



Bell Labs Consulting

The edge exponent

The future of edge infrastructure,
partnerships, and the impact on
communications service providers

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Contents

Executive summary	3
Why edge matters	4
Edge as the new battleground	7
Maximizing value through partnerships	14
A case in point	20
Future begins now	24
Authors	26
Acknowledgement	26
Acronyms	27
Reference	28

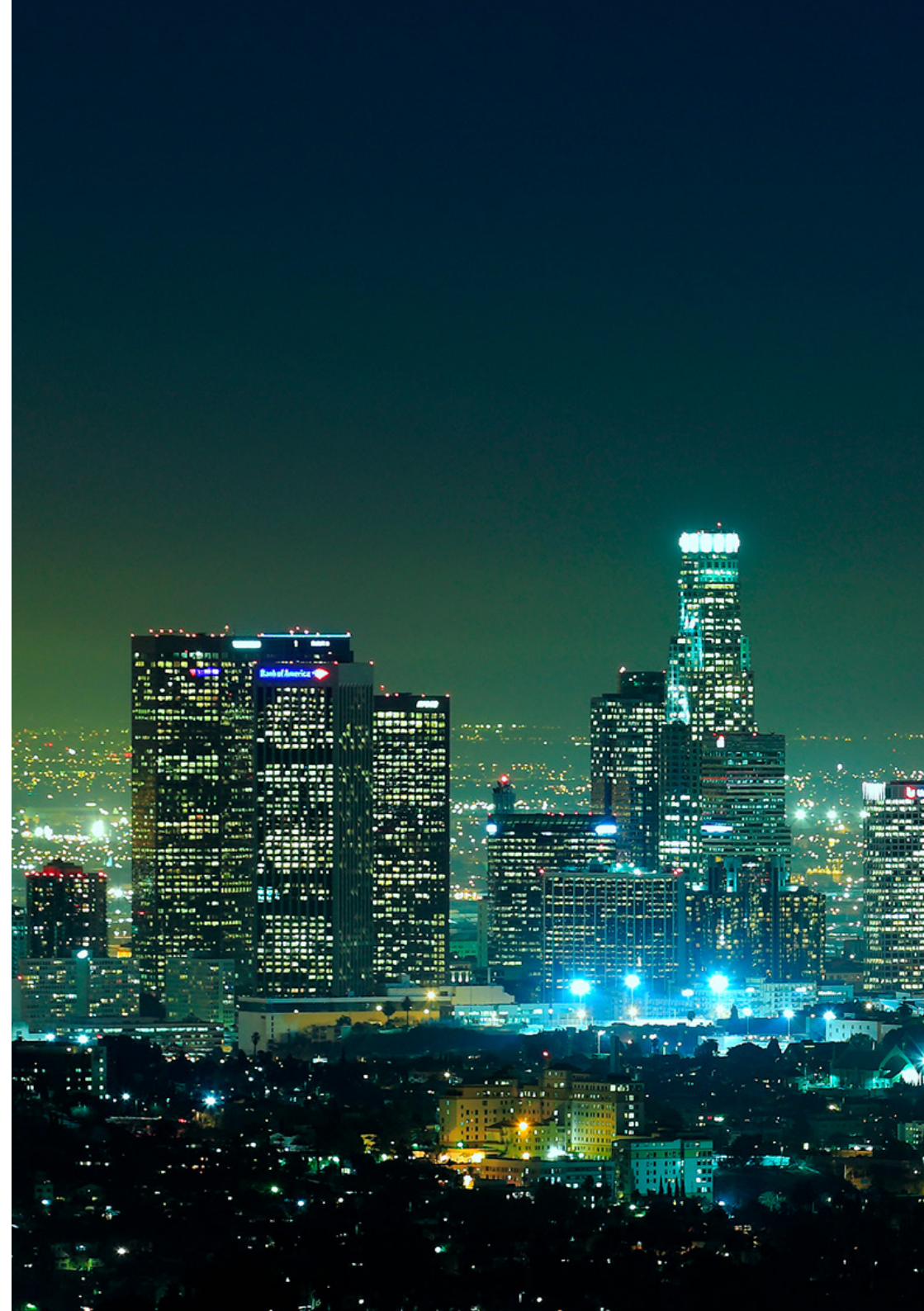
Executive summary

Bell Labs Consulting predicts the future economic order will be underpinned by rapid technological advancements in high performance networking, edge clouds and associated AI systems [1]. Future 5G architectures will see cloud, compute and connectivity all collapse into one tightly integrated localized edge fabric. This fabric will be foundational in digitalizing businesses, automating industries, and servicing local communities, spurring new levels of productivity growth with inclusive digitally augmented labor force participation.

However, achieving this will require massive roll-out of distributed edge cloud nodes, across cities, in every metropolitan area, communities with integrated service stacks capable of supporting new hyper-spectral sensory devices, new computing systems, new intelligent thinking systems (AI), new physical actuation systems and new on-demand production systems — all enabled by the power of local edge infrastructure.

This opens a unique new avenue for those CSPs that are local and trusted to go big, unleash a CSP edge-dominant strategy and claim a significant role across the entire edge architecture value stack: networking, sites, cloud platform, high performance cloud network functions and applications through far edge to capture a sizable share of a \$2.7T global edge-enabled opportunity.

We take a closer look at the emerging market trends, the critical nature of the edge and the imperative for CSPs to adopt an exponent mindset, take charge, strike optimal partnerships with other industry actors, and re-write their economic future by enabling a secure 5G edge — a plug-and-play connectivity plus compute infrastructure capable of running and monetizing industry solutions and realizing an up to 2X lift in enterprise revenues by 2030.



Why edge matters

As communications service providers (CSPs) seek increasing participation in enterprise digitalization, they recognize the stringent requirements it will impose on network performance. The emerging low-latency and/or high-bandwidth services, such as interactive AR/VR applications, industrial automation applications, and massive IoT data processing will require distributed network presence closer to devices. Moving high-bandwidth applications to the network edge also lowers costs by avoiding expensive traffic backhaul.

From a network perspective, the edge is the meeting point of the WAN and LAN, as well as other administrative domains resulting from hybrid and multiple clouds. Many current technological advances — such as Open RAN — require network functions to be placed and scaled at the edge to meet the required performance criteria. The optimal disaggregation of RAN functions into RU, DU and CU components to create multiple fronthaul and midhaul options, as well as the placement of near-real time

and non-real time RIC functions and MEC applications, requires strong edge presence.

The central clouds and core networks will play a critical role through these technological advances for providing rapid scalability, high processing capacity, end-to-end security, and resilience.

As the end-to-end network depicted in Figure 1 shows, the edge comprises multiple domains — the on-premises cloud at the enterprise edge located at or very close to enterprise sites, the far edge cloud at the CSP network edge and the metro edge, deeper into the network. While CSPs have dominated far edge and metro edge locations, cloud service providers — or web scalars such as Amazon Web Services (AWS), Microsoft (MS) Azure and Google Cloud Platform (GCP) — are rapidly building on-premises presence through platforms such as Outposts from AWS and Azure Stack from MS Azure.



Deconstructing the edge infrastructure

Edge integrates two clouds: the network-and-platform cloud and the services cloud, as shown in Figure 2. The network-and-platform cloud resides on top of the network infrastructure layer comprising physical media and radio and data center sites. It consists of the cloud infra layer for providing virtualization hardware and software for computing and storage. The cloud platform layer is responsible for runtime execution support through orchestration and management of the cloud infra layer; it also provides application enablement, artificial intelligence/ machine learning (AI/ML) and analytics, digital operations, and dynamic security. Cloud-native functions (CNFs) enable the underlying network, and applications functions generate the required enterprise services.

Figure 1. The end-to-end network and edge domains

		On-prem Cloud	Far Edge Cloud		Metro Edge Cloud	Central Cloud
Location	Devices	On-prem sites	Cell towers	Hub sites/ Central Offices	Regional sites	Central sites
Count	Billions	Millions	~100,000	~4000	~100s	~10s
Distance	0 km	0-5 km	<10 km	20-40 km	200-400 km	1,000-10,000 km
Latency	Instantaneous	<50µs RTT				

Source: Bell Labs Consulting

The services cloud includes infrastructure services, comprising compute and storage offerings, platform services, comprising IoT enablement functions such as device management, device data gathering, API management, cloud security and analytics, and enterprise applications,

comprising both common applications, such as collaboration and communication tools, and specialized applications designed for specific enterprises and verticals.

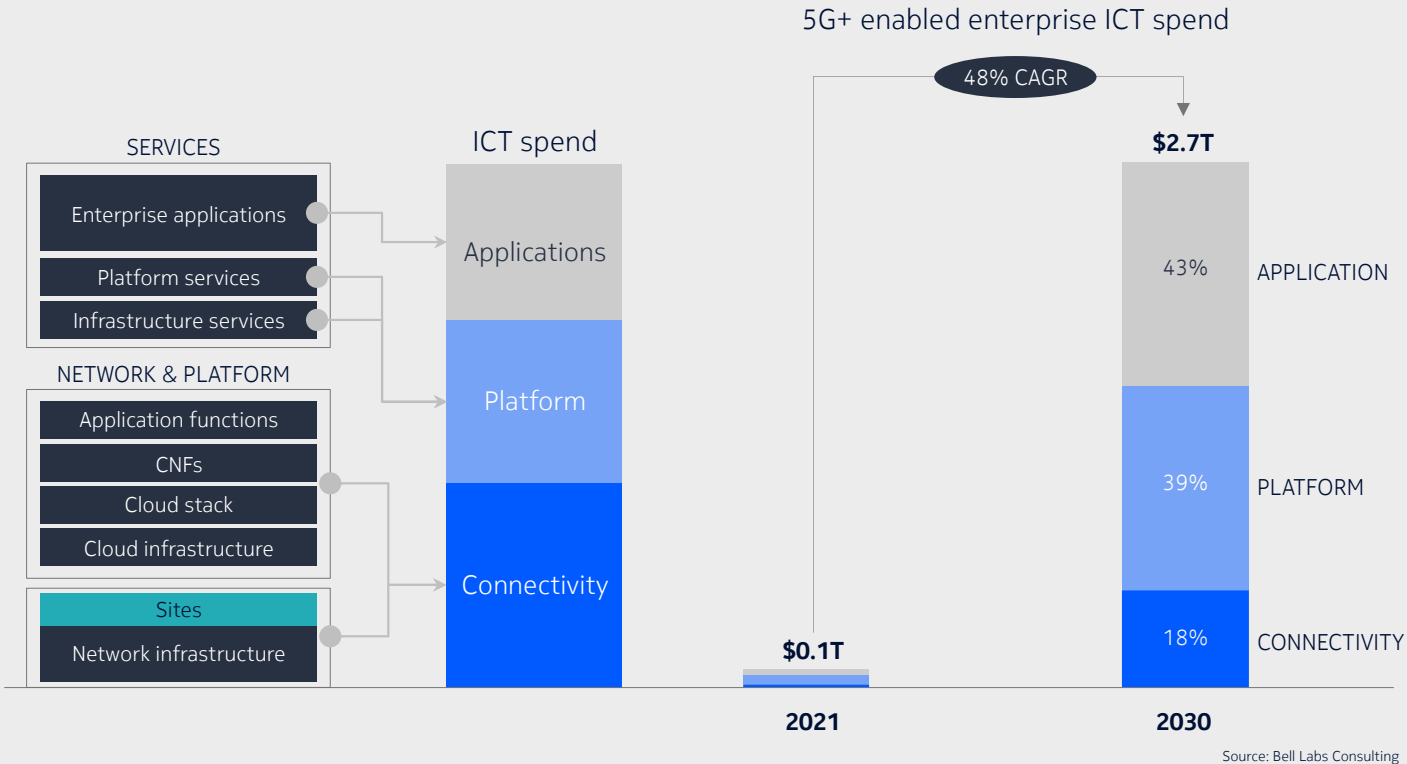
Figure 2. The edge stack and enterprise ICT spend

Enterprise ICT spend on 5G+

In an earlier study on The big inversion [1], Bell Labs Consulting introduced the 5G+ suite of technology enablers, which augment and work with 5G connectivity to digitalize every aspect of a company’s operations. These key technologies include edge clouds, private networks, augmented intelligence/machine learning (AI/ML), end-to-end security, advanced sensors, robotics and network-as-a-service business models. We argued that they would be the key drivers of enterprise digitalization in the next decade. Consequently, global 5G+ driven ICT spend will significantly increase during this period to reach \$4.5 trillion annually by 2030.

Figure 2 show that the edge will drive 60% of this spend, or \$2.7 trillion annually by 2030. The application layer will grow the fastest, increasing its share of 5G+ driven ICT spend to 43%. The platform layer ICT spend will represent 39% with investment in platform services seeing strong

growth in the initial years leading to 2030. The estimated connectivity share will be 18%, driven largely by strong private network buildout over the next decade.



Edge as the new battleground

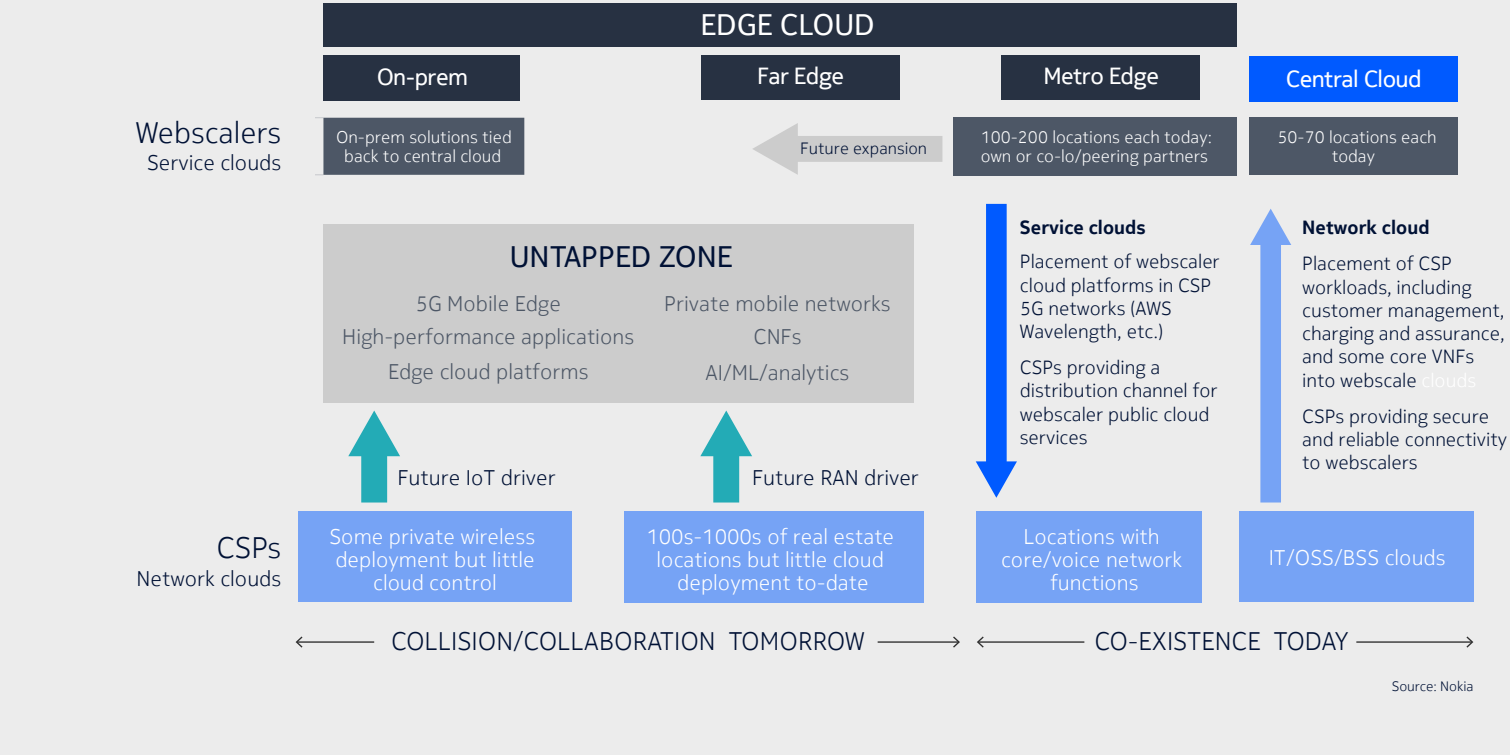
Led initially by AWS, but now increasingly joined by Microsoft, Google, Alibaba, IBM and a host of other companies, cloud services have underpinned the development of enterprise digitalization. Web-scalers have thrived in this environment by providing on-premises compute and storage platforms, easy application migration to the public cloud, and an extensive application developer ecosystem. CSPs have not fared as well; instead, they have watched the public cloud infrastructure expand into the telecom network and gradually take over some network core functions as shown in Figure 3. Much of the initial interaction between CSPs and web-scalers has focused on utilizing each other's strengths based on a vendor-buyer relationship. Many CSPs, such as AT&T and Telecom Italia, have migrated their internal IT applications and some BSS and OSS functions to the public cloud for better economics and greater scalability, while web-scalers have used CSP networks to connect their enterprise customers to their respective clouds.

While today, CSPs and web-scalers have found niches to work with each other to mutual benefit, their paths will collide as they each look to dominate untapped domains such as 5G-based mobile edge, AI/ML/analytics, and private networks as shown in Figure 3. These domains are exactly the enablers that will be driving the growth in 5G+ driven enterprise ICT spend discussed above. It is no surprise that the CSP-web-scaler intersection will occur at the network edge.

CSPs are well positioned to take advantage of this emerging opportunity. In addition to their ownership of 5G network connectivity, they also have distributed presence close to enterprise locations through their central offices (COs) and radio sites, which can be readily converted into edge infrastructure nodes. They have a local and long-standing relationship with enterprises as providers of traditional voice and data services. However, they have been stymied by a lack of cloud expertise and application developer base, and an inability to scale rapidly.



Figure 3. The CSP-webscaler intersection



While many leading CSPs are addressing the skill gap through new hires [2] and reskilling programs [3], they need to scale up their cloud services significantly to attract a large pool of application developers. This will require rapidly adapting their traditional network operations and maintenance practices to the changing needs of cloud services and overcoming resistance to experimenting with new business models. Their strong reliance on traditional vendors for technological advances has meant that the pace of network innovation is limited by the slow, deliberate new product release process adopted by these vendors.

Webscalers have been quick to start filling this void. In addition to working directly with enterprises to set up on-premises platforms such as Outpost and Greengrass, they have also been collaborating with CSPs to embed their compute and storage platforms such as Azure Edge Zone and AWS Wavelength at the network edge. All major webscalers have announced partnerships with CSPs to

launch their services from within their networks. Seen in conjunction with the application development ecosystem they bring, this underscores the near-term value boost for CSPs through webscale partnerships, but also the formidable threat in the long term if specific value contribution and risks from partners are not fully understood.

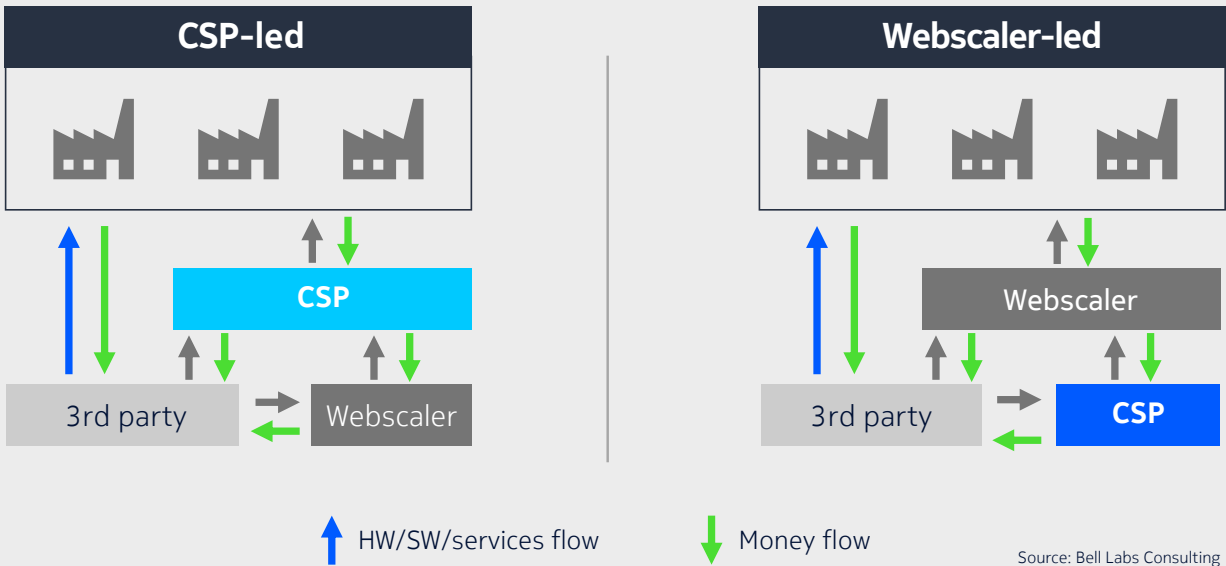
The CSP-webscaler intersection will result in one of two outcomes. In a competitive scenario, they will vie for

the same business opportunities by offering similar services to the same set of customers. Alternately, in a collaborative scenario, they will become partners and offer services jointly. Third-party players such as AI/ML analytics providers, application developers, integrators, managed service providers and neutral access providers play a critical role in influencing the outcome of this intersection. While they make independent contributions

of their own to the 5G+ enabled edge, they can also strategically alter the roles that CSPs and webscalers play in both competitive and partnership scenarios.

We discuss the competitive scenario in this section and the collaborative scenario after.

Figure 4. The emerging alternative customer engagement scenarios



Source: Bell Labs Consulting

Competing enterprise engagement models

To best characterize the competitive CSP-webscaler scenario, we consider two enterprise engagement models: CSP-led and webscaler-led, as shown in Figure 4. While there are other models such as enterprise-led and third-party-led deployments that capture alternative modes of how CSPs and webscalars can engage with enterprises, we focus on these first two models to best characterize the factors that favor the individual dominance of these two players, as well as the resulting impact on their revenue share.

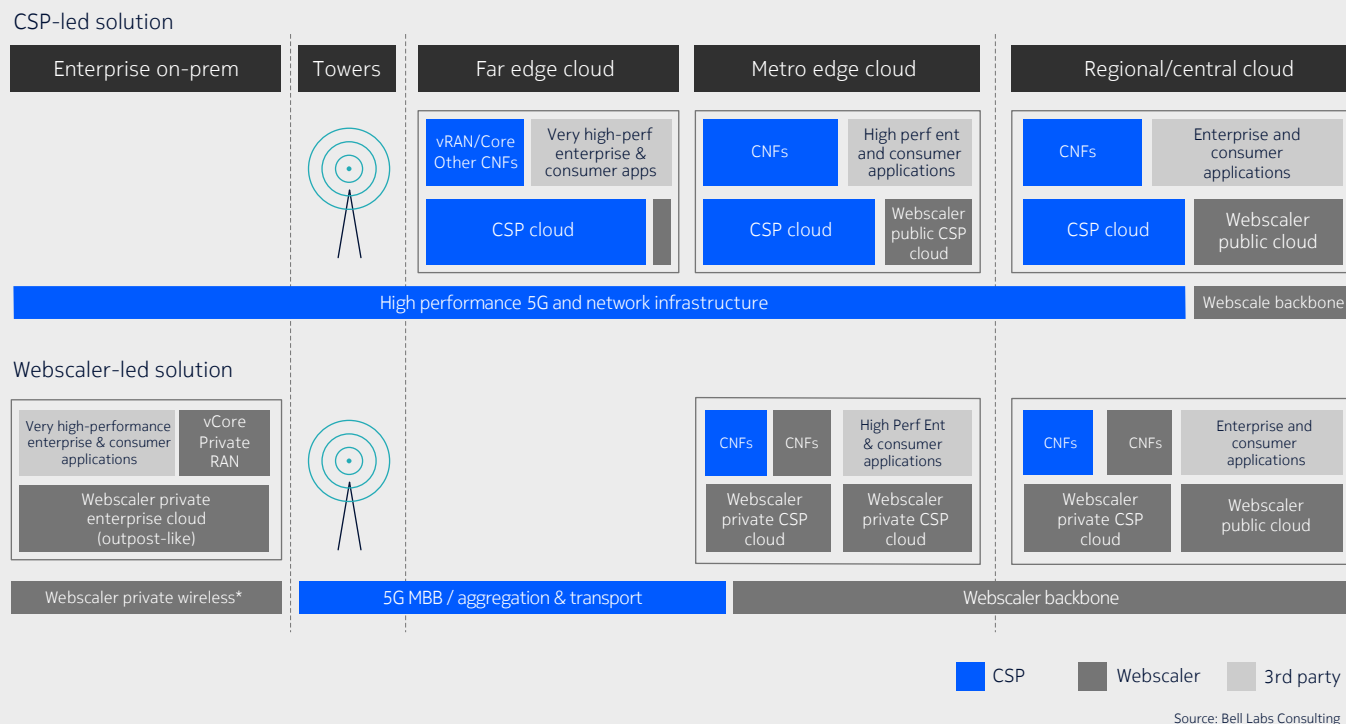
The CSP-led model reflects the traditional (and currently prevalent) structure in which the CSP owns the enterprise relationship for telecom services. The CSP manages the solution comprising the services stack, and the network and platform stacks and is also tasked with bringing in the necessary third-party support for

application development and solution optimization. Consequently, it has a significant share of the revenue stack, which reflects not only its share of deployed resources and services, but also its contribution to solution performance and service innovation.

Figure 5 shows the reference architecture of an example CSP-led solution that highlights the significant network edge presence and limited on-premises presence that these solutions typically entail. As shown in

Figures 4 and 5, webscalars can be a part of the CSP-led solution in the role of a vendor. The CSP plays the dominant role, potentially maximizing its revenue in the end-to-end solution.

Figure 5. Architecture of example CSP-led and webscaler-led solutions



ability to implement new commercial relationships and business models to maximize monetization opportunities. Other major CSP characteristics include its cost efficiency built upon its internal assets and an efficient ecosystem and network proximity to the enterprise customers through distributed edge presence. In many cases, customer trust, built by CSPs through years of dependable association, can be the deal clincher for CSP-led models.

While these requirements are central to a sustainable CSP-led model, most CSPs fall short of meeting them. Barring a few exceptions, they have been slow to adopt cloud-enabled virtualization as they grapple with retiring legacy infrastructure and workforce reskilling. They also face internal constraints to adopt new business models and develop innovative services at speed. While many of them have achieved significant network cost reduction, they haven't reached the scale of webscalers and can't drive comparable efficiencies in their cloud platforms.

Factors shaping the engagement model

An enterprise's preferred engagement model is determined by the CSP's intrinsic characteristics and environmental factors like market dynamics, regulatory intervention, and global developments. Table 1 depicts the Bell Labs Consulting's Cloud Navigation Framework that presents the various attributes of these four factors and shows how different realizations of these factors

support one engagement model over another. For example, a CSP with a market-dominant position is favored to engage in a CSP-led model, whereas a CSP with a weak market position is more likely to be associated with a webscaler-led model. The overall viability of each of these two models for a given scenario is determined by considering attributes across all factors.

The CSP's market position — in terms

of its product and technology leadership, price competitiveness and service support — plays a key role in determining the viability of the CSP-led model. Key CSP attributes also include its cloud proficiency — indicated by its ability to rapidly introduce and scale new services through cloud-based deployment — a service portfolio supported by a strong application and platform development ecosystem and the

Table 1. Bell Labs Cloud Navigation Framework

Factors	Attributes	Attribute realizations supporting	
		CSP-led model	Webscaler-led model
CSP characteristics	Market position	Dominant	Underdog
	Cloud proficiency	High	Low
	Service portfolio	Broad, innovative	Traditional; limited
	Cost efficiency	High	Low
	Network proximity	High	Low
	Customer trust	High	Low
Market dynamics	Strength of webscaler presence	Low	High
	Speed of cloud service adoption	Gradual	Fast
	Enterprise service requirements	High performance Highly customized	Limited customization Highly scalable
	Private networks adoption	Fast; widespread	Fast; widespread
Regulatory intervention	Need for local presence	Strong	Weak
	Data sovereignty	Mandatory	Not mandatory
	Financial support	Strong incentives	Few incentives
Global developments	Covid-induced disruption & recovery	Major disruption; slow recovery	Limited disruption; rapid recovery
	Impact of trade wars	Major impact	Limited impact
	Geopolitical events	Leading to tighter regulation	Minimal regulatory impact

However, many of them, especially the larger operators, have strong edge presence, and they enjoy trusted customer relationships.

Under factors, market dynamics address the strength of the competition — from CSPs, webscalers and enterprise private networks — and the market’s propensity to rapidly adopt new services. Many CSP attributes discussed above can be applied to evaluate webscalers’ strengths. While leading webscalers score high on cloud proficiency, service portfolio innovation and platform cost efficiency, many of them currently lack global presence and network proximity. However, they are rapidly addressing these shortcomings through on-premises cloud platform deployments, such as AWS Outposts and Azure Stack, and developing alliances with CSPs to co-locate their platforms at CSPs’ edge nodes, such as AWS Wavelength and Azure Stack Edge. Adoption of private networks can significantly impact both CSP-led and webscaler-led models, with a higher

impact on the CSP-led, as webscalers often provide the cloud infrastructure and public cloud services as part of the private network buildout.

The pace of cloud market adoption indicates enterprise readiness and willingness to switch providers for digital services. Sustaining a CSP-led model is difficult in a fast-moving market given the typical cautious and deliberate approach to new service creation and new business model adoption of CSPs. On the other hand, this model will thrive in a market with a strong need for stable, customized, and high-performance services.

Regulatory intervention manifests itself in multiple forms, but it could favor the CSP-led model. Strong data privacy and localization laws that mandate physical presence in local markets could rule out many webscalers located outside the country and region. Similarly, data sovereignty requirements prohibit data sharing with entities having foreign ownership. Government incentives to local CSPs in the form of tax breaks or financing

are examples of other, subtler forms of regulatory intervention.

Similar to regulatory intervention, global events with long-lasting and widespread impact tend to support local solutions, which typically favors the CSP-led model. Local enterprises and regulators are unsure how their concerns will be prioritized by global webscalers in the wake of these events. Take Covid-19 as an example. As nations enforced strict control over their exports, they created serious supply chain disruption that impacted many countries economically [4] [5]. Having learned their lesson, these countries are likely to increasingly rely on local solutions during the recovery phase. Global trade wars have a similar disruptive impact on global supply chains as they drive nations towards adopting more isolationist policies.

On balance, given the significant lead that webscalers have established over CSPs in terms of their cloud proficiency, platform cost economies, developer ecosystem and general service innovativeness, the CSP's

intrinsic characteristics strongly favor the webscaler-led model. Market dynamics also tend to support the webscaler-led model, although a slow-moving market could provide CSPs more time to catch up with the webscalers. The countervailing dimensions that can move enterprises towards CSP-led models are the trusted relationships built by CSPs, regulatory intervention and disruptive global events. In some regions, these dimensions are critical enough to outweigh other considerations for selecting the best engagement model.

Impact on CSP share of ICT spend

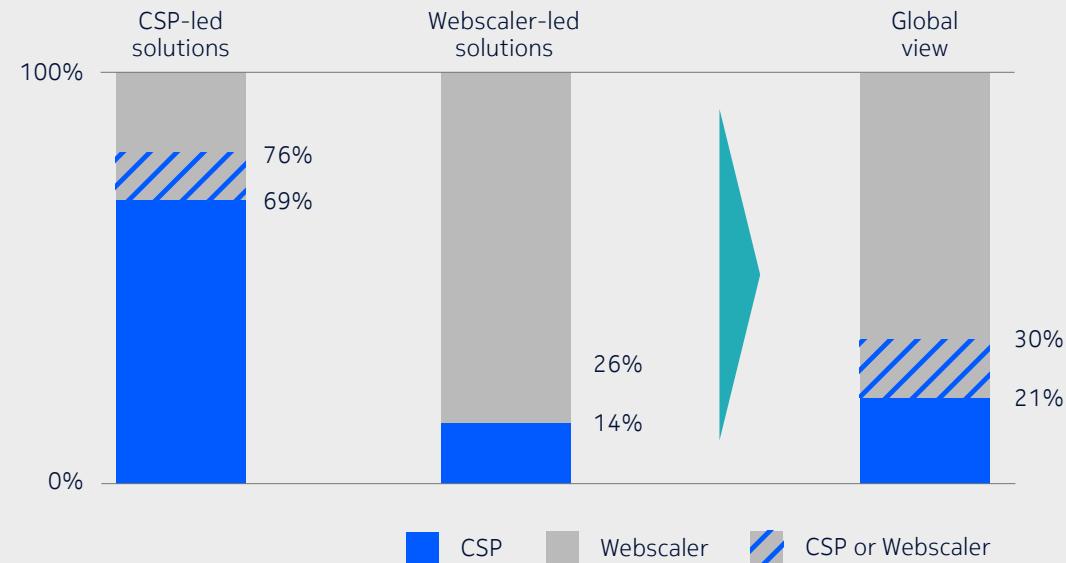
The prevalent engagement model is based on a CSP-led solution for traditional voice and data services. CSPs typically have the dominant share of connectivity, managed services, and integration revenues. They may also have significant application revenues and, depending on their cloud proficiency and cost efficiency, a substantial share of cloud infrastructure and platform revenues as well. They also benefit from their

role as the prime, customer-facing supplier of the end-to-end solution. As a potential vendor to CSPs, webscalers have a smaller share of revenues — limited largely to providing cloud infra and platform services.

Webscaler-led solutions can alter this revenue share mix significantly. Increased use of on-premises solutions and enterprise-owned private networks will diminish the CSP's share of connectivity revenue. While webscalers will dominate platform revenues, they will also capture a significant share of application revenues through their vast ecosystem of application developers. Enterprises are also likely to rely more on third parties for integration and managed services. CSPs will still play an important role, but it will be greatly diminished.

Figure 6 shows the impact of this shift in the revenue share between CSPs and webscalers as it applies to the edge-based 5G+ related enterprise ICT spend on telecom services — including connectivity, cloud

Figure 6. Share of 5G+ enabled, edge-driven ICT spend on telecom services



Source: Bell Labs Consulting

infrastructure and platform, applications, managed services, system integration, network operations and customer service. In order to clearly bring out the distinction between CSP-led and webscaler-led models, we consider the revenue stack to be split only between these two players. Consequently, we do not explicitly address third-party share of revenues; instead, we regard it as being subsumed within CSP and webscaler shares.

We estimate that a CSP's share of this revenue in 2030 will range from 69% to 76% in a CSP-led model, depending upon the strength of its characteristics, the market factors and the regulatory environment captured in Table 1. This share can drop to a level of 14% to 26% in a webscaler-led solution as the CSP's role is largely limited to being the connectivity provider.

The global view of CSP revenue share considers the scenarios likely to emerge by 2030 across all regions. Given the critical role of regulatory

considerations and geopolitical developments in the sustainability of CSP-led solutions, we note that this model will continue to dominate in China and the MENA region. On the other hand, regions that promote greater openness, such as the US and UK, will likely see a significant growth in webscale-led solutions. Straddling these two regions are countries, such as Germany, Japan and India, who have yet to adopt a definitive policy that balances data sovereignty and

protection with greater openness and efficiency. The "global view" shown in Figure 6 reflects a mix of these three segments; we estimate that CSPs' probable share of edge -based 5G+ driven ICT spend related to telecom services will range between 21% and 30% in 2030.

Maximizing value through partnerships

The alternate, more constructive approach in this advance to the edge is a mutually beneficial partnership between CSPs and webscalers. As network and platform functions are progressively disaggregated and services become more customized and nuanced, the CSP-webcaler partnership is likely to be the more sustainable outcome.

CSP-webcaler engagement models

CSPs and webscalers can engage with each other in multiple ways. We categorize their interaction along two dimensions: engagement relationship captures the depth of engagement, and engagement scope refers to the range of functions covered by the alliance. Figure 7 outlines the four models that result from this categorization.

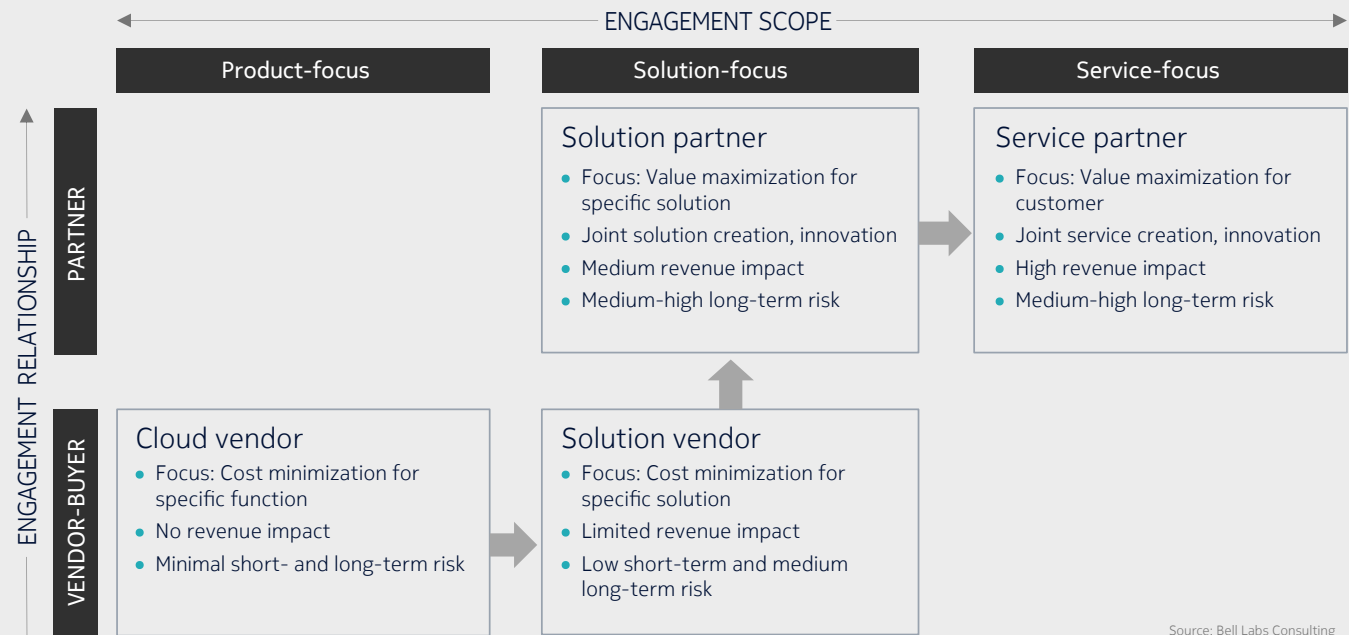
The Cloud Vendor model represents the most basic engagement between CSPs and webscalers in which they share a vendor-buyer relationship. Their interaction has a short-term, transactional focus, and vendor

selection is driven by cost, quality, delivery reliability and other operational considerations. The scope of engagement is limited to a specific set of functionalities with well-defined specifications laid out by the buyer who is also responsible for overall product innovation. The use of public cloud by several CSPs for their internal IT applications is a typical example of the Cloud Vendor model.

The Solution Vendor model is similar to Cloud Vendor in that CSPs and webscalers are in a vendor-buyer relationship with a transactional focus on cost, quality, and operational metrics. Solution innovation continues to be the buyer's responsibility; however, their interaction spans a broader set of solution functionalities; thus, the sustainability of their relationship over a longer time span is an important consideration. An example of the Solution Vendor model is the Telefonica-AWS alliance in which Telefonica Business Solutions will make use of the AWS cloud offering



Figure 7. CSP-webscaler engagement models



portfolio to enable digital transformation for their enterprise customers [6].

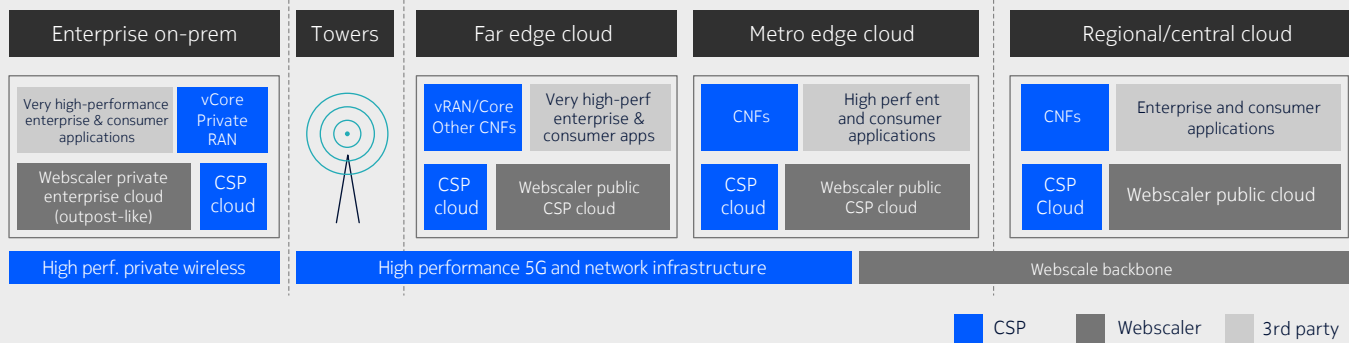
What separates the two partnership models — Solution Partner and Service Partner — from the two vendor models is the synergistic collaboration between CSP and webscaler to create new value for the partnership and/or the customer. In the Solution Partner model, this collaboration focuses on joint creation of a solution that they can offer application developers and use for their own operations. The partnering CSP and webscaler jointly determine the best way they can play to their respective strengths, address each other's weaknesses, and bring in the right third-party involvement to optimize their solution. Their association will span a longer time horizon involving co-creation of innovative solutions. An example of this model is the collaboration between Verizon Business and IBM that combines the Verizon 5G network and MEC platform with IBM's analytics and cognitive automation platform for industrial automation [7].

The Service Partner model extends Solution Partnership to also include the services stack shown in Figure 2. In so doing, it not only addresses solution optimization, but also focuses on value creation for customers through innovative use cases and services, thereby enabling enterprises to extract the maximum value from their ICT spend. The recently announced expansion of the AT&T and Google partnership is an example; they will not only integrate Google's

cloud platforms (including its AI/ML/ analytics capabilities) and application developer ecosystem with AT&T's MEC and 5G network, but they will also co-develop services for several verticals such as health care, manufacturing, and retail. Figure 8 depicts an example platform architecture that could result from solution or service partnership; note that it has both on-premises and network edge presence to ensure the optimal solution or service coverage for an enterprise.

While each of the four models admits a range of deployments that could vary in terms of factors such as the specific enterprise and vertical addressed, the solution and services under consideration, and the roles of each player and the ecosystem, these four models can be collectively viewed as phases of a CSP-webscaler alliance as it goes through a complete maturity cycle. Figure 7 depicts a likely transition path that goes through the Cloud Vendor, Solution Vendor, Solution

Figure 8. Example of a partnership architecture



Source: Bell Labs Consulting

Partner and Service Partner phases successively. However, there could be other paths that leapfrog one or both intermediate phases, such as the AT&T-MS Azure alliance that transitioned from a Cloud Vendor model to a Solution Partner directly. Similarly, the duration of each phase could vary across different CSP-webscaler alliances depending upon the pace at which they mature; some alliances may not progress to the next “logical” phase at all. For example, many CSP-webscaler collaborations announced over the past two years for MEC deployments in the cloud fall under the Solution Vendor model; while some of these could evolve into Solution Partnership, a large percentage may remain in vendor-buyer mode.

Evaluating partnership rewards and risks

Deeper engagement with webscalars through solution and service partnerships brings significant benefits to CSPs, but it also has major short- and long-term risks that need to be

carefully mitigated. Table 2 presents key aspects of these two facets that address market success, operational benefits, business model strength, innovation, and environmental advantages.

The overarching strength of a partnership lies in its ability to bring the best solution/service value to the customer. If the CSP and webscaler bring their respective technological, ecosystem and business strengths to bear, it can potentially result in an offering superior to what they could have achieved individually. Most other partnership benefits follow from this key value proposition. A superior solution/service can command higher and more stable revenues through greater market penetration and premium

prices. It also drives increased ICT spend as enterprises can realize greater safety, productivity, and efficiency (SPE) benefits. A high-quality solution/service also improves cost effectiveness and operational efficiency leading to a stronger and more resilient business model. Working with a webscaler also allows the CSP to better focus on building innovative network and service technologies and developing value-adding services for enterprises. It also accelerates their organizational growth in terms of acquiring and implementing cloud-related skills efficiently.

A CSP-webscaler partnership can also soften the impact of adverse regulatory and geopolitical events that may be sudden and difficult to anticipate. While it benefits from the CSP’s local

presence in the face of regulatory demands and constraints, it is also more insulated against supply chain disruptions because of the vast ecosystem supporting the webscaler.

Balancing these gains from partnerships are their inherent risks: disintermediation from customers, and loss of strategic, financial, and operational control over offered services. Webscalars may have existing relationships with enterprises — in the operations and IT domains, for example — that they could leverage to establish service ownership, potentially reducing the CSP’s role to that of a connectivity provider. These threats can be quite significant, especially for the Service Partner model as it provides the greatest customer proximity.

Table 2. Partnership benefits and risks

Category	Benefits	Risks
Market-centric	• Higher probability of product/service success • Larger products/services portfolio • Larger customer base and market share • Pricing advantage	• Potential loss of customer base and market share based on partners' standing in the local region
Operation-centric	• Potentially lower overall cost • Access to large application ecosystem • Potentially shorter time to market	• Technology and ecosystem lock-in • End-to-end accountability • Co-ordination of lifecycle management • Integration and implementation issues
Business model	• Potential for higher profitability • More resilient to adverse developments • Lower financial risk due to shared capital investment	• Threat of disintermediation • Loss of end-to-end service control • Inequitable profit share, margin erosion
Platform and service innovation	• Synergistic technological innovation • Faster solution/service innovation	• Erosion of in-house skill development • Inequitable compensation for use of intellectual property; resolution of foreground and background IP usage, AI/ML training data
Environmental factors	• Potential to mitigate regulatory constraints • Potential to reduce the impact of adverse geopolitical events	• Potential loss of customer base due to partners' status/affiliation

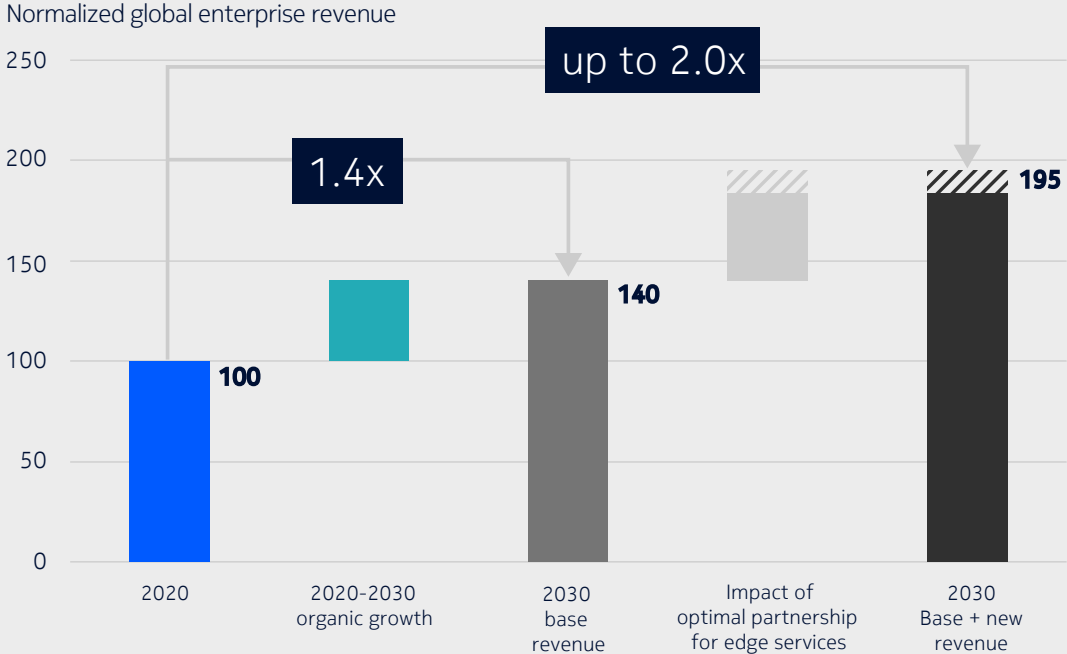
Other challenging risks include the threat of technology and ecosystem lock-in, which may thwart service innovation, cost economies and the need for a clear accountability framework to address service failures. There may be critical issues associated with exchanging data and applications among the various players. The use of webscale for all the cloud needs may erode in-house cloud expertise both within the CSP and in the enterprise/end-user. Thus, it is important to retain a minimum core set of experts to maintain the webscale contracts and end-user management. Increasingly many cloud-based applications have embedded AI/ML algorithms that require access to data for training and on-going optimization. This can create intellectual property (IP) issues regarding the ownership and use of training data, specific foreground IP, which is created jointly through the partnership, and background IP, which was created independently by individual partners.

Environmental factors are a double-edged sword. While they can create substantive gains as discussed above, they can also create regulatory roadblocks based upon the status and affiliation of the partner, especially in the face of the increasing need worldwide for data sovereignty and protection. For example, the US CLOUD Act and the European Union's GDPR can have significant ramifications for a partnership between a local CSP and a global webscaler.

These risks can be mitigated to varying degrees through suitable remedial measures:

- Use of non-compete, exclusivity and remediation clauses
- Defined end-user interfaces
- Contract flexibility to include technology and infrastructure risk mitigation
- Tight contract and change management
- Contractual obligation for renewal, exit and migration scenarios

Figure 9. Evaluating gains from an optimal partnership strategy



Source: Bell Labs Consulting

- Clear articulation of foreground IP development and background IP exploitation rights.

To complete the reward-risk evaluation of a partnership scenario, a CSP must also address the risk of not having a webscaler partnership. It needs to evaluate the likely strategic and economic fallout if it decides to forgo a partnership opportunity only to see it being picked up by competition. While these evaluations can have a significant probabilistic element to them, they can nonetheless be quite consequential.

Selecting the right engagement model

The choice of the right webscaler engagement model for a CSP will depend upon the prevailing context, which is defined in terms of the planning horizon, market parameters, technology needs, targeted applications and services, and enterprise types. A CSP will tailor its strategy towards a webscaler so that the reward-risk balance is optimized for the context in point.

The planning horizon refers to the expected duration of the partnership. A CSP may partner with webscalers in the near-term in order to gain cloud proficiency and build their own ecosystem, and choose to go alone in the longer term using either a Cloud Vendor or a Solution Vendor model. Similarly, the CSP could partner with webscalers in certain markets, for example to benefit from their widespread cloud presence, while going it alone in other markets. This is particularly attractive to CSPs who wish to establish

international presence with the ability to scale rapidly.

The partnership could also be defined in terms of technology or functionality alliance. The Orange-Google Cloud partnership [8] is a good example of this approach, focusing on AI tools, data analytics and cloud technologies. These partnerships will typically follow the Solution Partner model with an expectation to evolve into a Service Partner model.

A CSP can decide to partner with webscalers only for specific applications or services. For example, it might partner for yet-to-mature applications with uncertain and volatile demands and scaling needs, while going it alone for others with mature and steady demands. Similarly, it may decide to offer services that are conducive to slicing on its own and partner with webscalers for other applications. Partnerships can also target specific verticals, as exemplified by the AT&T-Google alliance.

Lastly, the choice of the engagement model can depend upon the enterprise types served. A CSP may decide to partner for supporting small and medium businesses (SMBs) scattered over wide regions, each with a relatively small demand for basic ICT services, while going it alone for large enterprises with significant individual needs for high-performance services. Or they may want to also cover large enterprises for specific verticals such as that require on-premises presence with a web scaler partnership.

Given these multiple engagement dimensions, the optimal strategy for a CSP can be to engage with several web scalers simultaneously using different models that best meet the needs of individual contexts. Adopting this multi-cloud strategy — encouraging active competition among the web scalers — will not only improve partnership efficiency and productivity, but it will also help reduce some of its inherent risks, such as technology and ecosystem lock-in.

A multi-cloud strategy also helps CSPs to increase their revenue share as they are not overly dependent on a single web scaler. CSPs must also seek to shape partnership in ways that emphasize their strengths. Key areas of participation include:

- High-performance 5G connectivity supported by widespread spectrum ownership and fiber presence
- Private network connectivity and applications
- Managed services including network and service support
- Functional integration in the face of increasing disaggregation caused by open architectures
- The ability to meet tight data residency and sovereignty requirements to complement the established, trusted relationship they have with enterprises.

We estimate that an optimal partnership strategy will add up to 19% to CSPs' share of enterprise edge ICT spend on telecom services over the competitive scenario, resulting in overall share of 31% to 40%. CSPs will also benefit from the revenue gains resulting from a superior solution/service coming out of the partnership, and accelerated revenue realization through a shorter time to market. Figure 9 captures the resulting impact of these two gains on a CSP's enterprise revenue during 2020-2030. Edge enablement leads to 1.4x revenue growth to increase the normalized revenue of 100 in 2020 to 140 in 2030. By selecting the optimal partnership strategy, a CSP can enhance it to 195 during this period to essentially double its revenue by 2030.

A case in point

Bell Labs Consulting was engaged by a Tier-1 CSP in the MENA region to develop a multi-cloud strategy that would maximize its share of new revenues generated by the digital transformation of key industries in the country. While the CSP had initiated network virtualization, it was interested in understanding what digital services could be offered and what the right implementation strategy should be to achieve optimum profitability with minimal risk.

Discovery of CSP and market attributes

Table 3 maps the key aspects of the CSP and its market following the Bell Labs Cloud Business Model Navigation framework.

The enterprises in the CSP's country of operation are concentrated in three to four regional clusters allowing the CSP to leverage its existing Central Offices (COs) and last-mile fiber connectivity to offer 5G-based services without

having to either build new datacenters or rely on enterprises to build on-premises clouds. The CSP had already transformed its COs to distributed telco and IT datacenters with the capacity and reach to serve 90% of nationwide enterprise demand through 2025.

Analysis of use cases, sector demands and implementation scenarios

The initial step identified the leading verticals from the perspective of the CSP's addressable market and determined the vertical-specific services with the best revenue potential. The prioritized verticals were oil and gas, construction, discrete and process manufacturing, and utilities. Services with the maximum revenue potential for these verticals were determined to be cloud-based IoT services — AR/VR immersive apps, AI-based video analytics, low latency process control and tele-operations services.



Table 3. Case study: CSP and market analysis

Areas	Attributes	Case scenario
CSP characteristics	Market position	Leading, 45% market share
	Cloud proficiency	Mature IT cloud. Moderate progress with network cloud
	Service portfolio	Limited, primarily conventional voice and data services
	Customer proximity	High; close to industry hubs
	Cost efficiency	Medium-high
Market dynamics	Strength of webscaler presence	Medium
	Speed of cloud service adoption	Gradual; increasing consumer savviness
	Enterprise service requirements	Very early 5G adoption Intent to provide high-performance services
	Private networks adoption	Slow
Regulatory intervention	Need for local presence	Strong local data residency need
	Data sovereignty requirements	Very strong
	Financial incentives	Low
Global developments	Covid-induced disruption and recovery	Moderate disruption, slow recovery. Strong government intervention to combat Covid impact through free internet data for healthcare and education apps, and promotions for online grocery and remote training
	Impact of trade wars	Moderate impact
	Geopolitical events	Moderate impact

The next step identified the architectural and deployment alternatives available to the CSP for offering these use cases. At the outset, the overarching regulatory requirements concerning governance, security and data residency and sovereignty ruled out a webscaler-led solution. It also virtually eliminated the Product Partner and Service Partner models of the CSP-webscaler alliance alternatives; besides, the CSP was not interested in any partnership with webscalers at this point.

As shown in Figure 10, this limited the CSP's choice of a webscale alliance to three models:

1. CSP working alone, assuming full responsibility for the service and infra stack, and procuring various infra and platform elements from different vendors (that are not webscalers)
2. CSP using webscalers as Cloud Vendors for procuring the cloud platform stack, such as Google Anthos or AWS EKS and ECS, and buying other elements from other vendors

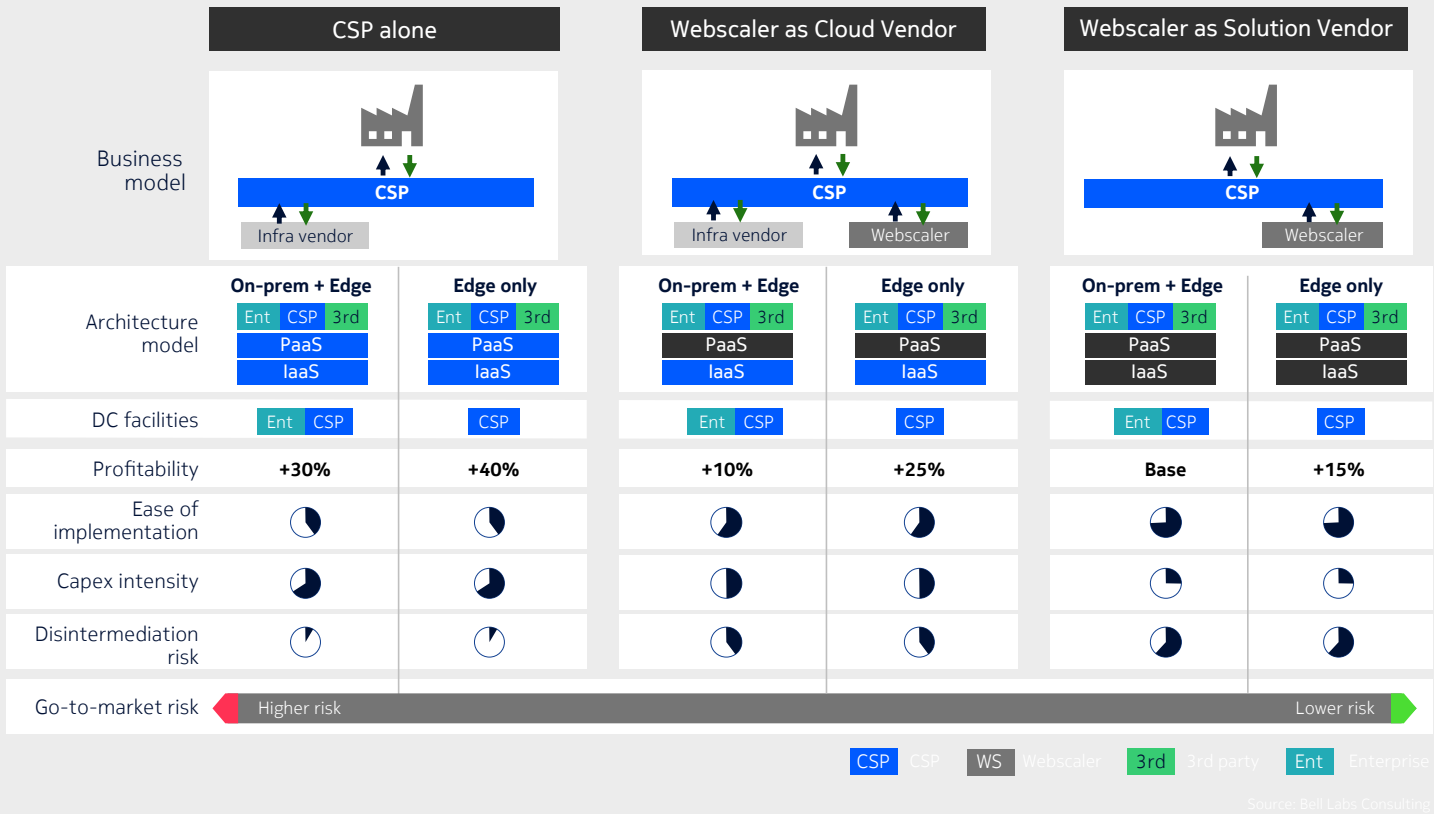
3. CSP using webscalers as Solution Vendors for procuring the entire cloud solution from them, such as Outpost from AWS.

The selected use cases had stringent performance requirements — in terms of low latency or high throughput — that necessitated cloud deployment either on premises in the enterprise datacenter or in the CSP edge cloud located within 50 kilometers of the enterprise site. Two sets of implementation alternatives were evaluated:

- A blanket rollout of edge clouds that was augmented by on-premises clouds for specific cases — such as extra-large enterprises, enterprise with stringent data residency requirements, etc.
- A uniform edge cloud rollout without on-premises clouds.

Bell Labs analysis helped the CSP to better understand the impact of industry vertical, enterprise size and the technological needs of use cases considered to best characterize

Figure 10. Case study implementation alternatives



service needs and determine the gains and risks of different webscale partnership strategies.

Insights on profitability and risk outcomes of implementation scenarios

Figure 10 shows the reward-risk map for the various implementation alternatives. The alternative where the webscaler is the Solution Vendor deploying the edge cloud plus on-premises clouds provides the smallest margins for the CSP — largely because of the significant webscaler contribution to the solution hardware and software. CSP-alone models generate the best margins, which are 30-40% higher largely because of the significant capacity already available in the CSP datacenters. The higher margin of the edge-cloud-only scenario relative to the edge cloud plus on-premises deployment stems from better utilization of the available datacenter capacity and the avoidance of on-premises investment. These factors also explain the 15% increase

in margins achieved with the edge-cloud-only scenario even with the webscaler as Solution Vendor deployment. Webscaler as a Cloud Vendor scenarios generate margins that lie between the two extremes. The CSP-alone alternative has other advantages as well. It maximizes enterprise value capture for the CSP,

provides the best scaling opportunity and presents the most secure deployment with respect to data residency and sovereignty. It is also the easiest to implement for the CSP, requiring nominal integration support. Furthermore, with no webscaler involvement, the CSP has minimal risk of being disintermediated from its enterprise customers.

However, the CSP-alone strategy also poses significant short- and long-term risks. The CSP would compete with webscalars and startups for hiring — and retaining — cloud-proficient software engineers at short notice from a limited pool of such expertise available in the market. Alternatively, the CSP could lean on the leading system integrator that they partner

with, but this would lead to significant margin erosion.

The major drawback of this strategy is that it exposes the CSP to major market- and operation-centric risks. It would compete with other CSPs who had partnered with webscalers, and consequently had ready access to their ecosystem of IT/OT application developers and service providers. The CSP would be challenged not only in the breadth of its services portfolio, but also the speed with which services can be brought to market. Competing against CSPs with webscaler partnerships also places this CSP at a disadvantage with respect to cloud and platform technology innovation. The CSP would also bear all integration risks associated with immediate deployment as well as future upgrades.

Recommendation: A CSP-led model with application-centric webscaler engagement

Bell Labs Consulting determined that the CSP should adopt an application-centric approach to webscaler engagement — described in Section 4.3. It should adopt a CSP-alone strategy for existing services and new enterprise applications with low demand volatility, while partnering with a webscaler using the Cloud Vendor strategy for new applications with uncertain and volatile demand.

Two factors that emerged during Bell Labs Consulting's analysis proved to be the critical determinants of these recommendations. First, while 5G deployment had started in the CSP's market, the enterprise adoption of cloud services and new high-performance applications has been slow, allowing the CSP to build up its cloud proficiency and service portfolio gradually. It also minimized the gains

resulting from the webscaler partnership on account of their application ecosystem. Second, data residency and sovereignty requirements will have significant impact on future partnerships and alliances between the CSP and global webscalers.

These factors considerably reduced the risks associated with market, operations, and environmental factors typical of the CSP-alone strategy relative to the alternatives. To further de-risk this strategy, the CSP can implement a multi-cloud abstraction layer that enables applications written for a webscaler cloud platform, such as AWS, Microsoft Azure and Google Cloud, to also execute on the CSP platform with minimum additional effort.

Benefiting from the lower relative risk enabled by these factors, the CSP-alone strategy scored over the alternative strategies because of its ability to generate higher margins and higher utilization of its data center

assets. However, these benefits can be reduced significantly by the variability of application demands. Applications with volatile demands require the platform to be highly scalable, both up and down; the webscaler as Cloud Vendor strategy provides this capability, making it better suited to support such applications.

Bell Labs also recommended that the CSP should closely monitor the enterprise adoption of new applications and the growth of its own cloud proficiency, reviewing and updating the application stacks represented by the CSP-alone and webscaler as Cloud Vendor strategies. The needs and maturity of applications vary across verticals in the local enterprise market, and the CSP should be flexible and willing to adopt the webscaler partnership model that provides the best overall balance between customer experience, revenue generation, delivery efficiency and sustained profitability.

Future begins now

Recognizing the criticality of edge presence, leading Tier 1 CSPs and webscalers have already started charting paths to their preferred future edge scenarios. Forming strategic alliances with other industry players has been integral to their strategies. The leading webscalers have been particularly agile in building alliances with CSPs. While CSPs are also seeking partnerships with ISVs and application developers actively, they have been slow to respond despite a fast-developing enterprise market.

The big three are building strong momentum

AWS leads the cloud infrastructure and platform market with 32% share, followed by MS Azure (20%), and Google Cloud (7%) with a host of smaller providers accounting for the remaining 35% of the market [9]. All three webscalers have clearly expressed their intent to have strong enterprise and network edge presence.

AWS has aggressively offered its Outpost (on-premises cloud infrastructure) and

Greengrass (IoT management) platforms to enterprise customers. It has also pursued partnerships in several regions with leading operators, such as Verizon, Korea Telecom, KDDI, Vodafone and Telus, to establish edge presence for its Wavelength (network edge cloud infrastructure) platform to augment AWS Local Zones (metro cloud infrastructure). Independently, AWS is also strengthening its compute platform by incorporating NVIDIA and its own Graviton processors in its platforms. It is also building satellite-based network connectivity to provide global broadband access. Its partnership with DISH gives it the opportunity to go deep into the network for providing platforms to support many RAN functions. Having grown from eight regions and 33 edge locations globally in 2012 to 25 regions (with eight more announced regions) and 265 edge locations today [10], AWS presents a formidable threat to CSPs with its mature and broad-based ecosystem even though it currently lacks strong network intelligence capability.



Microsoft Azure has over 200 datacenters in 62 locations [11] [12] with its own platforms — Azure Stack (on-premises) and Azure Edge Stack (network edge) — for edge deployments. While it currently lacks the diversity and depth of the AWS platforms, it has pursued the telecom value chain more holistically by building and/or acquiring many network functions such as OSS/BSS, IMS, ePC, and MEC. It has also been building deeper partnerships with CSPs, such as AT&T, Verizon, and Deutsche Telekom, with a view to becoming their Product Partner.

Google Cloud is a late entrant into the cloud infrastructure market. Nonetheless, it has expanded into 28 regions, 73 zones and 146 edge locations [13]. While Anthos Stack (on-premises) and Anthos edge (network edge) are its primary cloud platforms, Google has established a market niche in the domain of AI/ML and analytics involving big data, and it has struck many partnership deals with CSPs, such as Orange, in the role of a Solution Vendor.

Some CSP-webscaler partnerships, such as the deals struck between Jio and Google, Jio and Microsoft, Google and Vodafone Idea, and AWS and Airtel, involve equity participation by the webscaler in the local CSP. While this partnership is a positive development on paper — the webscaler is vested in the CSP's growth — it also provides a way for the webscaler, which is a foreign entity, to integrate into the local national fabric and avoid regulatory constraints. The disparity in the relative sizes of the investing webscalers and the CSPs they are investing in (with the notable exception of Jio) raises the possibility of ownership shifts in the long term.

CSP alliances focusing on the edge

Leading CSPs are simultaneously forming alliances of their own that specifically target the edge. The MobileEdgeX initiative, founded by DT, includes over 20 other CSPs including KDDI, SK Telecom, TIM, EE, BT, TEF, Orange, China Unicom and Singtel. The goal of this initiative is to build a platform for CSPs to aggregate edge

resources and have a common control and orchestration layer to manage public and private clouds. This provides a common, infrastructure-agnostic platform that application developers can write their applications to. The platform design and architecture is built around use cases, a typical example being the DT and KDDI joint effort to develop PaaS for XR applications [14].

The GSMA-supported Operator Platform Group's Telco Edge Cloud (TEC) platform initiative comprises 19 CSP members and aims to develop an interoperable telco edge architecture. It will allow CSPs to open up their edge assets and capabilities to application developers while providing data security and sovereignty. The work undertaken by this initiative also covers partnerships between CSPs and webscalers in addition to CSP edge clouds [15].

There are other smaller and more focused alliances as well. Six major operators — Verizon, Rogers, Vodafone, Telstra, América Móvil and KT — have formed the 5G Future Forum to specifically focus

on developing common specifications for 5G-enabling technologies and multi-access edge computing (MEC). This group released their first technical specifications in September 2020 [16]. SK Telecom has launched the Bridge Alliance comprising Global MEC Task Force with SK Telecom, Singtel, Globe, Taiwan Mobile and PCCW Global to focus on interoperability across CSPs and improved monetization of their networks.

Responding to the new normal

The emerging enterprise ICT space is being shaped by three major trends:

1. New telecom value is being created at the network edge, and enterprises are the target market for this value
2. There is a strong possibility of a big value shift away from CSPs as webscalers aggressively pursue enterprise solutions and services that can disintermediate traditional CSPs
3. 5G and 5G-enabled technologies have provided CSPs a major opportunity to play a significant role in new value creation and mitigate the value shift.

Despite their virtual monopoly on 5G deployments, CSPs have done little to wrest the initiative for 5G-based enterprise engagements from webscalars. For example, a recent study [17] showed that, while 71% of enterprises surveyed in 2020 believed that 5G networks will have a major impact on their business, CSPs led only 21% of enterprise-related deployments a year later. This study also found that the number of partnership deals signed by CSPs with third-party providers dropped by 33% during Covid-hit 2020, while webscalars increased their partnership deals by 76%.

CSPs need to chart their webscaler strategy now so that they can actively shape the partnership structure in ways that play to their strengths. Clarifying the role of the edge — including the network edge and on-premises deployments, as well as

private network rollouts — and the resolution of potential CSP-webscaler competition at the edge are central to this strategy. Successfully managing this strategy will also require CSPs to continuously monitor and evaluate the roles of other key stakeholders such as ICT vendors, application developers, system integrators and other third-party providers and governments to optimize any emerging micro- and macro-economic paradigms.

While processing proximity to end users is key to achieving better service performance, recent geopolitical events such as trade wars, pandemic-induced nationalistic tendencies towards hyper-localization, and the emergence of stringent local/national regulations have added new dimensions of criticality to the network edge. These events, as well as stringent data residency and sovereignty requirements,

favor the CSP-led engagement model, either in a CSP-alone mode or with webscalars in Cloud Vendor or Solution Vendor roles.

We believe that partnerships are inevitable in other cases that account for the vast majority of global enterprise engagements. They create better solutions and services for enterprises, thus providing CSPs and webscalars sustainable revenue streams. They also offer CSPs a better alternative to the competitive strategy, thus strategically and economically enabling exponential value from their edge infrastructure.

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Acronyms

AI	Artificial intelligence	DU	Distributed Unit	IMS	IP Multimedia Subsystem	PaaS	Platform as a service
AR	Augmented reality	ECS	Elastic Container Service	ISV	Independent software vendor	RAN	Radio access network
AWS	Amazon Web Services	EKS	Elastic Kubernetes Services	IT	Information technology	RU	Radio Unit
BSS	Business support system	ePC	Enhanced Packet Core	LAN	Local-area network	SaaS	Software as a service
CNF	Cloud-native function	GCP	Google Cloud Platform	MEC	Multi-access edge computing	SPE	Safety, productivity, efficiency
CO	Central office	GDPR	General Data Protection Regulation	MENA	Middle East and North Africa	VR	Virtual reality
CSP	Communications service provider	IaaS	Infrastructure as a service	ML	Machine learning	WAN	Wide-area network
CU	Central Unit	ICT	Information and communications technology	OSS	Operations support system		
				OT	Operations technology		

References

- [1] Bell Labs Consulting, “The big inversion – How 5G+ technologies will create new value for industries in a post-COVID world,” Nokia Corporation, 2021.
- [2] Vodafone. “Vodafone to accelerate build of digital platforms with 7,000 new software engineers,” Press Release, 21 October 2021. <https://www.vodafone.com/news/press-release/7000-new-software-engineers>
- [3] Ward, Marguerite, “The upskilling economy: 7 companies investing millions of dollars in retraining American workers so they can find better jobs,” Insider, 2 November 2020. <https://www.businessinsider.com/companies-investing-retraining-upskilling-reskilling-2020-10>
- [4] Yaya, Sanni, Out, Akaninyene, Labonte, Ronald (2020). “Globalisation in the time of COVID-19: repositioning Africa to meet the immediate and remote challenges,” BMC, 24 June 2020. <https://globalizationandhealth.biomedcentral.com/articles/10.1186/s12992-020-00581-4>
- [5] Hall, Matthew. “Resource nationalism surges in wake of Covid-19,” Mining Technology, 4 March 2021. <https://www.mining-technology.com/features/resource-nationalism-surges-covid-19/>
- [6] Telefonica, “Telefónica announces a strategic collaboration with Amazon Web Services to enable an easier journey to the cloud for enterprise customers,” Press Release, 28 May 2018. <https://www.telefonica.com/en/web/press-office/-/telefonica-announces-a-strategic-collaboration-with-amazon-web-services-to-enable-an-easier-journey-to-the-cloud-for-enterprise-customers>
- [7] Verizon, “IBM and Verizon Business to collaborate on 5G and AI solutions at the Enterprise Edge,” Press Release, 17 July 2020. <https://www.verizon.com/about/news/ibm-and-verizon-business-collaborate>
- [8] Google Cloud, “Orange and Google Cloud to Form Strategic Partnership in Data, AI and Edge Computing Services,” 28 July 2020. <https://www.googlecloudpresscorner.com/press-releases/>
- [9] Statista, “Cloud infrastructure services vendor market share worldwide,” July 2021. <https://www.statista.com/statistics/967365/worldwide-cloud-infrastructure-services-market-share-vendor/>
- [10] Amazon Web Services, “Global Infrastructure: The Most Secure, Extensive, and Reliable Global Cloud Infrastructure, for all your applications,” October 2021. <https://aws.amazon.com/about-aws/global-infrastructure/>
- [11] Microsoft Azure, “Azure geographies,” October 2021. <https://azure.microsoft.com/en-us/global-infrastructure/geographies/#overview>
- [12] Roach, John, “Microsoft’s virtual data center grounds ‘the cloud’ in reality,” April 2021. <https://news.microsoft.com/innovation-stories/microsofts-virtual-datacenter-grounds-the-cloud-in-reality/>
- [13] Google Cloud, “Cloud Locations,” October 2021. <https://cloud.google.com/about/locations>
- [14] EdgellR.com, “DT, KDDI lay out plans for edge PaaS targeted for AR/VR with MobileEdgeX,” 8 July 2021. <https://www.edgellr.com/dt-kddi-lay-out-plans-for-edge-paas-targeted-for-ar-vr-with-mobiledegex-20210708>
- [15] Le Maistre, Ray, “Operators rally around Telco Edge Cloud Platform initiative,” Telecom TV, 29 June, 2020. <https://www.telecomtv.com/content/edge/operators-rally-around-telco-edge-cloud-platform-initiative-39043/>
- [16] Lennighan, Mary, “If you are not living on the edge, you’re probably not a major international telco,” telecoms.com, 7 April 2021. <https://telecoms.com/509261/if-youre-not-living-on-the-edge-youre-probably-not-a-major-international-telco/>
- [17] OMDIA, “CSPs’ readiness to reap the benefits of 5G — a year on,” OMDIA eBook, 2021.

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