects for success are sky high. CSPs have the facilities, from core datacenters and central offices to neighborhood poles and pedestals to premises-mounted terminals and CPE, to accommodate the pervasive computing infrastructure that will bring the Metaverse to life. They have the relationships with the entire population of 4+ billion connected consumers that can be leveraged to their advantage.

And, for the first time, they have access to a multi-faceted cloud-based network and services management platform that empowers them to eliminate their own silos in a holistic, portal-based approach to enabling the Metaverse transition. Through utilization of the SaaS solutions hosted in the DZS Cloud, CSPs are free to move forward on a pay-as-you-go basis and free of vendor lock-in with consolidated network migration and activation of whatever services and applications customers need.

Critically, with the support of end-to-end quality management provided through the DZS Cloud software solution, CSPs can act immediately to implement the level of QoE across all services that consumers are ever more hard-pressed to find as their connected devices multiply and time spent using them surges. By establishing the foundation for a new level of customer loyalty, CSPs will be well positioned to take on the role of bringing a new realm of service experiences to life in the Metaverse.

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