Hype Cycle for the Future of CSP Networks Infrastructure, 2021

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By Analyst(s): Sylvain Fabre

Initiatives: CSP Digital Transformation and Innovation

CSPs must operate seamlessly across new network technology domains such as public and private cloud and edge, fixed and mobile access, core, and transport. This Hype Cycle captures most technologies that CSP CIOs should invest in to enable infrastructure modernization and transformation.

Additional Perspectives

- Invest Implications: Hype Cycle for the Future of CSP Networks Infrastructure, 2021 (11 August 2021)

Analysis

What You Need to Know

This Hype Cycle highlights the most essential technologies that are key to communications service providers' (CSPs) transformation. These technologies also enable a whole new set of competitors for traditional CSPs that includes new providers of telecommunications infrastructure.

Digital giants and dragons, which include public cloud providers, and newer startups are disrupting what were previously proprietary services (e.g., voice, messaging, private mobile networks, 5G infrastructure) of the CSPs. In addition, multiple agreements between CSPs and public cloud providers are occurring for the newer network domain of edge computing.

CSPs also have been outpaced in the pursuit of adjacent network opportunities, such as cloud (infrastructure as a service [IaaS]), Internet of Things (IoT) and e-commerce opportunities. They are now hoping to secure increased relevance beyond consumer offerings and basic business connectivity services, with 5G private networks and vertical-specific solutions.

Although the multilayered architecture of 5G (network plus software and services) can create opportunities for CSPs to expand beyond connectivity-centric solutions, the disaggregation also allows new entrants, including digital dragons, to influence and derive value. This includes recent moves by large hyperscalers into both infrastructure as well as connectivity as a service (see The Next Era of Communications Services (Part 3): A Radical Shift in Value Enablement Manifests as a New Taxonomy for more details).

Digital ecosystems are increasingly impacting the way industries function and how new value propositions based on technology solutions are defined. For example, sharing of intellectual property during co-creation is normal in an ecosystem approach (see How CSPs Can Approach Digital Ecosystems for Successful Collaboration). CSPs need to transform their networks for openness to facilitate, and participate fully in those ecosystems, as well as their IT systems. (CSPs should also consult Hype Cycle for Communications Service Provider Operations, 2021 for back-end and operations capabilities.)

The Hype Cycle

This year's Hype Cycle has some key changes over the last year (see Hype Cycle for the Future of CSP Networks Infrastructure, 2020) to reflect the need to align investments and efforts in capabilities evolution. CSPs, particularly those with network assets, are undergoing significant changes. There are disruptive forces from new types of CSPs (such as Dish and Rakuten) as well as players from other industries (such as hyperscalers' involvement in CBRS private LTE deployments in the U.S.). New cloud-native CSPs are ambitious with their market, technology, services scope and operating model. In such a scenario, incumbent CSPs in particular need a structured approach to continue modernizing their network platform.

We have applied a framework to decide what to include, across the following key network technology domains:

- Fixed network
- Wireless access
- Transport
- Edge
- Cloud
- Core

Business and technology imperatives include:

- Security
- Architecture, openness and ecosystem enablement
- Intelligent automation
- Business revenue, value of network
- Innovation, high performance
- Cost reductions and efficiency

The innovations chosen were included based on their fit and their potential to enable CSPs to achieve their business outcomes, and to ensure a balanced representation across all these dimensions.

CIOs for all types of CSPs should use this Hype Cycle to:

- Identify the required capabilities to enable their vision and business strategy.
- Develop consensus with business leaders, product and infrastructure teams on which technologies to introduce and when.
- Validate if they are investing in all the key capabilities.
- Plan investments in necessary technology and process-related capabilities.

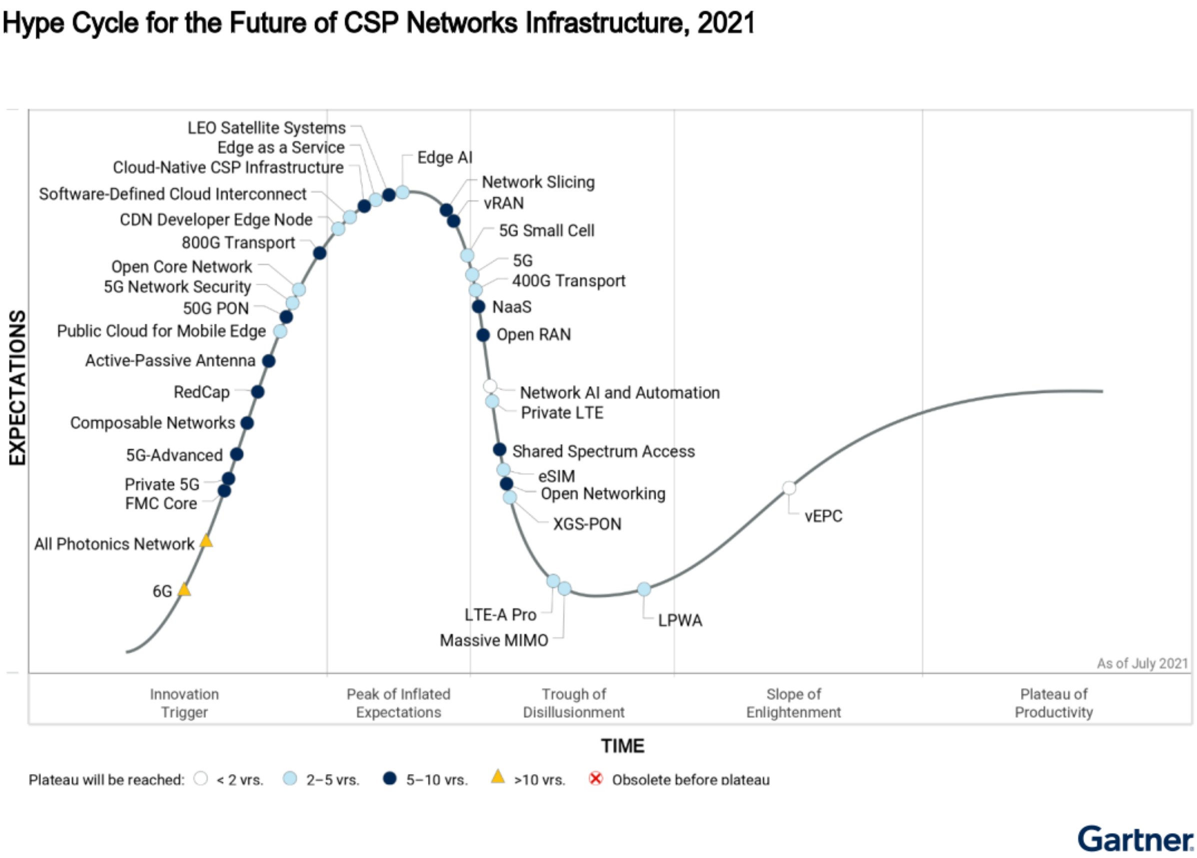
Primary changes made to this Hype Cycle are detailed below.

New innovations added:

- 400G Transport
- 50G PON
- 5G-Advanced
- 800G Transport
- Active-Passive Antenna
- All Photonics Network
- CDN Developer Edge Node
- Cloud-Native CSP Infrastructure
- Composable Networks
- FMC Core
- Open Core Network
- Software-Defined Cloud Interconnect
- XGS-PON

No single innovation will help CSPs make the transition to being digital service providers, and they must explore innovations from outside of CSP operational technology (CSP-OT). Many innovations on this Hype Cycle are not specific to CSPs only, but have different benefits and velocity compared with other industries and are reflected here within the CSP context, bearing in mind telecommunications-industry-specific trends.

Figure 1: Hype Cycle for the Future of CSP Networks Infrastructure, 2021



Source: Gartner (July 2021)

Downloadable graphic: Hype Cycle for the Future of CSP Networks Infrastructure, 2021

The Priority Matrix

The Priority Matrix indicates the need for strategic, long-term and sustained investments for capability improvement. Most capabilities will take more than two years for mainstream adoption, and in some cases, five years or more. Therefore, it is important for CSPs to carefully select capabilities in line with their business strategy and invest early with the aim to effect operational changes.

For some of the elements shown in the Priority Matrix, technology and process capabilities will not suffice to deliver CSPs' intended outcomes. CSPs require an active strategic orientation toward technology change. Many of these capabilities will have significant impact over the next three to five years.

One of the points to be noted is the need for dedicated and executive sponsorship for transformational capabilities, such as network artificial intelligence (AI) and automation, 6G, network slicing, and cloud-native CSP infrastructure. Deploying/evolving these capabilities may require sourcing of specific skills from outside the organization.

- Truly become a digital CSP with wide relevance to the industry
- Enable new competitors with easier access to the telecom space and reduce lock-in to a given CSP

Starting with the most immediate impact, vEPC supports virtualization of the CSP core, enabling a more scalable, cost-effective production platform. On the other hand, this capability is also now within the remit of a public cloud provider (Microsoft's acquisition of Affirmed Networks and Metaswitch).

Edge AI improves operational efficiency, such as enhanced visual inspection systems in a manufacturing setting, and enhances customer experience. It also enables cloud providers to add value and execute their AI at the CSP edge. eSIM allows choice across multiple CSPs, further commoditized connectivity, and may also enable easier entry for nontraditional CSPs and mobile virtual network operators (MVNOs).

MVNOs are also further enabled by network slicing, an opportunity for CSPs to support business-to-business-to-x (B2B2X) models and fuel growth of a large number of specialist IoT MVNOs. Cloud-native telco applications can provide a cheaper way to run network workloads, but conversely allow network infrastructure to be provisioned by hyperscalers.

CSP AI allows communications service providers to leverage AI and machine learning technology to improve customer experience, reduce costs, generate new revenue opportunities and optimize their IT and infrastructure operations. Conversely, other providers could step in to provide the telco AI as a service, gradually building up their expertise of the telecom domain.

On the wireless access side, low-earth orbit satellite systems may allow connectivity for currently underserved areas and wider private mobile networks, and are provided by satellite providers rather than CSPs, which should partner here to open up these new market opportunities.

Table 1: Figure 2: Priority Matrix for the Future of CSP Networks Infrastructure, 2021

(Enlarged table in Appendix)

Benefit	*Years to Mainstream Adoption*			
↓	*Less Than 2 Years* ↓	*2 - 5 Years* ↓	*5 - 10 Years* ↓	*More Than 10 Years* ↓
Transformational	vEPC	400G Transport Edge AI eSIM	Cloud-Native CSP Infrastructure Composable Networks LEO Satellite Systems Network Slicing	6G
High	Network AI and Automation	5G 5G Small Cell Edge as a Service LTE-A Pro Massive MIMO Private LTE Public Cloud for Mobile Edge XGS-PON	5G-Advanced 800G Transport Open RAN Private 5G RedCap Shared Spectrum Access vRAN	All Photonics Network
Moderate		5G Network Security CDN Developer Edge Node LPWA Open Core Network Software-Defined Cloud Interconnect	50G PON Active-Passive Antenna FMC Core Open Networking	
Low			NaaS	

Source: Gartner (July 2021)

Off the Hype Cycle

Several innovation profiles have been removed due to maturity or better fit in other research, including:

- LTE Roaming IPX
- LTE-M
- LTE-U

- VoLTE
- Bidirectional Brain-Machine Interface
- Software-Defined Wide-Area Network
- Drone Base Station
- Wi-Fi 6
- Communications Platform as a Service (cPaaS)
- mmWave
- CSP AI
- Virtual Network Function Marketplace

Some innovations were renamed for clarity or because their focus changed:

- 5G Security is now 5G Network Security
- AI-Based Mobile Network Optimization is now Network AI and Automation
- Mobile Edge Zone for Public Cloud is now Public Cloud for Mobile Edge
- NR-Light is now RedCap
- Open Networking/OCP Networking is now Open Networking
- Small Cells is now 5G Small Cells
- Standard Private LTE is now Private LTE

On the Rise

6G

Analysis By: Kosei Takiishi

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

6G is the generic name for the next-generation cellular wireless that is expected to be next in line after 5G. In 2021, the features and timetable for 6G are not clearly defined although it's expected to be commercialized in 2028 by some CSP pioneers. 6G will enhance recent 5G capabilities and will be able to provide higher peak data rate (e.g., 100 Gbps to 1 Tbps), lower latency (e.g., 0.1 msec latency), much more connection density and energy efficiency (e.g., 10 times more efficient).

Why This Is Important

The 2030 agenda including 17 sustainable development goals by the United Nations are heavily impacted by the mobile. Many of these social issues and ambitious goals will result in technologies that become part of 5G or future 6G cellular deployments. Design and research for 6G has already begun with many industrial associations, academic and commercial organizations. 5G can solve some of these challenges, but 6G is indispensable for continuous growth and problem solving in the 2030s.

Business Impact

Although there is no clear 6G definition and the telecom industry is just trying to add one generation every 10 years (same as before), many technologies and concepts from 6G research will find their way into other wireless systems (cellular and otherwise) over the next decade. 5G networks will also be modernized and democratized to become software-based networks based on client demands, and 6G will benefit from it.

Drivers

- Different from 4G and current 5G, 6G will become a sort of national network supported or impacted by countries and national policies. Some leading countries have started their initiatives: In August 2020, Korean government announced that the country plans to launch a pilot project for 6G in 2026. In October 2020, the Alliance for Telecommunications Industry Solutions (ATIS) in the U.S. launched the Next G Alliance to advance North American Leadership in 6G. In November 2020, Korean Ministry of Science and ICT hosted the first 6G Global 2020 in Seoul. In April 2021, the U.S. and Japan agreed to jointly invest $4.5 billion for the development of next-generation communication known as 6G.

- Competition for 6G leadership by local organizations has already started and this could further accelerate 6G standardization and commercialization. These major activities are: In July 2020, NTT DOCOMO hosted 5G Evolution and 6G summit and also renewed the 6G white paper published in January 2020. In November 2020, FuTURE Forum in China published 11 white papers for 6G. In May 2021, 6G Symposium Europe was held as a virtual event.

- Many commercial organizations have started their 6G research to be a part of the future 6G patent pool.

Obstacles

- The 5G journey has just started and its best practices and monetization are not clear. Success or failure of 5G will have a major impact on 6G commercialization and business.

- The telecommunications industry has formulated their own specifications and standardization (such as 2G, 3G, 4G and 5G) by themselves. It is unclear whether 6G will be able to incorporate external opinions more.

- Some 6G technologies such as THz wireless may not prove relevant or cost-effective for most cellular user's needs.

User Recommendations

CSP CIOs should:

- Check the current emerging 6G discussion carefully.

- Avoid deploying 6G commercially till late 2020s. However, there could be deliverables of the 6G research projects that emerge in other wireless areas before 6G. For example, THz wireless systems could well emerge before 2030.

- Support your regulators and government to create their new national policy by 5G evolution and 6G.

There is no action required for IT leaders as 6G commercial offerings are not available in the market.

Sample Vendors

Ericsson; Huawei; Nokia; NTT DOCOMO; SK Telecom

Gartner Recommended Reading

Predicts 2021: CSP Technology and Operations Strategy

All Photonics Network

Analysis By: Kosei Takiishi

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

All photonics network (APN) is one of the three fundamental technologies in Innovative Optical and Wireless Network (IOWN), which is called Open APN. It is a concept of the next-generation communication infrastructure that is targeted at practical use around 2030. Open APN aspires to achieve an optical full-mesh network over the end-to-end network infrastructure by innovating and simplifying the current hierarchical network architecture with photonics-electronics convergence technology.

Why This Is Important

Open APN introduces photonics everywhere, from network to terminals. It aims to reach the following three performance targets: 100-fold enhancement to energy efficiency, 125-fold enhancement to transmission capacity, and reduce end-to-end delay by 1/200. Current network infrastructure heavily relies on electricity signals including packet processing, but APN tries to achieve the goal by using optical signals all at once to eliminate overhead, and improve efficiency over flat architecture for CSPs.

Business Impact

Internet data explosion and the associated increase in power consumption are the major issues faced by the semiconductor industry and the telecommunications industry that support the internet and information processing platform. APN, together with IOWN, could become a game changer to solve the limits of Moore's Law and promote new digital business opportunities associated with 6G, IoT, and edge computing.

Drivers

- Easy-to-use electronics have been used in chips that perform calculations on computers and network equipment. However, with the recent trend toward chipset miniaturization, there is more wiring inside chips generating more heat, which limits performance.
- IOWN Global Forum was established in 2019 by NTT, Intel and Sony and this forum has gathered 52 members from the globe as of April 2021.
- NTT unveiled the world's first mockup of the photonics-electronics convergence module at the NTT R&D Forum in November 2020. It aims at commercializing this module business in 2023.

Obstacles

- Low industry awareness, not a mature ecosystem and few participating members.
- Unclear position of IOWN Global Forum in the industry, especially about division of roles and cooperation with standardization bodies (e.g., ITU-T, 3GPP, IEEE).
- Various players have been participating in IOWN Global Forum, but there are still many wait-and-see companies. The path to commercialization of the Open APN and IOWN initiative, and which companies, other than the NTT Group, will take the leadership, has not yet been revealed.

User Recommendations

- Develop your long-term network infrastructure strategy by referring to IOWN and APN initiatives.
- Estimate the timing to adopt APN by researching your network infrastructure's data consumption and power consumption.

Sample Vendors

Fujitsu; Intel; NEC; NTT; Sony

Gartner Recommended Reading

Predicts 2021: CSP Technology and Operations Strategy

FMC Core

Analysis By: Kosei Takiishi

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Fixed-mobile convergence (FMC) core is a core network that can manage and integrate with wired (e.g., FTTH) and wireless (e.g., 5G) access networks. This concept spans the wireless and fixed access network, which have been standardized and deployed completely separately, and will be accelerated by virtualizing the CSP network and using it as a software.

Why This Is Important

The current CSP networks can be divided roughly into analog telephone networks, the IP networks provided via the internet, and cellular networks. Since each of these networks is composed of different communications equipment, even the control of call sessions of services that are available both for fixed and mobile communications is performed differently. The convergence of services is very important, and FMC core can help achieve it by simplifying infrastructure and eliminating duplication.

Business Impact

- FMC solution can provide fixed and mobile users with unified voice, data and video services to improve quality of experience.
- Seamless connection between different equipment and network layers allows diverse applications to be transported between different network platforms seamlessly.
- Further network cost reduction can be achieved by unifying different network components for fixed and wireless including C-plane and U-plane management, subscriber data management and billing functions.

Drivers

- 3GPP specifications standardized access to the evolved packet core (EPC) via non-3GPP access networks, including Wi-Fi, previously on the 4G LTE. Implementing this requires evolved Packet Data Gateway (ePDG). While non-3GPP signals are transmitted through a different path as compared to LTE signals, 3GPP further advanced its standardization on 5G core. Non-3GPP access can be achieved on the same N2 (for C-plane) and N3 (for U-plane) interface as 5G NR and LTE data.
- Service-based architecture developed for 5G core's C-plane management can define each network function as a service using the same protocol: HTTP/2. As a result, even if a new network function is added, access to the existing network function can use the already defined procedure as it is.
- 3GPP and the Broadband Forum have jointly started to standardize 5G Wireless and Wireline Convergence (5G WWC) to accommodate both fixed and wireless access in a unified core network.

Obstacles

- Existing legacy infrastructure of nonvirtualized and cloudified purpose-built equipment especially could delay new deployment and integration of FMC core.
- Ongoing incomplete standardization activities between multiple stakeholders such as 3GPP and Broadband Forum could present an obstacle to FMC implementation.
- CSP organizations often run fixed and mobile networks as separate divisions. This could result in tough internal negotiations beyond expectation.

User Recommendations

CSP CTIOs should:

- Develop a plan to integrate fixed and mobile infrastructure in the medium-to long-term period by managing deployed network equipment life cycle.
- Prioritize which vendors are your primary partners by reviewing their roadmap and milestones.
- Prepare your organizational structure and processes to implement and manage FMC core, by bringing together wireline and wireless core functions, creating joint working processes.

Gartner Recommended Reading

Magic Quadrant for 5G Network Infrastructure for Communications Service Providers

Private 5G

Analysis By: Sylvain Fabre, Joe Skorupa

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Adolescent

Definition:

A private 5G network is based on 3GPP technology and spectrum to provide unified connectivity, optimized services and security for enterprise. A 5G PMN is used to interconnect people and also things in an enterprise, and can consist of a mix of public and private infrastructure (e.g., private slice over public network). Deployments can be hybrid with on-premises radio and local breakout and connections to the telco core, and/or a public cloud or fully on-premises implementations.

Why This Is Important

Multiple verticals will require 5G private mobile network (PMN) deployments to realize the full effect of their digital transformation initiatives. It can provide the required functionality, with guaranteed performance levels, earlier than CSPs can offer on their public infrastructure. Distinct from the public network, it supports voice, video, messaging, data and IoT with higher performance requirements and can optimize cost or connectivity (e.g., cheaper than Wi-Fi for large area coverage).

Business Impact

5G PMN enables truly transformational digital use cases for industry, especially in conjunction with other technologies such as edge computing, such as factory digital twin, or edge AI for computer vision.

5G PMN can offer enterprises improved security and independence and enable efficiency gains in several manufacturing and industrial processes. For example, BMW Brilliance Automotive (BBA, BMW's joint venture in China) claims complete 5G coverage in all of its factories.

Drivers

- Improved applicability to connected industrial applications: while 5G standards are defined by 3GPP, other bodies are now contributing, for example 5G Alliance for Connected Industries and Automation (5G-ACIA) or 5G Automotive Association (5GAA).
- Requirement for full, reliable network coverage of buildings, machines, sensors and equipment, including indoor, outdoor, office and industrial areas at lower cost than Wi-Fi.
- Need to meet the performance profile for demanding industrial use cases is a key justification for deploying a private 5G network, in particular when low-latency, high-bandwidth and reliability are required.
- A private set up is required if network performance requirements exceed the capabilities of the shared public infrastructure.
- There is also another class of use cases, not focused on mobility initially but requiring a high-performance backbone where wiring is complex and costly — such as in a factory deployment.
- In addition, there is a lot of interest from TSPs that can offer 5G PMN to various verticals, such as I4.0 factory automation, mining, oil, utility and railroad companies; IoT providers, universities, stadiums etc. thereby expanding into industries and generating new revenue.
- We also see an influx of alternative provider types beyond the CSPs, such as integrators, infrastructure vendors and hyperscalers, all of which are driving new deployments and POCs.
- Enterprises deploy private networks because data privacy is a key concern. They require more control and visibility of their data, with security controls, and ensure that sensitive information does not leave the enterprise perimeter.
- Some enterprises want to run their network more independently as their own infrastructure, with limited outside dependency.
- Some defence and government clients have also indicated a wish to have more control and visibility into the vendors involved in the provision of mobile services, which can be an issue over a shared public network built and managed by a CSP.

Obstacles

- Unclear business models and value justification vs. alternatives (e.g., 4G PMN).
- Perception that real value begins from 3GPP R16, and that maturity and availability of R16 solutions is still a work in progress.
- Complex deployment and operation.
- Networks and endpoints cost.
- Lack of outcome-based pricing models.
- Spectrum availability and/or cost in some countries.
- Perception of risk regarding timing and relevance of private 5G.
- Feedback from some industrial clients mentioned that the majority of their use cases could be serviced by a 4G private network, and/or NB-IoT and other LPWA such as LoRa.

User Recommendations

- Enable networks differentiated from other possible providers such as large equipment vendors, system integrators, resellers and smaller specialist network vendors — and more recently hyperscalers, by integrating PMN with other functions such as SIM management, IoT platform, edge computing, design and managed services, and national roaming.
- Co-create networks by partnering with SIs and consultancies for design, deployment and managed services engineering headcount and evaluation test bed environments. For example, build manufacturing 5G PMN as a platform that combines connectivity with security and AI capabilities.
- Design licensed and unlicensed/shared spectrum options where available.
- Supplement your engineering teams by working with IT service providers that have the required industry skills.

Sample Vendors

AT&T; Athonet; China Mobile; Druid Software; Ericsson; Huawei; Nokia; Vodafone; ZTE

Gartner Recommended Reading

Creating Your Enterprise 4G and 5G Private Mobile Network Procurement Strategy and RFQ

Architecting a Reference Framework for 5G Private Mobile Networks

Market Guide for 4G and 5G Private Mobile Networks

4 Hype Cycle Innovations That Should Be on the Private Mobile Networks Roadmap for 5G Security, CSP Edge and Slicing

Market Guide for 5G Network Ecosystem Platform Providers

5G-Advanced

Analysis By: Kosei Takiishi

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

5G has been commercialized in many countries based on 3GPP Release 15 and more recently Release 16. As 3GPP continues to standardize new technologies and features for 5G, discussions on 5G successor technology are rising. 3GPP decided to call it 5G-Advanced as 3GPP Releases 18 and beyond bridge the gap between current 5G and future 6G.

Why This Is Important

Just like LTE rebranding for subsequent releases (LTE, LTE-A and LTE-A Pro), 5G functionality will be delivered over several installments. 3GPP Release 18 is still at the stage of discussion of its content, including enhanced mobile broadband (eMBB) driven work, non-eMBB-driven functionality and cross-functionality for both priorities and timeline. This continuous improvement can aid CSPs in more efficient use of their limited spectrum.

Business Impact

5G-Advanced has two priorities, both of which can improve network and service capability for consumers and enterprise clients:

- One is to enhance the existing capability or cost reduction, such as multiple input/multiple output (MIMO) and power saving improvement.
- The other is to create new business, including extending terrestrial networks and vertical use cases supported by Sidelink and IIoT/URLLC enhancement.

Drivers

- Standardization bodies and related consortiums, such as 3GPP, ETSI, 5G ACIA and 5G AA, have been promoting new features that can solve the challenges facing stakeholders.
- End-user voices demand abilities that are lacking in the journey of digital transformation in force.
- Developing new technologies and standards takes time, thus this step-wise approach to adding more features and capabilities to 5G standards allows commercial equipment and deployment before the full vision of 5G is enabled. Iterative learning can then be incorporated into the standard process to address any gaps or further needs.

Obstacles

- COVID-19 and other uncertainties related to standardization work. Actually, 3GPP delayed the final version of its Release 17 standards until March 2022, which originally was scheduled to be frozen in 2H21.
- Increased complexity of coordination work due to the proliferation of technology related standard organizations and industrial consortia, as well as increased dependency on other technical domains such as edge, cloud.

User Recommendations

CSP CTIOs should:

- Develop a strategy for what features to add to your 5G infrastructure while observing the progress of standardization activities.

- Not consider deploying 5G-Advanced commercially till 2024.
- Not be confused by the fact that we refer here to a different technology from the 5G evolution that AT&T had been marketing since 2018. AT&T's 5G evolution technically was based on 4G LTE.

Sample Vendors

Ericsson; Huawei; Nokia; ZTE

Gartner Recommended Reading

Magic Quadrant for 5G Network Infrastructure for Communications Service Providers

Create Value and Drive Revenue With 5G Network Slicing Phased Approach

Composable Networks

Analysis By: Susan Welsh de Grimaldo

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Composable networks are composed of disaggregated, reusable network functions and elements that can be easily integrated and that serve as shared pools of resources. Composable networks are built with modular, automatable components to support the dynamic requirements of a composable digital business. Telecommunications network technology will evolve with modularity with microservices based on containers, and use open APIs to integrate with other interoperable components.

Why This Is Important

Composable networks for CSPs enable more agility to deliver DevOps and low-code/no-code value propositions to customers while reusing integratable and automatable network components to drive efficiency. Implementing composable networks supports broader composable business thinking and design to evolve how CSPs engage with customers and ecosystem partners. By using more granular and modular components to build a network architecture, CSPs can quickly compose workflows and service chains.

Business Impact

Composable networks provide CSPs:

- An open approach where network components can be provided by different players in the supply chain.
- Innovation/faster upgrades that can occur in specific areas as R&D occurs per function.
- Composable network elements that can be made available in digital marketplaces to facilitate discovery and incorporation into the composable technology stack.
- The ability to assemble elements to rapidly seize market opportunities and respond to disruption while being resilient.

Drivers

- Agility and faster time to market to address customer needs and react to competitive offers.
- Adoption of cloud-native architectures, with use of microservices and disaggregation of network functions.
- API-enabled architecture and broader adoption of open APIs (e.g., TMForum APIs); an API-first architecture that will also facilitate discovery, orchestration and automation is the path to modularity.
- Increasing levels of composability evolving over time as products mature and as the vendor community further adopts open frameworks, microservices/containerized solutions and open APIs
- Increasing commercial deployments of 5G stand-alone (5G SA), with the service-based architecture (SBA) in the 5G core.
- 5G network slicing, which enables increased agility for customer-centric service creation by creating a mechanism for composable services across network domains and elements. Using automated processes driven by slice templates to deliver desired service parameters that can be quantified in an SLA.
- Competition with hyperscalers and more digital competitors, and consequential shifts in demand to favor new business models for on-demand, consumption-based delivery and more digital experiences. CSPs will need to shift to sell solutions delivering business outcomes, not one-off products.
- Postpandemic awareness of the increasing need to be able to respond to uncertainty and pivot as needed with less risk, faster speed.
- CSPs increasingly participating in digital ecosystems to find new and differentiating value, and finding their traditional technical capabilities are barriers to such participation. CSPs rebalancing their technology portfolio to accelerate digital transformation to align their technical and nontechnical capabilities, old and new, to business outcomes (see 2021 CIO Agenda: A CSP Perspective).
- More CSPs are building networking, connectivity and IT capabilities agnostically of the services layer specifications and nuances, enabling on demand use.

Obstacles

- Challenges reaggregating functions to interoperate with high reliability.
- Orchestration across components, especially in a multivendor network environment.
- Slow movement toward cloud-native architectures, standard open APIs and 5G SA, all of which will enable increased network composability.
- Management of CI/CD pipelines across a wide range of composable/modular network elements from multiple vendors.
- CSP employee and vendor ecosystem mindsets.
- Siloed organizational structures at CSPs, with separate teams addressing IT and OT as well as network domains.
- Lack of comprehensive and consolidated real-time network inventories and discoverability of network elements.
- Legacy last mile and metro area networks inhibit multitenancy.

User Recommendations

- Plan your network roadmap with concrete steps to move toward composable networks, focusing on increasing automation and interoperability.
- Evaluate unique value propositions of different emerging technologies and vendor solutions/products to aid in developing a composable network.
- Select network vendors which have a vision toward supporting increasing levels of network composability, will work collaboratively and support integration of composable elements into your existing network environment.
- Focus on increasing adoption levels of enabling technologies, e.g., standard open APIs, cloud-native/microservices, 5G SA and real-time consolidated network inventory.
- Assess what aspects of your organizational structure, governance and mindset need to change to support a move toward a composable network.
- Conduct a comprehensive analysis of your available and required skills (business and technical) needed to design and operate composable networks. Identify gaps, and upskill where necessary.

Gartner Recommended Reading

Top Trends in Capturing New Value for Communications Service Providers in 2021

Use Gartner's Reference Model to Deliver Intelligent Composable Business Applications

Quick Answer: What Is Composable Business Architecture

Tech Providers 2025: CSP-Offered Composable Edge and 5G Services Will Enable Enterprise Agility and Growth

How to Prepare for the Rise in Digital Infrastructure Marketplaces Driven by Network Disaggregation

RedCap

Analysis By: Kosei Takiishi

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Reduced Capability New Radio (RedCap) is a 5G standard specification focusing on IoT by 3GPP release 17 that will be frozen in 2022. This was tentatively called NR-Light before. Release 16 for 3GPP covers high-performance (e.g., industrial) and low-complexity IoT (i.e., LTE-M/NB-IoT), but there is a gap between them. RedCap aims to reduce power consumption, which is indispensable for IoT applications, with communication speeds of several Mbps to 100 Mbps and delays of tens to hundreds of ms.

Why This Is Important

While NB-IoT and LTE-M enhancements have been covered by early 5G specifications in 3GPP releases 15 and 16, they are not very new and are just relatively minor improvements compared to other new functions. RedCap will support a new class of devices that is more capable than LTE-M/NB-IoT but supports different features and smaller bandwidth than 5G NR eMBB/URLLC. RedCap can be a suitable technology for use cases such as high-end wearables or industrial IoT cameras and sensors.

Business Impact

The concept of the enhancement of initial 5G — 5G evolution — becomes mature in the middle of the 2020s, and RedCap will be one of the important technology components. RedCap will not impact any businesses soon but its benefit is clear, and it can satisfy enterprise clients that are trying to find devices with a balance of functionality and cost.

Drivers

- RedCap can support new use cases that have not been supported by incumbent technologies by achieving reduced power consumption, affordable device pricing with communication speeds of several Mbps to 100 Mbps and delays of tens to hundreds of ms.
- The telecom industry is promoting 5G as a platform for vertical industries, such as automotive and healthcare, and RedCap capability will become the basis for the platform.
- Vertical industries, including the automotive industry (5G Automotive Association) and the manufacturing industry (5G Alliance for Connected Industries and Automation), are demanding RedCap for their digital transformation.

Obstacles

- Several years of preparation will be needed before RedCap is ready for commercialization. This preparation includes 3GPP standardization, vendor implementation, CSP deployment and device vendors' adoptions.
- Unclear use cases of RedCap could delay its commercialization. Currently, most IoT-related use cases could be satisfied by either LTE-M/NB-IoT or 5G eMBB.

User Recommendations

CSP CTIOs should:

- Estimate suitable use cases of RedCap by observing and participating in related 3GPP standardization.
- Adopt multi-IoT access technologies, including LTE-M, NB-IoT and RedCap to satisfy multiple demands from clients.

Sample Vendors

Ericsson; Huawei; Nokia; Qualcomm

Gartner Recommended Reading

Magic Quadrant for 5G Network Infrastructure for Communications Service Providers

Active-Passive Antenna

Analysis By: Kosei Takiishi

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Definition:

Active-passive antenna (APA) is an emerging antenna technology that integrates passive antennas and active antennas into a one-box solution. While passive antennas were commonly used for 4G, early 5G is rapidly adopting active antennas, including massive multiple input/multiple output (MIMO). APA has been adopted commercially to modernize CSP's cellular network quickly and efficiently.

Why This Is Important

Mobile CSPs are in fierce 5G competition. They are demanded to offer 5G services with wide coverage, high data traffic at an affordable price, quickly. Active antennas can enlarge data throughput, but require space for new installation, and their deployment is time consuming and costly. APAs can replace incumbent antennas by supporting both active and passive antenna capabilities including 5G massive MIMO and DSS over 4G and 5G.

Business Impact

- CSPs can add new 5G RAN features and technologies without time-consuming negotiations to acquire new locations for new antenna equipment.
- Maintenance efficiency and visibility can be improved by integrating antennas for past generations and 5G.

Drivers

- In 5G, higher radio spectrums are used, which leads to cell densification, making it more difficult to find new locations for base station antennas. APAs can solve this issue to some extent.
- Total cost of ownership (TCO) could be reduced by purchasing unified antennas and reusing power supply, cabling and so on.
- Leading vendors have already developed APA products and commercialized them. Examples include Huawei 5G Blade AAU and Ericsson's Hybrid AIR and Interleaved AIR.

Obstacles

- Chronic lack of space for base station antenna deployment.
- Product limitation of supported frequency bands for active and passive antennas.

User Recommendations

- Adopt APA by estimating its benefit through the comparison between current separated passive and active antenna deployment and APA.
- Extract 2G/3G users and these network traffic by leveraging APA that can support multiple radio bands of 4G and 5G.

Sample Vendors

Ericsson; Huawei

Gartner Recommended Reading

Magic Quadrant for 5G Network Infrastructure for Communications Service Providers

Public Cloud for Mobile Edge

Analysis By: Sylvain Fabre, David Wright

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Public cloud for mobile edge is an infrastructure deployed in the carrier network that hosts public cloud compute, storage and networking, that runs telecom workloads and is public-cloud-managed, to be deployed at the cloud provider's edge or within a telecom communications service provider's network. It is suitable to host a variety of telecom workloads stretching from the telecom back office out to the mobile edge.

Why This Is Important

Many different technologies and types of expertise are required to successfully deliver applications and services that are both cloud-based and telecom-network-enabled. CSPs and public cloud providers each can offer the capabilities needed to meet the needs of this market. Public cloud for mobile edge is at once both an architecture for deploying and managing telecom-enabled cloud applications, and can foster partnerships between CSPs and public cloud providers.

Business Impact

- Public cloud providers are consolidating more network capabilities, used to become more of a partner, supplier or competitor to infrastructure vendors and CSPs, thanks to adoption of VNFs, CNFs and shared spectrum options.
- Public cloud for mobile edge accelerates CSP transformation at the edge by providing a strong alternative to traditional vendors with lower infrastructure commitment and a mature technology partner ecosystem.
- Public cloud providers can reach new markets for mobile and real-time edge use cases in both the B2B and B2C realms.

Drivers

- The public cloud providers are adapting their IaaS and PaaS infrastructure to better integrate with and complement telco CSP network environments. Examples include 5G multiaccess edge computing (MEC) with AWS Wavelength. AWS will self-OEM the hardware for its Wavelength zones. Another example is Microsoft Azure Edge Zones for telco (optimized x86 plus virtual Evolved Packet Core [EPC] plus certified partner virtual network functions [VNFs]). Microsoft will partner for integrated certified hardware. An additional example is Google Global Mobile Edge Cloud (GMEC) will run on a variety of third-party container-compliant hardware.

- Microsoft and Google are explicitly including the use of their own edge network access points and capabilities in the offering; AWS has not yet specified this aspect.

- Microsoft has purchased virtual EPC (mobile packet core) provider Affirmed Networks, and agreed to acquire Metaswitch Networks (cloud native telecom networks). AWS has partnered with Nokia. In all three cases, the goal is to “tether” the mobile domains to the public cloud and manage them from there, at least partially.

- The desire of telecom CSPs to reduce operating costs, and to sell services that monetize their 5G network and license investments will continue to propel them toward the cloud providers, and likewise the telecom VNF/app independent software vendors (ISVs) will see a scalable route to market.

Obstacles

- Public cloud for mobile edge solutions can involve complexity and multivendor scenarios such as the telco CSP, the public cloud provider, a third-party mobile application ISV, a system integrator, carrier-neutral access network providers, software-defined cloud interconnection providers.

- Sharing of revenue, margins and customer control between these parties. CSPs will be wary of taking a heavy dependence on a cloud provider without assurance of appropriate revenue sharing for the “over the top” services delivered on the provider’s platform. Cloud providers will be wary of giving CSPs undue control over their larger enterprise customers.

- Some CSPs are cautious of partnerships with public cloud providers, due to perceived risk for CSPs when public cloud providers compete in providing private mobile networks to enterprises. Interventions by regulators, who may be concerned about hyperscalers’ market power, could slow down adoption.

User Recommendations

- Focus on business through leveraging the public cloud enterprise channel and developer ecosystem.
- Increase differentiation by enabling integration of the edge computing offering from the public cloud providers into private mobile network solutions for industries.
- Retain long-term value by designing an edge architecture with edge public cloud providers so that the CSP can secure most value from enterprise networks and related IoT data.
- Preempt competing offers by cloud providers for mobile private networks by enabling complementary solutions such as slice as a service to cloud providers and mobile virtual network operators (MVNOs), using shared as well as licensed spectrum options.
- Leverage what public cloud providers bring: something the telco CSPs have never been able to develop: a truly horizontal application hosting and management environment.

Sample Vendors

Alibaba Cloud; AWS; Google; IBM Cloud; Microsoft Azure; VMware; XGVela; HPE

Gartner Recommended Reading

Emerging Technologies: Venture Capital Growth Insights for mmWave 5G

Market Trends: How TSPs Are Preparing 5G Solutions With Cloud Edge Providers

5G as a Service: Deployment Scenarios of Private Networks in the 5G Era

Routes to the Future for CSPs — Technology Strategy

Market Guide for 5G Network Ecosystem Platform Providers

Creating Your Enterprise 4G and 5G Private Mobile Network Procurement Strategy and RFQ

50G PON

Analysis By: Peter Liu

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Embryonic

Definition:

50G PON is the next-generation passive optical network (PON) standard formulated by International Telecommunication Union's Telecommunication Standardization Sector (ITU-T). It supports 50 Gbps uplink and downlink over a single wavelength, and provides a bandwidth five times faster than 10G PON. It uses the time division multiplexing (TDM) PON mechanism, and supports the coexistence with 10G PON and the deployed optical distribution network (ODN) infrastructure.

Why This Is Important

Applications like augmented reality (AR)/virtual reality (VR), video, etc., are continuously putting pressure on CSPs transport infrastructure. In addition, various critical enterprise use cases and adoption of 5G bring more strict performance requirements. With 50G PON, CSPs do not just improve their bandwidth and capacity, but also support backhauling of 5G and various mission-critical services through optimizing clock synchronization and providing data processing of each end of PON.

Business Impact

50G PON has been considered as the next-generation PON technology specification by industry standards organizations such as ITU-T, CSPs and equipment vendors. 50G PON allows CSPs to offer shared internet speed up to 50 Gbps and deliver 5 to 10 Gbps services to end users. In addition, optimized clock synchronization and improved latency enable CSPs to support innovative services that pose strict requirements on SLA and performance.

Drivers

- Growth in cloud computing, artificial intelligence (AI) and 5G has driven an increasing demand for access bandwidth that requires continuous improvement of the access network capacity. 50G PON provides larger shared bandwidth to support more users and more application delivery options.
- The access network upgrade tempo generally happens every seven years. Based on the deployment pace, the next generation of PON technology would start to deploy in around 2025 to 2026. 50G PON technology is expected to be a preferred choice that attracts more investment in this domain and accelerates the maturity.
- 50G PON can reuse some of the existing 10G PON resources like cabling and in doing so it can reduce deployment costs. Depending on the selected wavelength plan option, 50G PON can also support GPON coexistence.
- Compared with 10G PON, the 50G PON further optimizes clock synchronization and data processing at each end of the PON. It gains CSPs attention since it allows CSP to effectively support enterprise services which pose strict requirements on delay and clock synchronization and, in turn, generate new revenue.
- Another driver is high-density small cells for 5G fixed wireless access (FWA), which require larger bandwidth for the backhaul transport. The current 10G PON can hardly meet the increasing bandwidth requirements or premium service-level agreement needs.

Obstacles

- 10G PON will continue to be deployed on a large scale and should be sufficient to meet the market demand in the next few years. In addition, although 50G has some benefits, the economics of some use cases need to be proven.
- 50G PON is still a future-proof technology and likely to be the preferred choice to migrate from 10G PON to 50G PON. It is still not mature enough to fulfill the large-scale commercial rollout. Frequently upgrading fiber networks in a short-time interval cannot be supported economically or operationally. 50G PON technology is expected to be technically achievable in three to five years.

User Recommendations

- Establish your next-generation PON rollout strategy which is in-line with multiple business objectives such as long-term and stable returns, recognized and established technology. Include 50G in your roadmap.
- Focus on XGS PON now and take a step-wise approach for your PON evolution. CSPs can start limited scale 50G PON trials in areas that have strict requirements on latency and clock synchronization.
- Position 50G PON as a key enabler for 5G hauling and enterprise scenarios instead of residential services.

Sample Vendors

ADTRAN; Calix; Cisco; DZS; Huawei; NEC; Nokia; ZTE

Gartner Recommended Reading

Routes to the Future for CSPs — Technology Strategy

Predicts 2021: CSP Technology and Operations Strategy

Top Trends in Capturing New Value for Communications Service Providers in 2021

Top Trends in Managing Disruptive Influences for Communications Service Providers in 2021

Top Trends in Driving Operational Excellence for Communications Service Providers in 2021

5G Network Security

Analysis By: Sylvain Fabre, Bernard Woo, Peter Liu

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

5G provides a unified authentication framework, which is open and access-network agnostic. 5G security mechanisms improve 4G security with enhancements such as new mutual authentication capabilities, enhanced subscriber identity protection, and address the new threat surface from emerging technologies such as cloud-native architecture, network slicing and edge.

Why This Is Important

Securing 5G networks is a priority for CSPs and enterprises as the rise of private deployments, vertical applications, cloud architecture and massive IoT connections in 5G creates new vulnerabilities and challenges, such as potential DDoS attack vectors and entry points. 5G's unified authentication framework is both open (e.g., with the support of EAP) and access-network agnostic (e.g., supporting both 3GGP access networks and non-3GPP access networks such as Wi-Fi and cable networks).

Business Impact

Guaranteed security levels enable 5G use in more demanding applications. For example, the home control feature verifies device location when in a visited network, preventing some spoofing attacks. 5G mitigation against bidding down attacks prevents a fake base station from pretending not to support higher 5G security features. Flexible security policies attached to other 5G chargeable features such as slice as a service, guaranteed low-latency, allow for premium security services.

Drivers

- Pressure from enterprises looking to deploy private 5G while managing security and liability exposure.
- Increased regulation around user data privacy.
- Increased scrutiny on 5G infrastructure vendors, and heightened competition between them for perceived security levels.
- Legacy networks and devices with lower security capabilities will interconnect with 5G networks, which need to be able to handle such connections safely.
- Cloud-based delivery of 5G network infrastructure and services, including packet core, network slicing and edge computing require cross domain security .
- Demand for edge enterprise solutions will accelerate 5G security.
- 5G SBA infrastructure virtualization, automation and orchestration of a service-based architecture, as well as increasingly multivendor solutions, increases risk exposure for CSPs and enterprises.

Obstacles

- Wider ecosystem delivering industrial 5G use cases, with varying security competencies and credentials, make SLAs, service assurance including E2E security, challenging.
- Backward compatibility with 4G/LTE means some legacy security issues persist in 5G.
- 5G end-to-end security represents a new set of challenges, in particular when edge slicing is included.
- Integrated network security is not typically handled by the enterprise CIOs — but here they need to own 5G security for their on-premises 5G private mobile networks, and can not afford to rely exclusively on their vendors and CSPs.
- Not all components are (yet) known and defense models may have to broaden as implementation progresses, which does not necessarily help with the trust angle, especially with international relations and geopolitical hesitations.
- Standards won't cover everything — implementation will hugely influence outcomes (e.g., private network versus public infrastructure, on-premises versus cloud-based infrastructure).

User Recommendations

- Assess and anticipate increased attack risk such as DDoS by improving design of 5G network infrastructure and endpoints, and recovery procedures.
- Implement layered-DDoS defense by using the best-of-cloud scrubbing, cloud web application firewall, bot mitigation, DNS protection, ISP and on-premises DDoS appliances.
- Initiate effective mitigation by correlating network traffic, application availability and server performance.
- Complement 5G infrastructure security with distributed AI/ML anomaly-detection algorithms, including edge and core slicing.
- Implement edge protection concepts used in application security for elasticity and focused on app-layer protection, and commonly provided via a CDN provider, SaaS or cloud provider.
- Implement 5G E2E security by managing algorithm strength, secret keys negotiation, enforcing confidentiality protection, securing cross-domain slice orchestration and HetNet layers.

Sample Vendors

Ericsson; Huawei; Mobileum; Netcracker; Nokia; VIAVI; Palo Alto Networks; Microsoft; A10 Networks

Gartner Recommended Reading

4 Hype Cycle Innovations That Should Be on the Private Mobile Networks Roadmap for 5G Security, CSP Edge and Slicing

Creating Your Enterprise 4G and 5G Private Mobile Network Procurement Strategy and RFQ

5G as a Service: Deployment Scenarios of Private Networks in the 5G Era

Open Core Network

Analysis By: Peter Liu

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Open Core Network (OCN) is an initiative from the Facebook Telecom Infra Project (TIP), which aims to develop an open, cloud-native and convergence core, running on standardized software and hardware infrastructure, and supporting 4G and 5G access technologies.

Why This Is Important

CSPs want more flexible sourcing options for their core solution to reduce costs and vendor locking and increase innovation. TIP's OCN project is an attempt to address this need by creating a core network for 4G and 5G that will be formed by open and composable software elements provided by independent vendors. Cloud-native network, service-based architecture and network slicing form the major building blocks of an open and converged core network.

Business Impact

- The open and disaggregated architecture provides the flexibility to deploy 5G core components in different locations with multiple vendors, based on a standard open interface.
- Breaking core functions into software elements that can be deployed, managed and sourced independently increases competition and allows a more flexible sourcing strategy.
- Separating hardware from software, so core software can be deployed in commercial-off-the-shelf (COTS) hardware, reduces cost.

Drivers

- In the telecom domain, there is increasing interest in network virtualization and cloudification, driven by a desire to move away from vendor-proprietary stack and/or leverage the pace of innovation associated with popular open-source initiatives.
- A strong commercial ecosystem is forming around network function virtualization and cloudification. This drives increasing customer interest in the open network concept.
- 5G core is supposed to be the first telco cloud network that is natively virtualized, software-defined, elastic and automated at scale. The growing stand-alone deployment of 5G accelerates the 5G core roll out.
- 5G core microservices architecture allows new vendors to enter the ecosystem without the burden of providing end-to-end solutions. This increases competition and innovation, with either best-of-breed vendors for each network element, or selection of vendors for fit-for-purpose use-case deployments.

Obstacles

- It faces the challenge of being adopted by the big players in the industry.
- A multivendor environment may be attractive to some CSPs; however, there are challenges associated with integration, management and operation. For example, identifying and isolating network issues becomes more difficult in a complex multivendor environment. A 5G core made up of multiple vendors' software elements increases threat surface areas.
- OCN concepts and standardization are still evolving and not mature enough for the large-scale rollout. We expect to see wider adoption by CSP starting from 2025.

User Recommendations

CSP CIOs/CTIOs who are in charge of network virtualization and cloudification should:

- In the short term, focus on open and disaggregated architecture for your 5G core instead of a multivendor environment, since it will increase the integration complexity even if all vendors claim they are based on the same open interface.
- Influence standards by actively participating on the OCN technical workgroup, and monitoring the progress and maturity of OCN closely.

- Evaluate and test OCN products in specific use cases that do not need a full, complex end-to-end core solution — for example, private mobile networks for enterprise.

Sample Vendors

Amdocs; Entel; Wavelabs; FreedomFi

Gartner Recommended Reading

Create Value and Drive Revenue With 5G Network Slicing Phased Approach

Drive 5G Network Slicing From POC to Scale

Emerging Technology Horizon for Communications

5G as a Service: Deployment Scenarios of Private Networks in the 5G Era

800G Transport

Analysis By: Peter Liu

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

800G is a programmable, coherent optical technology that operates at high baud (90-100G symbols/second) and is capable of processing and transporting more capacity than has been previously possible over a single optical channel or wavelength, up to 800 Gbps.

Why This Is Important

800G technology is important due to its ability to increase fiber capacity or extend wavelengths across any path through remotely adjustable line rates. With an 800G solution, CSPs, service and content providers can transport more throughput for every wavelength they deploy or extend wavelengths across longer distances without regeneration. It also means significant reduction in footprint, power and transport costs with fewer wavelengths to deploy and manage.

Business Impact

- Exponential growth of data traffic continues to push for higher interconnection data rates to reduce the cost/bit and energy/bit. With programmable 800G, CSPs can transport more throughput for every wavelength they deploy, and across longer distances without regeneration.
- CSPs can offer higher connectivity services while evolving to a greener network by reducing footprint and energy consumption. These advancements support the growing digital economy and efficient transport of content.

Drivers

- Network traffic will continue to increase sharply in the next 10 years as new technologies and services such as 5G, cloud computing, big data and AR/VR approach maturity. Therefore, the construction of transmission infrastructures in addition to the evolution of equipment and technology must make strides to keep up with the wave of the digital flood.
- 5G drives the need for faster optical transport in the fronthaul, midhaul, and backhaul parts of the network. That's pushing the state-of-the-art optical transport past 400 Gbps to 800 Gbps, also called 800G.
- The new fifth-generation coherent digital signal processor (DSP) represents significant technical achievements and pushes wavelength capacities close to the Shannon theoretical limits, making 800G more practical to deploy.
- Several CSPs started live trials of an 800G ultra-high-speed optical transport network, marking a step closer to the commercialization of the 800G optical transport network solution.

Obstacles

- 800G is still in its early stage, and maturity of the 800G technology and standard is a key issue for CSPs who want to adopt the 800G technology.
- The cost associated with 800G technology is substantial. The equipment is still not mature and the limited scale of the market makes it more expensive and impedes adoption.
- Evolution path is another concern. While 400G is still on its way to become a mainstream technology, it will take much longer for 800G to gain momentum.

User Recommendations

- Conduct detailed assessments of the network traffic pattern and utilization before adopting 800G. It's important to understand actual, realistic network performance that can be expected when using high-capacity wavelengths when planning a network's evolution.
- Work closely with vendors and standardized organizations to understand the technology progress trends and learn from best practices.
- Define the long-term evolution path of your optical transport network and position 800G as a critical milestone in your evolution journey.

Sample Vendors

ADTRAN; ADVA; Ciena; Cisco; FiberHome; Fujitsu; Huawei; Infinera; Inphi; ZTE

Gartner Recommended Reading

Routes to the Future for CSPs — Technology Strategy

Predicts 2021: CSP Technology and Operations Strategy

How CSPs Can Approach Digital Ecosystems for Successful Collaboration

Hyperautomation: How Can CSPs Prepare for and Implement It?

Top Trends in Capturing New Value for Communications Service Providers in 2021

Top Trends in Managing Disruptive Influences for Communications Service Providers in 2021

Top Trends in Driving Operational Excellence for Communications Service Providers in 2021

At the Peak

CDN Developer Edge Node

Analysis By: Ted Chamberlin

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

CDN providers continue to provide developer tools, APIs and runtime environments at their edge nodes. CDN developer edge nodes provide either stateful- or stateless-based processing environments that support the execution of code. Technologies deployed in CDN edge nodes include containers, kubernetes clusters, key value stores, NoSQL databases and Chrome V8 engines.

Why This Is Important

CDN providers have been on a long slow path to manage their investments in commodity networks and value-add services. Severless and containerized microservices architecture has gained considerable enterprise popularity as a way to build cloud-native applications and to enable continuous delivery. As developers venture into applications requiring low latency and high performance, edge environments that can support some degree of stateful processing will become another valuable endpoint.

Business Impact

Adoption of CDN/edge-based serverless architecture will:

- Lead to increased scalability, reduced costs and faster time to market for IT-supported business initiatives
- Help achieve true benefits of cloud-native operations and create a more consistent and manageable environment for cloud operations
- Require adjustments in the organization practices and strategies around security, infrastructure and operations, and application development, mandating closer coordination.

Drivers

- Gartner expects that the enterprise CDN market will grow from around 14% compound annual growth rate through 2025.
- As many enterprises deploy applications and workloads that can't tolerate latency delay (4K video, gaming and trading), consumers of CDN will begin to look beyond content delivery and dabble in developer edge services.
- Gartner sees typical edge use cases, including geographic fencing, A/B testing and stage migrations. Developer edge offerings from CDNs vary based on maturity, so enterprises should consider test and Q/A projects as candidates for deployment.

Obstacles

Obstacles for adoption could include:

- Disparate technology stacks that fail to deliver performance and low latency
- Regional compliance and privacy considerations that preclude code or data from existing outside of a specific location
- Failure of vendors to support multiple development languages beyond JavaScript
- Preset limits around compute or storage that limit use cases' applicability
- Stagnated development by vendors to develop innovation roadmaps around develop edge delivery
- Lack of APi and container registries

User Recommendations

CIOs, CTOs, IT leaders and planners should:

- Evaluate CDN developer edge services for use cases extending cloud-native applications, microservices implementations, or service integrations to achieve improved productivity and cost-efficiency.
- Avoid CDN edge delivery if the project requires fine-grain control over application infrastructure operations, or where cost estimates are excessive.
- Choose a CDN provider based on its service portfolio, support, footprint and management tools.

Sample Vendors

Akamai; Cloudflare; Fastly; StackPath; Macrometa; Rafay Systems

Gartner Recommended Reading

Market Guide for Global CDN

Market Insight: CDN Global Market Evolution Requires Specialization

Emerging Technologies: IoT Platforms at the Edge Needs Secured and Composable Architectures/Design

Software-Defined Cloud Interconnect

Analysis By: Lisa Pierce

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Software-defined cloud interconnect (SDCI) provides private network connectivity between enterprises and public cloud service providers (CSPs). SDCIs pre-provision physical connectivity from their hubs to public CSPs, internet service providers (ISPs) and network service providers (NSPs). SDCIs serve as aggregators and intermediaries to quickly provision logical connectivity to CSPs and complement this with billing, monitoring/management, security and administrative functions.

Why This Is Important

Capabilities provided by SDCIs reduce complexity by providing enterprises with a single interface to potentially dozens of CSPs (IaaS, PaaS and SaaS providers), ISPs and NSPs. These functions are also useful when a CSP site experiences either an interim or prolonged/catastrophic outage. SDCI services are key enablers of private, high-performance connectivity to public cloud services and are simpler than dealing with individual cloud services providers on a one-off basis.

Business Impact

Simplifying the method of connecting into multiple public CSPs is essential to optimizing the end-user experience, performance, security and cost. Because it supports rapid provisioning and modification of configurations via a centralized dashboard and programmable controls, SDCI is the most agile of private methods to connect into CSPs. In addition, many SDCI offers also include other services, such as security features, SD-WAN gateways and inter-SDCI hub WAN transport.

Drivers

- Gartner clients often assume they will employ one method to connect into all CSPs, but most enterprises are best served by employing at least two types of connectivity. Direct internet access into CSP ports doesn’t scale well, since each CSP has unique administrative and management portals, billing, SLA and security requirements.

- The global COVID-19 pandemic exacerbated this scaling problem by accelerating enterprise migration to CSPs, which will grow at a compound annual growth rate (CAGR) of more than 24% from 2021 through 2024 (see Forecast: Public Cloud Services, Worldwide, 2018-2024, 4Q20 Update). Today, most enterprises connect to 20+ public CSPs. In addition to internet connectivity, clients can employ carrier cloud connect services like AT&T NetBond and cloud hubs like Equinix or SDCI. With the exception of internet connectivity, all of the remaining connectivity choices into CSPs are private — and they connect into CSP private ports like Amazon Web Services (AWS) Direct Connect. Gartner anticipates enterprise spending on cloud connectivity will grow by over 17% year over year between 2019 and 2024, with 75% of enterprises employing private WAN cloud connectivity services (see Forecast Analysis: Enterprise Networking Connectivity Growth Trends, Worldwide).

- Simplifying the method of connecting into multiple CSPs is essential to continued adoption of CSP services. In addition, I&O leaders must optimize the end-user experience, performance, security and cost — and this is where SDCI excels. SDCIs are the most flexible private method, both to connect to multiple CSPs and to manage that connectivity going forward; by the end of 2024, we anticipate that 30% of enterprises will use SDCI services to connect into public CSPs — up from less than 10% in 2020.

Obstacles

- The largest obstacle to SDCI adoption is the widely held perception by many I&O leaders that they only need to employ internet connectivity directly into CSPs.
- Many I&O leaders are unaware of the availability of private connectivity options.
- I&O leaders often are unfamiliar with the differences between the types of private connections into CSPs, and the use cases that best align with each type of connection.
- SDCI functions are evolving over time, which makes it difficult for some clients to decide the best time to jump in.
- Current SDCI market leaders are smaller companies that are often unknown to enterprise clients, which increases perceived risk.

User Recommendations

Today, four considerations enterprises must address include:

- Assess basic functions: Clients who want SDCI providers to connect into CSPs and also provide WAN and access should use MSPs for SDCI. Clients who only want connectivity into CSPs can also assess SDCI from non-MSPs.
- Availability and maturity of other functions: Assess SDCI offer breadth with other services like security, monitoring/management, billing, UCaaS and SD-WAN. As to their level of integration with the foundational SDCI service, favor in-line/integrated services versus bolt-ons.
- Hybrid computing needs: Assure that end-end reliability, security and performance meet your requirements in hybrid environments like mixed computing and applications environments, and multicloud use cases.
- Assess alternatives: A growing number of providers offer connectivity to multiple cloud providers, enhanced internet backbone providers and carriers. Carefully assess both your own needs and the changing provider landscape.

Sample Vendors

Alkira; CoreSite; Epsilon; PacketFabric; Unitas Global

Gartner Recommended Reading

How to Optimize Network Connectivity Into Public Cloud Providers

Innovation Insight for Software-Defined Cloud Interconnection

How to Architect Network Connectivity Across Multiple IaaS Cloud Providers and Regions

How to Architect Your WAN for Hybrid Cloud and Multicloud

How to Interconnect With Azure, AWS and Google Backbones

Cloud-Native CSP Infrastructure

Analysis By: Susan Welsh de Grimaldo

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Cloud-native CSP infrastructure is a new network architecture that leverages cloud computing characteristics. These include capabilities delivered on demand that are scalable and elastic, service-based, programmable (API-driven), and loosely coupled. Network functions that are fully rewritten or developed to take advantage of the cloud capabilities on public, private or hybrid clouds are considered cloud native.

Why This Is Important

CSPs are facing increased competition from more agile, digital, cloud-native companies and a need to integrate more partner solutions in their offerings to meet customer needs. More CSPs and innovative, newer vendors of telecom network infrastructure are pushing for added cloud-based capabilities, utilizing microservices architecture based on containers and supported by CI/CD, API-driven infrastructure and application software to increase CSP agility and partnerability.

Business Impact

A cloud-native approach promises a transformational impact on both CSP operations and business — offering a number of benefits, such as flexibility, agility, scalability and improved products and feature velocity. Cloud-native infrastructure can enhance automation, service orchestration, partner ecosystems and product innovation to offer improved services and efficiencies as well as an ability to pivot to meet new challenges.

Drivers

- More vendors, particularly in BSS and increasingly in OSS, have been increasing their commitment to migrate products to cloud-native architecture and adopted an integrated platform approach to support this process.
- CSPs and vendors are participating in Cloud Native Computing Foundation (CNCF) and Open Networking Foundation (ONF) to promote and collaboratively develop cloud-native and open source specifically for telecom infrastructure.
- As CSPs seek to increase their enterprise value proposition beyond traditional connectivity, they are motivated to move to cloud-native infrastructure that will make them more attractive to key partners. For example, the more cloud-native capabilities CSPs develop, the more they are attractive to hyperscalers as partners or supply chain providers.
- More scalable, elastic and programmable infrastructure technologies are gaining popularity over traditional ones, with microservices deployed in containers as a core technology, especially for new workloads. Compute, jointly with infrastructure functions such as storage and networking are evolving to support cloud-native principles.
- Agile providers have been able to leapfrog bigger competitors by leveraging the major cloud providers' infrastructure, showcasing best practices and driving attention to the benefits of cloud-native infrastructure by sharing performance metrics.
- Cloud-native approaches by greenfield operators Rakuten Mobile and Dish Networks aim to showcase the potential of cloud-native infrastructure for enabling more automated, lower headcount/opex to manage networks and provide 5G network-slicing-ready advantages.
- Increasing deployments of edge commute (MEC) by large CSPs supports distributed cloud-native infrastructure deployments.
- Frequency and modularity of software updates to increase pace of incorporating advances in R&D and iterative lessons from deployments around the globe, which can be done in each function/element without full solutions being taken offline.

Obstacles

- Confusion over what cloud native means and how each vendor is implementing it in their products.
- Lack of transparency on vendor roadmaps on how cloud native their current commercial offerings are, steps planned to become more cloud native and benefits they will offer.
- A skills gap; for example, skills to manage frequency of software updates and continuous integration/continuous delivery (CI/CD) pipelines across multiple vendors (for container-based and VM-based), particularly for new solutions, such as 5G coreCSPs that had sold off cloud business and not retained talent, there is a tech debt.
- Reluctance to move from investments in reliable legacy infrastructure, particularly with the complexity to transition processes and organizational structure to support cloud native and scale to serve a large base of users.
- Growing CSP concerns over the potential growth in OPEX as infrastructure hosted in public clouds scales, compounded by over-dependence on few hyperscalers over time.

User Recommendations

- Identify skills gaps that will limit your ability to move to a more cloud-native environment.
- Identify areas that can be moved to cloud native sooner, to build knowledge and skills, by working through details of network roadmaps.
- Prioritize selection of vendors that will best support your transition to become more cloud native, by assessing vendors with ability to work as true partner on transition journey; increased out-of-box functionality; standard open APIs; clear and transparent roadmap of their products in terms of how cloud-native they are and what is currently commercially available, and what features will be enabled or developed during the project delivery time frame.
- Support shifts in processes and decision making, as well as KPIs, to understand performance, cost structures and workflows that moving to cloud-native infrastructure necessitates.

Gartner Recommended Reading

Market Trends: The Rise of Cloud-Native Technology Ecosystems (Container Perspective)

Lessons Learned From Rakuten's Fully Virtualized and Cloud-Native 4G Network

How CSPs Can Use Cloud to Gain a Competitive Advantage — Lessons From the Pandemic

Edge as a Service

Analysis By: Bob Gill

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Edge as a service describes a model in which the edge platform or even the edge applications are offered via provider-owned and operated assets, requiring little to no ownership of infrastructure on the part of the customer.

Why This Is Important

The lack of standards and the diversity of edge devices and workloads make implementation challenging for even the most tech-savvy enterprises, while the potential for selecting a technical "dead end" is high. Edge as a service features a delivery model for edge computing in which a system integrator, ISV and/or cloud provider offers all of the infrastructure required to deliver edge-based applications, shielding the customer from technical complexity and market volatility.

Business Impact

- Most enterprises do not possess the skills or experience to build and manage complex, distributed systems incorporating a diversity of end systems and software stacks.
- EaaS delivers and maintains prebuilt solutions with a primary focus on meeting SLAs based on business outcomes.
- EaaS simplifies adoption of complex edge initiatives, while lessening complexity, risk of obsolescence and technical debt incurred.

Drivers

- Organizations looking to deploy edge computing are finding that the crowded and rapidly shifting technology space is making vendor selection a nearly impossible task.
- Enterprises looking to limit risk find edge as a service to be a safe and defensible choice. Rather than making technology choices, they can contract for a business outcome (for example, retail store operations with explicit SLAs) and be insulated from the infrastructure that the provider uses to deliver the solution.

Edge as a service solves for:

- Lack of skills and experience in building and operating edge computing solutions.
- Exposure to technology obsolescence.
- The business unit preference for business outcome-based solutions rather than technology.
- Unpredictable costs when the number of sites is either growing or shrinking.

Obstacles

- Edge use cases are so individual that providers may not be in a position to solve all enterprise requirements economically.
- Ongoing operations at scale may be more costly than if the enterprise operated the infrastructure at a high degree of efficiency and automation.
- Placing all responsibility in the hands of the provider naturally drives vendor lock-in.

User Recommendations

- Evaluate edge as a service offerings by creating a build vs. buy model for edge deployment and operations.
- Reduce initial cost outlays and pressure on accurate configuration sizing, by positioning the edge capabilities as a more elastic service, rather than explicit hardware configuration and purchase.
- Weigh enterprise needs for customization and differentiation against realistic assessments of in-house technical expertise, the organization's stance on "opex vs. capex" and the breadth of the solution (targeted, specific application set vs. a more general, distributed infrastructure platform).
- Examine edge as a service to speed time-to-market for many use cases, by lowering the initial cost outlays, technical hurdles, operational expertise required, and "platform risk" present in such a nascent market.

Sample Vendors

Akamai; Cloudfare; Fastly

Gartner Recommended Reading

2021 Strategic Roadmap for Edge Computing

LEO Satellite Systems

Analysis By: Bill Ray

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

Low Earth orbit (LEO) extends to around 1,300 km, significantly closer than geostationary orbit, which is more than 35,000 km from Earth. Connecting to satellites in LEO uses significantly less power, supporting low latency and faster data. However, coverage may require a large number of satellites, most of which will have a limited life span (around five years). Several companies are in the process of launching LEO services for broadband internet access and low-speed IoT connectivity.

Why This Is Important

Companies like Amazon and SpaceX have invested heavily in satellite services intended to provide internet access to consumers and enterprises. Innovations from the smartphone industry have reduced the price of satellites significantly, and the cost of launch is also declining, making these constellations economically viable. As of 2Q21, Starlink was already providing internet access to tens of thousands of users, with plans to rapidly scale up the service and exploit its first-mover advantage.

Business Impact

LEO services will make broadband internet, and IoT data gathering, globally available. Companies and employees can assume that internet access will always be available, removing network access as a limit on locations to work or live. Remote offices will always be able to get a reliable connection, and home workers will be able to live where they like. In time, this connectivity will extend to include aeroplanes, ships and sea platforms, creating a ubiquitous internet (and corporate intranet).

Drivers

- LEO satellite constellations are being launched to address two, distinct, markets: broadband internet access, and low-power IoT connectivity. These markets are being addressed by different companies using different constellations, as the requirements are quite distinct.

- Despite the widescale deployment of terrestrial wired and wireless services, there are still millions of homes and businesses that lack sufficient internet access, even in developed markets. Satellite broadband is relatively expensive (SpaceX's Starlink is charging $99 per month plus $499 installation) and won't compete with already-installed fibre to the cabinet or home. However, Gartner has calculated that there are enough homes without connectivity in the U.S., Europe and Australasia to sustain the Starlink service.

- Other customers will include airlines, ships and the military. LEO satellites can also provide backhaul for cellular services — a single satellite uplink can provide connectivity to a cell tower providing 5G, 4G, Wi-Fi or any other local access technologies. This reduces the cost of network deployment for cellular operators, extending coverage into areas that have previously been economically impossible.

- Starlink is the first mover, with more than 1,000 satellites deployed by 2Q21. However, in time, it will need to compete with offerings from Amazon as well as regionally-backed projects including OneWeb (U.K.), Telesat (Canada), Sfera (Russia) and Hongyan (China).

- IoT connectivity is a different market, focusing on low cost and low power to provide global asset monitoring and tracking. Companies like Myriota already offer a sensor with a five-year battery life and satellite connectivity, while Lacuna Space uses chips and radios conforming to the existing Lora standard, reducing the cost of a satellite-connected IoT sensor to a few dollars. Asset tracking is certainly the killer application, but condition and environmental monitoring will also be an important use case.

Obstacles

- To provide oceanic and remote region coverage (needed by military customers), links from satellite to satellite are required. Only the Iridium narrowband constellation currently has such links, although other companies are testing and designing them.
- Customer equipment currently costs more than $2,000. Developments in antenna design and mass production should reduce that cost, which needs to get below $500 for widespread adoption.
- Maintaining 30,000 satellites, with a life of five years, requires 500 new satellites per month. Current launch vehicles, such as the SpaceX Falcon 9, can launch 60 satellites at a time. This will not be sufficient, so larger launch vehicles (such as the SpaceX Starship or Blue Origin's New Glenn) will be needed.
- Satellite operators are required to avoid interfering with incumbent deployments, limiting the radio spectrum they can use. We expect that radio spectrum access will become a key point of negotiation, and perhaps litigation, in the next five years.

User Recommendations

- Exploit the rapid development of LEO services by adding satellite connectivity into future and strategic planning.
- Check the location of teleports to predict early-service availability; early services will only be available within 500 km of a teleport (earth station).
- Prepare for international availability by liaising with local regulators and resellers. LEO services are inherently global, so will spread internationally as quickly as regulators will allow.
- Protect investment by validating the technical and financial ability of your provider to launch and maintain its constellation.

Sample Vendors

OneWeb; Starlink; Telesat Canada

Gartner Recommended Reading

Market Trends: LEO Satellites Will Provide Practical Connectivity to Remote and Mobile Offices

Emerging Technologies: LEO Mega Constellations — Market Disruption Ahead

Edge AI

Analysis By: Alan Priestley

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Edge AI refers to the use of AI techniques embedded in IoT endpoints, gateways and edge servers, in applications ranging from autonomous vehicles to streaming analytics. While predominantly focused on AI inference, more sophisticated systems may include a local training capability to provide in-situ optimization of the AI models.

Why This Is Important

An increasing number of edge computing use cases are latency sensitive (autonomous navigation), data intensive (video analytics), and require an increasing amount of autonomy for local decision making. This creates a need for AI-based applications in a wide range of edge computing and endpoint solutions. Examples include video analytics which, driven by the rapid growth in use of surveillance cameras and the need for real-time interpretation of captured video, is starting to see adoption.

Business Impact

The business benefits of deploying edge AI include:

- Improved operational efficiency, such as manufacturing visual inspection systems.
- Enhanced customer experience.
- Reduced latency in decision making, with the use of local analytics.
- Communication cost reduction, with less data traffic between the edge and the cloud.
- Increased availability even when the edge is disconnected from the network.
- Reduced storage demand through a more reactive exploitation of the data.
- Preserved data privacy at the endpoint.

Drivers

- Increasing demand for the deployment of DNN-based data analytics close to or at the point of data capture, either in edge computers or endpoint devices.
- Edge AI implementations are impacted by application and design constraints of the equipment being deployed; this includes form factor, power budget (i.e., battery powered versus mains powered), data volume, decision latency, location, and security requirements.
- AI systems can be hosted within an edge computer, gateway or aggregation point and data captured at an IoT endpoint may need to be transferred. In this architecture, the IoT endpoint is a peripheral to the AI system. The endpoint acts as a data gatherer that feeds this data to the AI system. An example of this is environmental sensors deployed for a smart agriculture application.
- AI embedded in the IoT endpoint. In this architecture, the IoT endpoint is capable of running AI models to interpret data captured by the endpoint and drives some of the endpoints' functions. In this case, the AI model (e.g., a machine learning model) is trained and updated on a central system and deployed to the IoT endpoint. An example is a medical wearable that leverages sensor data and AI to help visually impaired people navigate the world in their daily lives.
- R&D into training AI models at the edge for decentralized machine learning.

Obstacles

- Systems deploying AI techniques can be nondeterministic. This can limit the ability to control and replicate analysis results, and may impact applicability in certain use cases, especially where safety and security requirements are important.
- The autonomy implicit in an AI deployment can lead to questions of trust, especially where the operation of the AI models is not transparent.
- The deployment of edge AI solutions can raise governance and privacy concerns. While analyzing data at or close to its point of capture can alleviate some privacy concerns, it may not mitigate them completely.
- Training DNNs is a compute-intensive task, often requiring the use of high performance chips with corresponding high power budgets. This can limit deployment locations, especially where small form factors and lower power requirements are paramount.

User Recommendations

- Determine whether the new AI developments are applicable to their IoT deployments, or whether traditional centralized data analytics and AI methodologies are adequate.
- Evaluate when to consider AI at the edge versus a centralized solution. Applications that have high communications costs are sensitive to latency or ingest high volumes of data at the edge are good candidates for AI.
- Assess the different technologies available to support edge AI and the viability of the vendors offering them. Many potential vendors are startups, which may have interesting products but limited support capabilities.
- Use edge gateways and servers as the aggregation and filtering point to perform most of the edge analytics functions. Make an exception for compute-intensive endpoints, where AI-based analytics can be performed on the devices themselves.

Sample Vendors

Baidu; Google; Intel; Microsoft; NVIDIA; Qualcomm

Gartner Recommended Reading

Emerging Technologies: Neuromorphic Computing Impacts Artificial Intelligence Solutions

Emerging Technologies: Critical Insights on AI Semiconductors for Endpoint and Edge Computing

Forecast: AI Semiconductors, Worldwide, 2019-2025, 1Q21 Update

Emerging Technologies and Trends Impact Radar: Artificial Intelligence

Network Slicing

Analysis By: Susan Welsh de Grimaldo

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Network slicing is a form of virtual network technology. It allows a network-based CSP to create multiple independent end-to-end logical networks in the form of a network slice on top of a common shared physical infrastructure at the provider's network domain. Each slice can be customized to have its own network architecture, engineering mechanism, network provisioning methodology, configuration and service quality profile based on the requirements that it serves.

Why This Is Important

Network slicing allows multiple logical networks to be created on top of a common shared physical network. These logical networks are tailored to meet the specific needs of applications, services, devices, customers or operators. Slicing provides CSPs with a mechanism to translate the business needs of end customers into parameters that can be defined and measured, such as required bandwidth, speeds, latency and reliability, in order to deliver tailored connectivity.

Business Impact

With network slicing, CSPs can run multiple independent business end services on a common physical infrastructure. This increases infrastructure utilization and economic efficiency, and it also helps generate new business models, especially for vertical industries. With network slicing, business customers will be able to access highly customized network slices tailored to specific requirements in a cost-effective, timely and efficient way, and backed by a service-level agreement (SLA).

Drivers

- Broader commercial deployments of 5G stand-alone (SA) with 5G core will serve as a catalyst for more rapid growth of network slicing in commercial service offerings. Slicing does not require 5G or 5G SA, but 5G core will accelerate slicing commercialization as it adds further value.
- More CSPs have started evaluations and trials of network slicing in partnership with their vendors. They include BT, China Mobile, Deutsche Telekom, SK Telecom and Vodafone UK.
- CSPs in China began deploying stand-alone 5G and multi access edge compute (MEC) on a large scale in 2020, which we believe will accelerate the network slice maturity and enable more innovation opportunities.
- Network slicing offers improved security and data traffic isolation, as each slice is completely isolated in operations so that no slice can interfere with the traffic in another slice. This will enable slices on the public network to more cost-effectively deliver private networking services, bringing the benefits of network slicing downstream to smaller businesses through more affordable offers.
- As vertical industries push further in their digital transformation efforts and integrate connectivity, cloud services and sensor data into their mission-critical operations, they have specific requirements that drive a need for ability to deliver SLAs. An example is for secure, reliable low-latency/high-bandwidth connectivity to AI on edge computing.
- Network slicing enables increased agility for customer-centric service creation by creating a mechanism for composable services across network domains and elements, using automated processes driven by slice templates to deliver desired service parameters that can be quantified in an SLA.
- Dynamic network slicing that can be quickly instantiated — and spun down when no longer needed — through automation will provide more agility to deliver required value propositions to customers while reusing integratable and automatable network components to drive efficiency.

Obstacles

- Numerous capabilities such as comprehensive network inventory, automated data-driven operations, and ability to test and assure SLAs across domains are required for commercializing network-slicing-related offerings; many of the capabilities are still evolving.
- The maturity level of slicing varies across network domains, and multivendor environments add more complexity, thus, enabling the full promise of end-to-end network slicing is a continued challenge in CSP operations.
- 5G SA is still not being widely adopted for commercial deployment, which will delay broader slicing implementation.
- Standards supporting truly dynamic, end-to-end (E2E) slicing across multivendor network domains (core, transport, edge, RAN) are still being developed, necessitating a phased approach to deployment.
- Key areas such as dynamic orchestration for low-touch operations and management of subdomains/subnets still need further development and are likely to be addressed differently by CSPs.

User Recommendations

- Prepare for slicing by addressing key enablers, e.g., SDN, cloud RAN, edge computing and cloudification.
- Do not wait for full readiness of slicing capabilities to launch offers. Create early wins using static slicing to add value to current service offerings.
- Drive customer centricity by focusing on business outcomes. Work with product teams to translate how technology features can help solve problems or create opportunities for end customers.
- Evaluate technologies and use cases by working with vendors and customers to co-develop solutions, identify performance gaps and measure business impact.
- Identify ways to deliver cost optimization while supporting revenue growth by working with vendors to get the right out-of-box functionality, low-code solutions to support use by business units, flexible procurement for pay as you grow and licensing that fits the use cases.
- Prepare to efficiently scale and drive revenue by adopting automation, monetization and security by design as guiding principles.

Sample Vendors

Amdocs; Ericsson; Huawei; Intel; Nokia; STL; ZTE

Gartner Recommended Reading

Create Value and Drive Revenue With 5G Network Slicing Phased Approach

Drive 5G Network Slicing From POC to Scale

Emerging Technology Horizon for Communications

5G as a Service: Deployment Scenarios of Private Networks in the 5G Era

Routes to the Future for CSPs — Technology Strategy

vRAN

Analysis By: Kosei Takiishi

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Early mainstream

Definition:

Virtualized RAN (vRAN) that decouples software and hardware by running BBU over generic COTS servers is different from classic purpose-built RAN that usually adopts its own SoCs. This also includes BBU containerization by microservice deployment on Kubernetes containers. While current distributed RAN (dRAN) and centralized RAN (cRAN) use dedicated purpose-built hardware, vRAN is a new architecture that can aggregate baseband processing functions to the server cloud, for many radio access nodes.

Why This Is Important

vRAN will lower the barrier to entry for new vendors in the ecosystem. New entrants can accelerate innovation, reduce operating costs, and lay the groundwork for flexible network and cloud infrastructure closer to the customer. New disruptors are mainly vendors with software and service backgrounds, including Altiostar, ASOCS, Mavenir and Parallel Wireless. Key 5G use cases focused on providing the best, most efficient network for customers, will heavily rely on the programmability of vRAN.

Business Impact

- Using COTs hardware leads to greater flexibility and agility in the introduction of new products and services. CSPs can host not only vRAN software but also enterprise applications near base stations (so called edge computing). Instead of adding or upgrading purpose-built hardware, the move to a cloud native, container-based virtualized architecture leads to greater scalability and improved cost efficiency in networks.

Drivers

- New standardization, ecosystem creation and multivendor interoperability assurance led by O-RAN alliance and Telecom Infra Project (TIP).
- The software-based nature of vRAN is treated as a cost-effective approach to replace the traditional, distributed RAN architecture to enable new serviceability and simplified deployment approach.
- Leading CSPs adopting vRAN spurs further adoption by other CSPs. In 2016, SK Telecom and Nokia announced the successful implementation of 4G vRAN in a commercial network. In 2019, Nokia also indicated the world's first commercially deployed 5G vRAN is live in the U.S. In 2020, Verizon commercialized Samsung's fully virtualized 5G RAN solution including vDU and vCU. Rakuten Mobile, a greenfield CSP in Japan, has commercialized more than 10,000 4G RUs based on vRAN which integrate multiple vendors solutions including RAN, core and platform.
- Government efforts to support more diversified and/or local supplier ecosystems.

Obstacles

- vRAN is still missing commercial best practices adopted by incumbent CSPs, as Open RAN adoption usually does not mandate vRAN (Open RAN could work on classic base station equipment [e.g., RRH and classic dedicated hardware BBU that adopts their own SoCs]).
- Since incumbent NEPs are slowly adopting virtualized deployment models as it cannibalizes their revenue from selling proprietary hardware-software integrated solutions, new software innovators are trying to disrupt the market. However, their ecosystem and solutions are not as mature as incumbent vendors' products. This includes interoperability issues between different radio equipment vendors, for instance performance concerns related to white box, especially power consumption by external hardware accelerators (e.g., FPGA).
- Cloud-based (software) processing is inherently less efficient than using dedicated hardware using ASIC chips.
- Incumbent CSPs possess massive siloed network resources locked in by their vendors.

User Recommendations

- Implement best practices and future roadmap of vRAN by participating in O-RAN alliance and TIP.
- Prioritize new technologies that are most needed for sustainable development and operational efficiency. vRAN is one of the candidates.
- Evaluate bottlenecks, difficulties and immaturity before implementing this new technology. Discuss feasibility with your incumbent and possible partners to better understand their capabilities. So far, large-scale commercial adoption of vRAN has come through from only one company — Rakuten Mobile in Japan. For incumbent CSPs to follow Rakuten's example, a thorough understanding of vRAN adoption is crucial.

Sample Vendors

Altiostar; ASOCS; Mavenir; Parallel Wireless; Radisys

Gartner Recommended Reading

CSPs' Success With 5G Initiatives Requires O-RAN and vRAN

5G Small Cell

Analysis By: Peter Liu

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

A small cell is a cellular base station that transmits and receives 3GPP-defined RF signals with small power and small form factor. 5G small cell is one of several network elements that are compliant with 3GPP TS38 series specifications (5G radios). 5G small cells are deployed to increase the 5G network capacity and coverage in localized areas, and they are also used to provide indoor 5G services and support mmWave.

Why This Is Important

As subscribers' 5G performance expectations grow, supplementing macro networks with small cells can be a cost-effective way to provide coverage and capacity indoors and outdoors, in various avenues. Therefore, CSPs have increasingly adopted small cells to improve their 5G network coverage and density. In addition, the emerging private 5G networks will focus mainly on indoor environments, or indoor/outdoor campus scenarios, where 5G small cells have particular advantages over macrocells.

Business Impact

- 5G operates on a higher frequency band, which means shorter coverage and poorer indoor performance. CSPs face the challenge of cost-effectively improving their 5G coverage and performance.
- Network densification through small cells helps deliver the necessary micro capacity and coverage, while keeping cost of ownership at a manageable level.
- Small cells nowadays also become a strategic 5G enabler for specific use scenarios like private mobile networks and indoor solutions.

Drivers

- As the market moves to 5G with higher frequency bands, including mmWave, CSPs are facing more challenges in terms of coverage and network capacity, as well as fulfilling diversified services economically. Therefore, small cells can play an important role in the 5G era for both indoor and outdoor environments.
- Demand and interest from enterprises for 5G is growing. This is spurring the vendor community to develop innovative products, digital solutions and deployment models for small cell infrastructure.
- Advanced technologies like OpenRAN further reduce the barrier to entry, which brings more players into the market, accelerating innovation in the small cell domain.
- CSPs and enterprises need a more dynamic-on-demand access to 5G connectivity, and they are looking for a solution that can support a widening variety of connectivity requirements, deployment scenarios and applications.
- Traditional distributed antenna systems (DASs) struggle to support 5G standards that rely on intelligent antennas; this means the existing DAS installed base will largely leverage small cell technology to introduce 5G services.

Obstacles

- Site acquisition and aesthetics are obstacles. Small cells are designed for street-level deployment or indoor deployment. Site acquisition and accommodating the varied technical and aesthetic requirements are challenging.
- Power and fiber backhaul are challenges. Small cells require more power than a streetlight and fiber to the site. Although it sounds simple, getting it there can be costly and a long process.
- 5G small cell remains an emerging technology among TSPs and enterprises overall. The expanded capabilities in new releases make 5G small cell use cases more compelling, but having a large initial investment and an unclear business model requires innovative models for sharing risks and benefits to accelerate deployment.
- Current 5G deployment still focuses on raw coverage, with all the funding being allocated to macrocells to boost the overall coverage. Network density and indoor coverage are yet to be a priority in the CSP investment agenda.

User Recommendations

- Establish your 5G small cell deployment strategy beyond coverage through prioritized investment in network densification, PMN projects and digital services.
- Address diversity challenges through a multivendor approach. There is no "one size fits all" in the future small cell market. A scenario-oriented product evaluation process needs to be implemented.
- Reduce the complexity and improve cost-efficiency by prioritizing the deployment feasibility as well as operation intelligence and automation.
- Work closely with emerging suppliers, and establish an objective and structured process to thoroughly evaluate and develop quick prototypes using new open-source components.
- Anticipate indoor coverage opportunities in the 5G era by investing in and developing a 5G-ready indoor solution strategy. Differentiate yourself through enhanced digital capabilities on top of connectivity.
- Continue to build a hybrid spectrum strategy that includes licensed, unlicensed and new spectrums for local networking.

Sample Vendors

Airspan; Baicells; Comba Telecom Systems; CommScope; Ericsson; Huawei; Mavenir; Nokia; Samsung; ZTE

Gartner Recommended Reading

Routes to the Future for CSPs — Technology Strategy

Predicts 2021: CSP Technology and Operations Strategy

How CSPs Can Approach Digital Ecosystems for Successful Collaboration

Hyperautomation: How Can CSPs Prepare for and Implement It?

Top Trends in Capturing New Value for Communications Service Providers in 2021

Top Trends in Managing Disruptive Influences for Communications Service Providers in 2021

Sliding into the Trough

400G Transport

Analysis By: Peter Liu

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Definition:

400G is a term to describe a communications link that can carry 400 billion bits per second, or 400 Gbps. 400G transport refers to 400 Gbps carried over a single carrier in a fiber optic cable that can transport a mix of different client traffic rates (e.g., 10 GbE, 100 GbE or 400 GbE) across long distances over an optical infrastructure. A coherent optical transponder is used to aggregate client traffic and transport them over a single 400G wavelength.

Why This Is Important

The exponential demand for connectivity and bandwidth driven by cloud computing, video streaming, artificial intelligence (AI), Internet of Things (IoT), 5G and more is pushing the limits of existing 100G transport networks. CSPs are increasingly adopting 400G transport intent to have a scalable solution in place in anticipation of further spikes in demand now and in the future.

Business Impact

400G-capable transport solutions are ideal for high-volume telco providers, large data centers and enterprises grappling with unrelenting traffic growth. 400G enables a new level of scale, providing four times higher bandwidth than 100G, reducing transport and operational costs with fewer transponders to deploy and delivering significant reduction in footprint and energy consumption.

Drivers

- Massive growth in cloud computing, AI and 5G has driven an exponential demand for high bandwidth, scalable solutions that can support new 400G techniques and architectures.

- Large telcos like AT&T, Verizon, NTT and Telstra have also been trialing or deploying 400 Gbps capabilities in their global optical backbones, which further accelerates the 400G transport adaptation.

- The need for improved operational workflows, better economics and concrete business outcomes continues to push 400G adoption forward.

- Maturing and advancing in 400G optical technologies in transmission, optical line amplification and reconfigurable optical add-drop multiplexer (ROADM) switching technologies are supporting the emergence of 400G transport adaptation.

- The COVID-19 pandemic has highlighted the critical nature of access to “affordable, reliable, high-speed broadband.” Many countries are increasing investments in the network infrastructure which accelerates new technologies like 400G adaptation.

- Significant demand for high-speed transport to support customer demands for direct cloud connections and interconnections as IaaS and SaaS usage increase due to digital investment ramp-up post-COVID-19 by enterprise customers.

Obstacles

- 400G is not a natural extension to existing network infrastructure, and requires taking into account new restrictions and a redesign of the optical network infrastructure.

- The cost associated with a complete network rebuild to upgrade to 400G is substantial, and will often deter carriers and enterprises from opting to upgrade their existing infrastructure.

- There are substitutes to 400G, like 250G, which may not perform as well but are more mature or cost-effective, which may further delay adoption.

User Recommendations

- Conduct an assessment of your existing transport network infrastructure and establish an 400G upgrade path with a 12- to 36-month adoption strategy, aiming to assess the potential economics and technical optimization over current 100G and lower speed transports.

- Choose wisely from vendors that conduct rigorous testing with multiple OEM equipment and have a good track record for support.

- Look beyond capacity. CSPs also need to have access to vendor management and monitoring solutions. The ability of deploying and operating a programmable infrastructure in an intelligent and automated way is critical.

Sample Vendors

ADTRAN; ADVA; Ciena; Cisco; Fujitsu; Huawei; Infinera; NEC; Nokia; ZTE

Gartner Recommended Reading

Routes to the Future for CSPs — Technology Strategy

Predicts 2021: CSP Technology and Operations Strategy

Top Trends in Capturing New Value for Communications Service Providers in 2021

Top Trends in Managing Disruptive Influences for Communications Service Providers in 2021

Top Trends in Driving Operational Excellence for Communications Service Providers in 2021

5G

Analysis By: Sylvain Fabre

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

5G is the next-generation cellular standard by the 3rd Generation Partnership Project (3GPP). The standard targets maximum downlink and uplink throughputs of 20 Gbps and 10 Gbps respectively. Latency is as low as 4 milliseconds in a mobile scenario and can be as low as 1 millisecond in ultra-reliable low-latency communication scenarios, and massive scalability. New system architecture includes core slicing as well as wireless edge.

Why This Is Important

5G is key for industry digital transformation, with 162 operators rollouts (Source: GSA, April 2021), 20% of mobile networks (up from 9% one year ago). 3GPP 5G standards releases deliver incremental functionality:

- R15: Extreme mobile broadband
- R16: Industrial IoT (massive IoT, slicing and security
- R17: MIMO enhancement of MIMO, Sidelink, DSS, IIoT/URLLC, bands up to 71GHz, nonterrestrial networks and RedCap
- R18: Under definition

Business Impact

- Material impact on multiple industries and use cases by enabling digital transformation.
- 5G enables three main technology deployment and business scenarios, which each support distinct new services, and possibly new business models (such as latency as a service), namely enhanced mobile broadband (eMBB) supports high-definition video, mMTC supports large sensor and IoT deployments, and URLLC covers high-availability and very low-latency use cases, such as remote vehicle/drone operations.

Drivers

- Increasing device penetration: Gartner estimates that 5G-capable handset penetration will reach 87% in 2023 in Western Europe, similar to North America.
- Operational cost savings for industry use cases.
- Agility — in particular, in oil and gas and manufacturing.
- Requirements from industrial users value 5G lower latency from ultra-reliable and low-latency communications (URLLC) and expect 5G to outperform rivals in this area.
- Demand for massive machine-type communications (mMTC), to support scenarios of very dense deployments up to 5G target of 1 million connected sensors per square kilometer.
- Increased availability of industry-specific spectrum options (e.g., CBRS).
- mMTC addresses the massive scale requirements of IoT.

Obstacles

- Availability of spectrum, in particular for industrial private networks, in some countries.
- Security concerns over certain vendors, and when using 5G in critical industrial scenarios.
- Readiness of R16 solutions; availability and pricing of networks and modules.
- Use of higher frequencies and massive capacity requires very dense deployments with higher frequency reuse.
- Uncertainty about use cases and business models that may drive 5G for many CSPs, enterprises, and technology and service providers (TSPs).
- Different dynamics by regions: where in many parts of Africa for example, 5G would not be the next step up from lower bandwidth services, and handset cost may be an inhibitor for lower-income subscribers. Adoption is more aggressive in APAC and NAR, with Europe cautiously enthusiastic — and the developing world lagging.
- Feedback from some industrial clients mentioned that the majority of their use cases could be serviced by a 4G private network, and/or NB-IoT and other LPWA such as LoRa.

User Recommendations

- Enable a diverse network that can offer adequate and cost-effective alternatives to 5G for many use cases (e.g., LPWA, NB-IoT, LoRa, Wi-SUN).
- Enable 5G for temporary enterprise connectivity, mobile and FWA secondary/tertiary use cases for branch location redundancy, as long as 5G is not the primary link for high-volume or mission-critical sites, unless there are no other options.
- Provide clear SLAs for network performance by testing installation quality for sufficient and consistent signal strength, signal-to-noise ratio, video experience, throughput and coverage for branch locations.
- Ensure backward compatibility to 4G devices and networks, so 5G devices can fallback to 4G infrastructure.
- Focus on architecture readiness — such as SDN, NFV, CSP edge computing and distributed cloud architectures, and end-to-end security — in preparation for 5G.
- Build their ecosystem of partners to target industry verticals more effectively with 5G.

Sample Vendors

Cisco; Ericsson; Huawei; Mavenir; Nokia; Qualcomm; Samsung; ZTE

Gartner Recommended Reading

U.S. Telco 5G Plans Take Shape

Emerging Technologies: 5G Technology Spending, 2020 Survey Trends

5G as a Service: Deployment Scenarios of Private Networks in the 5G Era

Market Guide for 5G Network Ecosystem Platform Providers

Creating Your Enterprise 4G and 5G Private Mobile Network Procurement Strategy and RFQ

NaaS

Analysis By: Ted Corbett, Gaspar Valdivia, Jonathan Forest

Benefit Rating: Low

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

NaaS is a delivery model for networking products. NaaS offerings deliver network functionality as a service, which include the following capabilities: self-service capability, on-demand usage, including dynamic scaling up and scaling down. It is billed on an opex model that is consumption-based, via a metered metric (such as ports, bandwidth or users), and not based on network devices/appliances. Its offerings may include elements such as network switches, routers, gateways and firewalls.

Why This Is Important

Many NSPs and non-NSPs are creating NaaS offers, while enterprises seek consumption-based spending for networking akin to what cloud offers for compute. Thus TSPs are investing to bring offerings to market to match these needs — marketed as NaaS. Globally, enterprise networking annual spending is $240 billion for 2020, and each provider wants their share. New entrants see huge enterprise spending, while many incumbents seek to hold on, invest in their NaaS strategy and grow amid emergent competition.

Business Impact

- Many enterprises pursue a flexible, consumption-based networking model regardless of user or application location. NaaS seeks to provide enterprises with agility, service delivery quality, automation and end-to-end customer experience — with up/down scalability and predictable all-opex spending.
- Emerging NaaS providers seek to disrupt current NSP vs. non-NSP customer consumption norms. Over time, this disruption is expected to expand enterprise buyer options and pricing models.

Drivers

- Many enterprises envision a future where their end-to-end networking estate spans LAN, data center and WAN edge cloud-based network functions, WAN services and life cycle network operations delivered in a consumption-based, predictable spending model.
- Though historically common, the all-opex network product procurement model where operational leases (rentals) turn an all-capex purchasing model into opex has long served the purpose of amortizing payment for networking products. However, they are not significantly more flexible than common capex-based approaches.
- Currently, the key drivers for an all-opex model for the enterprise have evolved: Enterprise buyers seek a greater focus on end users and their applications for improved service delivery quality, automation and predictable customer experience from the market. Also, WAN services from NSPs have increasingly evolved from enterprise locations to virtually any cloud-based provider or hosted endpoints. These continue to drive enterprise objectives for increased agility, more flexible consumption models and a seamless experience across their network consumption life cycle. Finally, NaaS providers see these bundled, opex-driven services as very “sticky,” making it more difficult for enterprise clients to peel off individual components to seek out those with better value (cost and/or performance)
- More recently, in response to evolving enterprise needs, non-NSPs are seeking to drive revenue by pursuing their own emergent offers for NaaS.

Obstacles

- There is no evidence that buyers will pay less for any NaaS proposition from providers.
- Return on investment (ROI) models for a NaaS proposition do not exist from providers.
- Enterprises entering into NaaS agreements relinquish control over their network design and face full replacement of NaaS components upon early or end of term based exit events.
- Enterprises that sweat their network assets to reduce refreshes lose this flexibility, since NaaS providers become the entity sweating any assets included in their offers.
- NaaS offers currently in the market (primarily from NSPs) are not comprehensive solutions. These offers are focused on the provider's PoP where many NaaS components reside, such as gateways and cloud connectivity bandwidth on demand.
- The all-opex procurement is complicated by scaling, life cycle operations and refreshes of network product technologies.

User Recommendations

Exert caution with NaaS at this emerging market stage.

I&O leaders should:

- Avoid NaaS offers if you want to retain network design control or prefer to sweat assets beyond typical refresh cycles — smooth spending via financial leasing.
- Create a before and after ROI calculation by capturing all relevant in-scope costs and uniformly comparing proposals to identify the economic differences before further consideration.
- Choose NaaS to achieve operational, lease-based network spending when this is your primary goal and have a predictable consumption pattern.

Technology service providers should:

- Build NaaS capabilities by investing in consumption-based, commercial models across LAN, WAN and cloud connect services.

- Build trust in NaaS by providing itemized pricing, standardized service definitions, and scale up and down commercial flexibility.
- Prove to prospective buyers the commercial value of NaaS offers by disaggregating proposals and providing detailed comparison against alternative options.

Sample Vendors

Aryaka; AT&T; BT; Hewlett Packard Enterprise (HPE); Juniper; Microsoft; Open Systems; Orange; PacketFabric; Verizon

Gartner Recommended Reading

2020 Strategic Roadmap for Enterprise Networking

Magic Quadrant for Managed Network Services

Magic Quadrant for Network Services, GlobalDebunk the Misperceptions About Network as a Service

Open RAN

Analysis By: Kosei Takiishi

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Early mainstream

Definition:

Open RAN indicates disaggregated interoperable RAN architecture using open interface specifications on 4G and 5G infrastructure.This open RAN mainly focuses on the multivendor integration inside RAN that includes open fronthaul interface between RRH and BBU standardized by O-RAN alliance. This open RAN does not cover radio intelligent control (RIC), MANO and vRAN. This also covers proprietary interoperable RAN by some Tier 1 CSPs that have commercialized in the past.

Why This Is Important

While end-to-end network virtualization/slicing are needed for the future success of 5G, RAN is the last nonvirtualized network component. The market share of mobile carrier infrastructure by four vendors was around 90% in 2020. This oligopoly and vendor lock-in could delay 5G monetization. While open RAN vendors are newly emerging, supported by O-RAN Alliance and TIP, they could become a rival against incumbent vendors and accelerate the infrastructure modernization and innovation.

Business Impact

Open interface is the key to achieve best-of-breed vendor selection by balancing features and cost. Most current 5G commercial deployments reluctantly permit vendor lock-in due to difficulty of multivendor integration over 5G NSA architecture that requires anchors on 4G network. Tier 1 CSPs, including NTT DOCOMO and Verizon, had commercialized open fronthaul interface in a proprietary way, but the global adoption did not go well. Now the telecom industry is promoting standardized open RAN.

Drivers

- Standardization bodies and related consortiums with strong CSP participation, such as O-RAN Alliance and TIP supported by Facebook, have been promoting open RAN by creating new specifications and accomplishing interoperability testing.
- Early commitment by greenfield CSPs, including Rakuten Mobile and Dish Network, can contribute to open RAN maturity and vendor ecosystem creation.
- Governmental efforts to promote more diversified and/or local vendor ecosystems have considered open RAN as an area for potential support.

Obstacles

- Current open RAN solutions are not as mature as classic purpose-built base station equipment, and at least two to three years could be needed to be useful.
- Insufficient experience and poor integration power by CSPs related to open RAN. CSPs need to decide how to assure the multivendor integration.

User Recommendations

CSP CTIOs should:

- Define your open RAN adoption scenario by discussing the feasibility with your incumbent network vendors and as well as new vendor partners.

- Enrich your open RAN strategy by learning from vendors you have never selected or met before.

Sample Vendors

Airspan; Altiostar; Federated Wireless; Fujitsu; Mavenir; NEC; Samsung; Sercomm

Gartner Recommended Reading

CSPs' Success With 5G Initiatives Requires O-RAN and vRAN

Network AI and Automation

Analysis By: Peter Liu

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

Network AI and automation involves the orchestrated use of multiple technologies, tools or platforms. These include, but are not limited to AI, machine learning, event-driven software architecture, RPA, packaged software, and other types of decision, process and/or task automation tools, which together empower rapid end-to-end intelligent network automation and management.

Why This Is Important

AI-driven automated network operations, maintenance and planning are critical:

- CSP infrastructure becomes more complex and heterogeneous, particularly with deployments of 5G, MEC and open RAN.
- CSPs want to achieve operational efficiency, less human error, and near-real-time decisions through leveraging network intelligence and automation.
- CSPs want to improve the productivity of network operations staff by eliminating repetitive tasks and enabling employees to focus on innovation and creativity.

Business Impact

- Provides significant savings in operations and impacts the way future networks are set up, managed and planned
- Gains customer insight and pattern of their data usage that might lead to improved customer satisfaction and revenue
- Leverages new approaches, such as analytics, machine learning (ML) and AI to add more value to network quality and customer experience in an increasingly predictive manner.

Drivers

- During the past year, more and more network equipment vendors started to embed “intelligent and automation” capabilities into their network operation and management tools to address the operation efficacy and complexity challenge.
- The COVID-19 pandemic refocused network infrastructure on resilience, which for many resulted in accelerating the intelligent automation agenda.
- Maturing and expanding data science initiatives, better algorithms, more cost-effective computing power and a substantial increase in available network data support the emergence of intelligent techniques.
- The use of intelligence automation will transform how IT and network infrastructure is delivered and supported, including delivering more agility to address resource demand, which is attractive for CSPs that are building next-generation operation and management platforms.
- The rise in connected endpoints driven by the IoT, as well as 5G, will also require automation to improve network KPIs and allow automation of maintenance tasks and energy saving.
- With over 7 million base stations worldwide, and the need to densify networks for 5G, a larger role for AI is required for scaling operations.

Obstacles

- Although automation is not a new idea in the telecom space, adding AI in the process cycle is a relatively new concept. Management and frontline employees sometimes have misconceptions about what they should expect as AI becomes part of their work lives.
- Many CSP employees lack skill sets to work effectively with new network AI and automation tools that are now, or will become, part of their workflow.
- The accuracy of algorithm models is limited by the completeness and accuracy of the data being used. Fragmented data and data quality are always major concerns of a successful intelligent-based automation adoption.
- The multivendor, multilayer and cross-domain environment challenges the network automation and intelligent implementation.
- Most of today's network AI and automation projects have a tactical approach that is difficult to scale due to the lack of cross-domain orchestration and collaboration, which often creates internal-technology-based silos.

User Recommendations

- Enhance network intelligence and automation capabilities through investments in advanced technologies like augmented analytics, AI/ML, low-code platforms, API-centric SaaS and decision intelligence (DI).
- Improve the efficiency of the network automation process before introducing AI, as introducing intelligence on top of an inefficient automation process always leads to a worse situation.
- Build a transformational mindset for AI and automation across the network operation and management team through accelerating AI skills and talent development.
- Establish an automation roadmap through requesting intelligent capabilities into vendors' products, or consider how internal capabilities can be developed that can create this intelligent automation.
- Include multiple factors such as the SDN/NFV approach, orchestration strategy, big data management and solution architecture changes in implementation roadmaps. Identify suppliers and vendors with a well-defined, holistic roadmap.

Sample Vendors

Ericsson; Netcracker; Huawei; ZTE; Juniper; Cisco; Amdocs; P.I. Works; MYCOM OSI; Nokia

Gartner Recommended Reading

Infographics: Telecommunications CSP Network AI Prism

Routes to the Future for CSPs — Technology Strategy

Predicts 2021: CSP Technology and Operations Strategy

Hyperautomation: How Can CSPs Prepare for and Implement It?

Top Trends in Driving Operational Excellence for Communications Service Providers in 2021

Private LTE

Analysis By: Sylvain Fabre, Tim Zimmerman

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Definition:

Private LTE is a private wireless network based on 4G/Long Term Evolution (LTE) technology infrastructure to interconnect people/things in an enterprise setting, independently of the networks of cellular service providers. It precedes private 5G and can support voice, video, messaging, broadband data and IoT, typically only available to the enterprise's own authorized SIM cards, increasing security, with better and predictable performance as the infrastructure is not publicly shared.

Why This Is Important

Private LTE enables enterprises to customize their own LTE network for mission-critical applications, low-latency and specific SLAs — without interference from the often-congested public wireless spectrum, or in areas CSPs do not provide public infrastructure. Shared spectrum access allocations such as U.S.' CBRS, Japan's sXGP, Australia's band3 sees CSPs and their suppliers now compete directly, as CSPs no longer have exclusive, licensed ownership of spectrum resources.

Business Impact

The need for private connectivity in industry verticals is growing. Verticals such as public safety, mining, oil, railroad, health, logistics, utilities and banking are seeking private connectivity on demand to support their premises and specialized applications. A private LTE network is perceived as one aspect of increasing productivity and cost reduction by providing cellular coverage in areas where it is not commercially available.

Drivers

- There is an increasing interest in deploying private LTE networks by enterprise business customers in various vertical industries, such as public sector, mining/oil and gas, and transportation, to increase network security and control.

- Unlike the traditional private radio networks, private LTE can also support growing M2M/IoT communications. TSPs are developing private LTE solutions to offer directly to enterprise customers in addition to selling through CSPs. Private LTE is shaping up as a viable option for enterprise mobility, especially since implementation does not require the CSP and can be implemented either by a service provider, the enterprise or emerging competitors such as hyperscale cloud providers.

Obstacles

- From an IoT/M2M perspective, the roadmap from 4G to 5G promised capabilities requires a much higher density of endpoints, up to 1 million per sq. km. As such it is a significant step, and some enterprises are cautious on embarking on a 3GPP roadmap — 4G and then 5G. Positioning these options as clearly distinct projects can help TSPs.
- CBRS or LTE-U implementations will require separate modems for devices which will add costs.
- Backhaul will still be needed from the remote implementation.
- Concerns about coexistence with private 5G, and whether to launch for example PLTE over CBRS now, or wait and go directly to private 5G over CBRS.

User Recommendations

- Enable CSP differentiation against the widening choice of suppliers such as vendors and integrators in your private LTE offerings by supporting off-site mobility and national roaming.
- Include VoLTE, VoWiFi, video, messaging, RCS, fixed-mobile convergence, etc. in private LTE solutions.
- Differentiate as a CSP by offering, by bundling other value-added technologies, such as agile and scalable network, SIM management, self-healing, closed loop automation, national roaming, etc.
- Develop customized private LTE network configurations for various vertical industries by investing in an ecosystem of partners.
- Clarify your technology and coverage roadmap from 4G to 5G, such that disruption is minimal and interference managed during coexistence of these technologies.

Sample Vendors

Athonet; Ericsson; Huawei; Nokia; Druid software; AT&T; China Mobile; Vodafone; Ericsson; ZTE

Gartner Recommended Reading

Creating Your Enterprise 4G and 5G Private Mobile Network Procurement Strategy and RFQ

Market Guide for 4G and 5G Private Mobile Networks

4 Hype Cycle Innovations That Should Be on the Private Mobile Networks Roadmap for 5G Security, CSP Edge and Slicing

Telecom Insight: Top Use Cases for 4G and 5G Private Mobile Networks

Tech Providers 2025: Future of Telecommunications Infrastructure Vendors Ecosystem Landscape

Shared Spectrum Access

Analysis By: Kosei Takiishi

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Definition:

Shared spectrum access is based on the concept of sharing licensed access to infrequently used spectrum by adopting IT to find unused radio spectrum and optimize its usage. In the U.S., the current shared band is citizens broadband radio service (CBRS) that opens a 150 MHz piece of spectrum in the 3.5 GHz band, and plans are in place for 6 GHz. Other countries' regulators are considering shared spectrum licenses, often for 5G or Wi-Fi 6E use.

Why This Is Important

While incumbent users of this shared spectrum frequency bands have priority (e.g.,, the Navy in the U.S. by CBRS), some portions of the frequency allocation can be licensed to registered service providers or enterprises at a particular location (such as a campus environment, a city environment or indoors). Other parties may be allowed a third-grade of access if spectrum is available. This more efficient spectrum usage is fundamental to increase spectrum bands for wireless systems.

Business Impact

- CBRS has gained a wide range of interested parties in the U.S., and opens the potential for new types of small cell networks. Other countries’ regulators are expected to follow with shared spectrum access provisioning.
- New business cases can emerge. For example, the use of these frequency bands for neutral host small cells and private LTE and 5G networks.

Drivers

- The U.S.' early commercialization of CBRS opened the door to this technology. CBRS Priority Access License (PAL) auction ended in September 2020. PAL commercial enablement has just started in April 2021 and now CBRS infrastructure can utilize both General Authorized Access (GAA) and PAL bands.
- More and more CBRS capable devices such as iPhone 11 and Samsung Galaxy S10 series are on the market.
- CBRS alliance has standardized its latest release 3 in February 2020, which covers some 5G specifications (3GPP Release 15).
- Other countries’ regulators are examining similar concepts. In Europe, the European Telecommunications Standards Institute (ETSI) standards body has completed specifications for LSA, which would operate in the 2.3 GHz frequency band, but was not commercially adopted. Evolved LSA is coming next with more focus on private network usage.

Obstacles

- There are a few best practices developed to date to guide adoption, given the only recent start of commercialization of shared spectrum access including CBRS.
- Much more difficult and complicated network implementation and deployment compared to unlicensed Wi-Fi technologies.
- Delays in the Federal Communications Commission (FCC) certification and auction process in the past.
- Lack of allocations of shared spectrum bands in more markets.

User Recommendations

CSP CIOs/CTIOs should:

- Diversify their network solution by adopting shared spectrum access solutions, when available in their markets.
- Promote partnerships with stakeholders such as cities and governments, property owners and integrators to satisfy various demands and needs for their private LTE-based networks.

Sample Vendors

CommScope; Ericsson; Federated Wireless; Google; Nokia; Samsung

Gartner Recommended Reading

Market Insight: Impact of 5G Radio Spectrum Fragmentation

eSIM

Analysis By: Pablo Arriandiaga

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Definition:

The embedded SIM (also called eSIM or eUICC) is a programmable subscriber identity module (SIM) that is physically embedded into a mobile device. It is designed to remotely manage multiple CSPs profiles and be compliant with GSMA specifications. An eSIM is provisioned over-the-air (OTA) with operator credentials, giving users the ability to change providers.

Why This Is Important

Enterprises, OEMs and communication service providers (CSPs) need common standards for mobile and IoT connectivity that enable them to scale their business while reducing costs. More than 200 mobile network operators (MNOs) worldwide support eSIM. Leading smartphone and laptop manufacturers such as Apple or Samsung support eSIM in their new devices. Adoption is accelerating, mainly in consumer devices, driven by use cases such as wearables, where mobility and life cycle are important.

Business Impact

- **Smartphones, tablets and PCs —** eSIM enables the user to switch between mobile operators without removing the physical SIM from the device.
- **Wearable devices —** eSIM (and an embedded radio module) removes the dependence on smartphones as IoT gateways, making wearable devices always-connected IoT devices.
- **IoT —** eSIM enables industry transformation, standardizing the manufacturing process and simplifying device activation, no matter which country the product is delivered to.

Drivers

- Main device manufactures like Apple or Samsung support eSIM both in their latest smartphones and wearables. eSIM shipments for 2020 were 309 million with a 83% year-over-year (YoY) increase as reported by the Trusted Connectivity Alliance.
- In IoT, one of the main drivers is the connected car where Gartner forecasts that by 2023, two-thirds of all new connected vehicles produced will feature an eSIM for cellular connectivity, up from less than 5% in 2021. Regulations, such as eCall in Europe, are also accelerating adoption. In IoT most use cases are using eSIM as insurance to avoid future lock-in. Other industry-verticals such as utilities and logistics are also driving adoption as well, though reported eSIM connections by participants in Gartner's Magic Quadrant for Managed IoT Connectivity Services, Worldwide is really low.
- In IoT, multinationals are looking for more sustainable IoT connectivity platforms to avoid switching them each time they change the IoT connectivity provider so they can integrate the platform with other IoT and internal business systems. This positions eSIM as a key driver for this increasing trend as most enterprises Gartner talks to prefer standardized mechanisms that guarantee future compliance for their devices as the technology evolves.
- In IoT, specialized providers that act as local connectivity IoT hubs for CSPs around the world could accelerate adoption if they are able to add as many local MNOs as possible, including commercial agreements, not just technical integration. One example of this is Eseye with the Anynet Federation. These initiatives apply mainly to multinationals looking for local IoT connectivity in bring-your-own-connectivity scenarios.
- For CSPs, facilitating digital transformation of SIM provisioning with eSIM, creating cost and process efficiencies and ability to drive customer engagement.

Obstacles

- Complexity for multinationals in IoT of assessing MNOs support by country, including version of the standard supported, and interoperability with other eSIM subscription management platforms.
- Some CSPs have been reluctant to embrace eSIM because the technology reduces the barriers for automakers and telematic service providers to switch mobile operators. Some IoT MVNOs tell Gartner that sometimes even when they sign agreements with an MNO for eSIM, that agreement only applies to that particular client.
- In IoT, due to the lack of scale, pricing is a big problem as eSIM vendors don't see scale so they are not bringing prices down. And CSPs don't see competitive pricing to promote it, apart from their reluctance to open their networks to third parties.
- Immaturity of the standards: Low power standards, such as NB-IoT, struggle to support eSIM provisioning despite being a popular platform for IoT projects.

User Recommendations

Recommendations will vary, depending on the type of user:

- **Enterprises** — Evaluate the eSIM service CSPs offer acting as prime contractors by assessing MNOs supporting each by country including version of the standard supported, and interoperability with other eSIM subscription management platforms with special focus on NB-IoT support.
- **OEMs** — Promote eSIM in designs where its advantages are attractive(e.g., swapping cellular providers regularly across countries) and with big amounts of data by working with the GSMA and CSPs to present end users with a superior solution and a balanced playing field for new and innovative offers.
- **CSPs** — Leverage the flexibility of eSIM to attract new customers with superior service offerings that also motivate existing users to stay by, for example, eliminating per-device fees and instead bundling in content, wearables and more.

Gartner Recommended Reading

Magic Quadrant for Managed IoT Connectivity Services, Worldwide

Critical Capabilities for Managed IoT Connectivity Services, Worldwide

Emerging Technology Horizon for Devices

Market Trends: Reinvigorate Wearable Devices by Reinventing NFC and eSIM Technologies

Cellular Data Trading: Why the Automotive Industry Could Be an Early Adopter

Open Networking

Analysis By: Andrew Lerner, Mark Fabbi

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Definition:

Open networking refers to: (a) the disaggregation of hardware and software on networking devices, and/or (b) the use of open-source networking software. Examples include disaggregated physical switches that conform to OCP specifications, and software such as SONiC and FRR. Most open networking technologies are based on Linux, and designed for data center environments, but are expanding into campus and WAN.

Why This Is Important

Open networking can reduce expenditures and increase flexibility while reducing vendor lock-in, which, when combined, can enable faster network innovation. Open-based networking is still in its early adoption phase for enterprise deployments, but is well-established in cloud and service provider networks.

Business Impact

Open networking options reduce reliance on tightly integrated vendor-proprietary approaches, which enables enterprise network teams to evolve at a pace that is not determined by a specific vendor. Ultimately, this can drive more-flexible and agile networking capabilities to support the business, and at a reduced acquisition cost.

Drivers

- In data center environments, there is increasing interest in Software for Open Networking in the Cloud (SONiC) as an open-source NOS, driven by a desire to move away from vendor-proprietary stack and/or leverage the pace of innovation associated with popular open-source initiatives. Technologically advanced organizations seek to standardize on an NOS that is supported across hardware vendors, creating the potential for innovation in the same manner that Linux offered in the server OS market.

- A strong commercial ecosystem is forming around SONiC. Dell Technologies, NVIDIA, Arista Networks, Juniper Networks and nearly all white-box vendors are on the official SONiC hardware compatibility list. Multiple vendors, including Dell Technologies and NVIDIA, provide commercial support and/or a commercial distribution for SONiC. This drives increasing customer interest.

- Brite-box switches offer disaggregated hardware and software, but are supported via a single commercial supplier and thus represent a more mainstream approach to leveraging the open networking movement. Brite-box solutions from vendors such as Dell Technologies and NVIDIA have over 4,000 production customers. These brite-box solutions are more attractive to enterprise buyers as the complexity of integrating hardware and software, as well as support, is dealt with by the brite-box provider.

- Vendors are increasingly allowing modules to be loaded on supported NOSs, which enables organizations to run open-source software for specific features such as Border Gateway Protocol (BGP).

- In very large campus switching environments (100+ switches), technologically advanced enterprises are looking at brite boxes to reduce initial switching costs.

- Data center original design manufacturer (ODM) or white-box switches have an average selling price that is 76% less than traditional OEM switches. ODM switches are highly aligned with disaggregated switching, and accounted for 29% of unit shipments of data center switches in 2020.

Obstacles

- Many vendors lead with integrated switches, instead of brite-box offerings.
- The number of open-source software options (i.e., SONiC, OS10 Open Edition, OpenSwitch, etc.) could fragment efforts and delay broader adoption.
- A strong culture of risk aversion among enterprise network teams results in them preferring vendor-proprietary solutions.
- There is a perception that brite-box and/or open-source software will create new support challenges and/or increase support costs.
- Competition and acquisitions between vendors are limiting availability of brite-box options.

User Recommendations

- Organizations with larger data centers (100-plus switches) should include SONiC and brite-box options on their shortlist for refresh and build-out opportunities.
- Organizations with a strong cultural preference for open-source software should prefer SONiC in their data centers.
- Any organization pursuing a disaggregated open-source approach must have advanced technical expertise to deal with the support and integration requirements.

Sample Vendors

Dell Technologies; Edgecore Networks; IP Infusion; NVIDIA; Pica8

Gartner Recommended Reading

Market Guide for Data Center Switching

XGS-PON

Analysis By: Peter Liu

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Definition:

XGS-PON is a symmetric 10G-PON standard based on ITU-T G.9807.1. It supports up to 10 Gbps upstream and downstream (symmetrical) over a single wavelength and provides a bandwidth 10 times faster than existing gigabit-capable PON (GPON) technology.

Why This Is Important

XGS-PON is the 10G-PON technology of choice to serve both residential and business segments. It is 10-Gbps-symmetrical and is better-suited for enterprise subscribers, which enables CSPs to generate new revenue streams from the enterprise market. Cost-conscious CSPs are looking for balance between near-term investment and long-term strategy. XGS-PON can coexist with existing GPON solutions and support smooth upgrades to TWDM-PON, making it a preferred solution in the PON evolution journey.

Business Impact

- XGS-PON allows CSPs to provide higher-bandwidth 10G-PON to premium subscribers, such as enterprises, or for the deployment of broadband to high-density multidwelling units.
- CSPs can leverage XGS-PON to better support symmetrical and high-bandwidth upstream services, which are increasingly popular nowadays and become one of the key marketing opportunities.
- XGS-PON can be used for mobile backhaul as well as the aggregation of remote access node traffic, which is key for 5G rollout.

Drivers

- XGS PON is a high ARPU opportunity for CSPs, enabling them to expand their addressable market from home-office/small-office customers to large enterprises that need symmetrical services.
- Symmetrical and high-bandwidth upstream services are increasingly popular with residential customers that create occasional peaks in upstream traffic. Symmetrical bandwidth is a crucial differentiator, and the next big marketing opportunity for CSPs.
- Gradual uptake of 5G services, 10G symmetrical fiber networks can be used for mobile backhaul as well as the aggregation of remote access node traffic.
- Increasing investment in digital infrastructure assets and fiber broadband from government and CSPs further drive the PON market growth, and XGS-PON is a key beneficiary.
- Growing interactive services, such as online gaming, video conferencing, and cloud computing, will generate more symmetrical traffic. It’s apparent that, in the long-term, optical access will have to evolve toward symmetrical traffic transport.

Obstacles

- The main obstacles for switching from legacy GPON technology to XGS-PON has been the cost of equipment. The XGS-PON technology itself is technically matured and standardized, but we have not yet seen any economies of scale due to low volumes in the market.
- Currently business demand is not enough to justify the investment. Most CSPs have not yet exhausted legacy capacity. GPON is considered sufficient for most of today’s use scenarios, and there is still hesitancy to upgrade for some CSPs.

User Recommendations

- Prioritize XGS PON as NG PON evolution. Establish your next-generation PON rollout strategy, which is in line with multiple business objectives, such as long-term and stable returns, recognized and established technology.
- Take a stepwise approach and start from a small scope in areas that have strong network performance requirements by providing an XGS-PON broadband service and current GPON service simultaneously in the same network. This reuses existing network equipment and the optical distribution network, eliminating the need to change the existing fiber network or take up extra floor space.
- Explore business opportunities in the enterprise market that are enabled by XGS PON deployment.
- Expand from home office/small office customers to large enterprises that need symmetrical services.
- Evaluate and invest in open, programmable and disaggregated solutions that allow you to react quickly or proactively to customers' needs and avoid vendor lock-in.

Sample Vendors

ADTRAN; Calix; Cisco; DZS; Huawei; NEC; Nokia; ZTE

Gartner Recommended Reading

Routes to the Future for CSPs — Technology Strategy

Predicts 2021: CSP Technology and Operations Strategy

How CSPs Can Approach Digital Ecosystems for Successful Collaboration

Hyperautomation: How Can CSPs Prepare for and Implement It?

Top Trends in Capturing New Value for Communications Service Providers in 2021

Top Trends in Managing Disruptive Influences for Communications Service Providers in 2021

Top Trends in Driving Operational Excellence for Communications Service Providers in 2021

LTE-A Pro

Analysis By: Kosei Takiishi

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Long Term Evolution Advanced (LTE-A) Pro, defined by 3rd Generation Partnership Project (3GPP) Release 13 and later, is intended to mark the time when the LTE platform was dramatically enhanced to address new markets as well as add functionality to improve efficiency. This release 13 standardization was frozen in 2Q16. Its technical targets are a peak rate of more than 3 Gbps and delay of less than 2 ms.

Why This Is Important

As of March 2021, there are over 200 mobile CSPs that are investing in LTE-A Pro based on the GSA. These CSPs' networks support 3GPP Release 13 or 14 LTE-Advanced Pro features, e.g., those making use of carrier aggregation of large numbers of channels, 4 x 4 multiple input/multiple output (MIMO) to massive MIMO, 256 QAM and others. Same as LTE-A's smooth migration from LTE, LTE-A Pro has been introduced gradually. LTE-A Pro could also be a bridge between 4G LTE and 5G that have been commercialized by many leading CSPs.

Business Impact

- Higher speeds and better capacity by LTE-A Pro for existing smartphone users by aggregating many more frequency bands and deploying more antennas at base stations or devices.

Drivers

New additional capabilities for CSPs to achieve network capacity increase and new business support by LTE-A pro with the completion of release 13 include:

- Machine-type communications enhancements, such as LTE-M and NB-IoT
- Public safety features, such as device-to-device (D2D) and D2D proximity services (ProSe)

- Small cell dual connectivity and architecture
- Carrier aggregation enhancements
- Interworking with Wi-Fi and licensed assisted access (at 5 GHz)
- 3D/Full dimension (FD) MIMO
- Indoor positioning
- Single-cell point to multipoint
- Latency reduction

Obstacles

- Chronic radio spectrum bandwidth shortages to satisfy increasing data traffic demand. One solution is to reuse current 2G/3G bands for LTE-A pro, however there are still massive numbers of feature phone users and M2M devices remaining. This could cause a longer timeline for migration from previous cellular systems to LTE-A pro and later 5G.

User Recommendations

- Acquire a new frequency asset for LTE-A Pro by negotiating with regulators and other stakeholders, and improve user experience continuously.
- Adopt LTE-A Pro by confirming existing LTE equipment's upgradability to LTE-A Pro at minimal additional cost and ensuring that adequate backward-compatibility testing with LTE, LTE-A and existing 3G networks is undertaken by vendors during acceptance and interoperability testing.

Sample Vendors

Ericsson; Huawei; NEC; Nokia; Samsung; ZTE

Gartner Recommended Reading

Magic Quadrant for 5G Network Infrastructure for Communications Service Providers

How to Select 5G NSA/SA Migration Paths

Massive MIMO

Analysis By: Kosei Takiishi

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Multiple input/multiple output (MIMO) can multiply the capacity of a radio link by transmitting and receiving more than one data signal simultaneously over the same radio channel. MIMO is an essential technology element for 4G and 5G, and it can improve the data throughput as the number of antennas increases. Existing MIMO is mainly composed of two or four antenna elements at a base station, but massive MIMO utilizes dozens or more than 100 antenna elements.

Why This Is Important

By increasing the signal-to-noise ratio of transmissions, massive MIMO enables transmissions to travel greater distances within a given transmit power. It also increases channel capacity by using sophisticated adaptive properties that enable automatic signal direction lock-in and optimization of radiation patterns. Massive MIMO for CSP networks operates by controlling the amplitude and phase of each antenna in both the network array and the device array.

Business Impact

- Massive MIMO with beamforming technology can support a larger number of users in the cell and improve the end-user experience in densely populated areas.
- Massive MIMO can provide excellent spectral efficiency achieved by spatial multiplexing of many terminals in the same time-frequency resource (so-called multiuser MIMO).

Drivers

- Increased deployment of 5G is driving more use of massive MIMO, since 5G is frequently deployed in higher spectrum bands (such as millimeter wave and 3.5GHz) than 4G LTE. This is because of the smaller antenna array needed for massive MIMO in higher frequency bands, as opposed to the large size that lower bands would require.

- Incumbent vendors are competing to provide better solutions, including hardware (e.g., chipset development) and software (e.g., smarter antenna beamforming algorithm).

- 5G often utilizes higher spectrum's time division duplexing (TDD) allocated bandwidths. TDD utilizes uplink and downlink communication on its same bandwidth and this TDD is more suitable for massive MIMO because its channel estimation and feedback are much easier compared to FDD.

Obstacles

- Bigger size and weight and higher costs than normal MIMO radio units is a major concern. As a result, CSPs prefer to introduce more realistic, fewer antenna elements (such as 3.5GHz's 32T32R) in early 5G.

- The complexity of operating and optimizing massive MIMO in real deployments based on information gathered at base stations.

- While massive 5G investment in some countries comes from lower FDD bandwidths (e.g., 2.1GHz, 1.8GHz and 850MHz), FDD massive MIMO products have not been commercialized mostly, mainly because of its different uplink and downlink radio spectrum utilization.

User Recommendations

CSP CTIOs should:

- Add more arrays with smaller-beam-width antennas to increase channel capacity. However, this move will also significantly increase the complexity of signal processing and need to care for the balance.

- Take advantage of massive MIMO to maximize spectral efficiency and provide improved coverage and quality of service. Massive MIMO will play a significant role in improving the performance of data throughput and the spectral efficiency in LTE and 5G.

Sample Vendors

Antenova; ArrayComm; CommScope; Ericsson; Huawei; NEC; Nokia; Westell Technologies; ZTE

Gartner Recommended Reading

Magic Quadrant for 5G Network Infrastructure for Communications Service Providers

LPWA

Analysis By: Tim Zimmerman, Bill Menezes, Aapo Markkanen

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Definition:

Low-power wide-area (LPWA) network technologies are a set of wireless wide-area network solutions designed for IoT applications that are characterized by their long signal range, low cost and low throughput. Communications are typically over 5 miles/10 kilometers. and involve small amounts of data at throughput of 0.3 Kbps to 50 Kbps between low-powered devices such as sensors that have a battery life of several years.

Why This Is Important

The number of IoT devices continues to grow rapidly. Use cases are not limited to in-building or close proximity applications, but instead include smart cities, agriculture, oil and gas, mining, and other industries. The sensors, which may be battery-operated or connected to power, are used in solutions that communicate small amounts of data over vast distances.

Business Impact

LPWA allows sensors to communicate status or change in status, enabling organizations to act or react to information that can reduce risk and liability, and potentially save lives, depending on the application. LPWA also allows the elimination of human labor to collect the data from disparate sensors such as meters, pipes or machinery, making it available in near real time instead of hours or days. Similarly, the labor costs associated with battery replacements can be reduced considerably.

Drivers

- The ability to collect near-real-time information from widely disparate locations
- The cost savings from applications such as metering, where currently personnel manually collect data from an end device, or service it in remote or challenging locations
- The ability for non-CSP vendors to deploy an infrastructure to meet end-user needs

Obstacles

- The expense of the radio infrastructure to collect the information
- The proprietary tags and protocols that limit interoperability (e.g., LoRa, Sigfox, Narrowband Internet of Things [NB-IoT], LTE-M)
- Immaturity of standards for eSIM-related use cases
- Lack of roaming agreements for NB-IoT and LTE-M

User Recommendations

- Organizations with large numbers of geographically dispersed sensors should consider LPWA for sensor communications including smart metering, smart outdoor lighting or remote sensors used for monitoring applications such as agriculture, construction and utilities.
- Evaluate 5G NB-IoT, which was introduced as part of release 13 of the 3GPP specification for 5G and should be considered as a possible alternative.
- Enterprises must continue to monitor data plan pricing to ensure that any solutions provide the required ROI.

Sample Vendors

AT&T; Deutsche Telekom; Sierra Wireless; Sigfox; Verizon; Vodafone

Gartner Recommended Reading

Magic Quadrant for Managed IoT Connectivity Services, WorldwideCritical Capabilities for Managed IoT Connectivity Services, Worldwide

Tech Providers 2025: Edge Ecosystems will Challenge CSP’s Dominance in Managed IoT Connectivity Services

Climbing the Slope

vEPC

Analysis By: Peter Liu

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Mature mainstream

Definition:

Virtual evolved packet core (vEPC) is the virtualization of Long Term Evolution (LTE) core network functions, which traditionally run on dedicated hardware, in virtual machines implemented on commercial off-the-shelf (COTS) servers. These services include mobility management entity (MME), serving gateway (SGW) and packet data node gateway (PGW). It can further expand the definition by including home subscriber server (HSS), and policy and charging rules function (PCRF).

Why This Is Important

Communications service providers (CSPs) like AT&T, Telefónica, NTT DOCOMO, Verizon, BT, China Mobile and others have rolled out their network function virtualization (NFV) projects. vEPC has become one of the most feasible examples for demonstrating the benefit of NFV. CSPs are convinced that vEPC is both financially and technically viable for their networks, and have started their vEPC commercial rollout on a large scale. vEPC supports not only 4G networks, but also early 5G NSA deployments.

Business Impact

As CSPs continue to implement NFV, the maturity of vEPC makes it a logical priority project in a CSP NFV and cloud native transformation journey. Benefits from virtualizing LTE core network functions on COTS include:

- Greater scalability, elasticity, service velocity/agility.
- Reduction of total cost of ownership.
- Support for new business such as IoT and video in an effective and efficient way.
- Fast service innovation and expansion and streamline asset utilization.

Drivers

- Lower infrastructure cost as proprietary hardware is replaced with common COTS hardware.
- Economics scaling to meet the growing user traffic on LTE networks.
- Higher service velocity and agility.
- Affordable and fast service innovation, and expansion such as the Internet of Things (IoT).
- Evolution to 5G NSA and then 5G SA next generation core, since network slicing and the inclusion of very-low-latency applications will necessitate a virtual core network and vEPC sets the stage.
- CSPs have commercially launched vEPC with different business purposes such as capacity on demand, cloud-based core, multitenant core to support “vEPC-as-a-service” or new business support (e.g., IoT, enterprise).

Obstacles

- Challenges in integrating a new vEPC with CSPs existing mobile core and back-office systems (OSS/BSS), as this requires significant customization.
- Slow pace on the NFV and cloud native transformation, which slows down vEPC scaling up.
- There is still sufficient capacity available on legacy EPC equipment. A large portion of CSPs still position vEPC to serve as a backup capacity or niche use cases.

User Recommendations

- Identify the lead use cases and a clear set of objectives for vEPC implementation that are in alignment with the intended business outcome. Make this central to your EPC virtualization strategy.
- Prioritize SDN/NFV or cloud native infrastructure transformation and position vEPC as a key component for the whole journey. Do not rush to containerized EPC solutions if you already started a virtual-machine-based transformation, but make sure the infrastructure itself is able to support both methodologies.

- Include investment in new orchestration architectures and management tools to achieve operational efficiency in the multivendor, heterogeneous network environment enabled by vEPC.
- Evaluate the organizational impact in terms of required skill set, initial goals and responsibilities. Create an open and cross-organizational structure that enables and champions the vEPC deployment.
- Assess vEPC solutions with a combination of containers and microservices architectures.

Sample Vendors

Athonet; Broadcom; Cisco; Ericsson; Huawei; Mavenir; Microsoft (Affirmed Networks); Nokia; ZTE

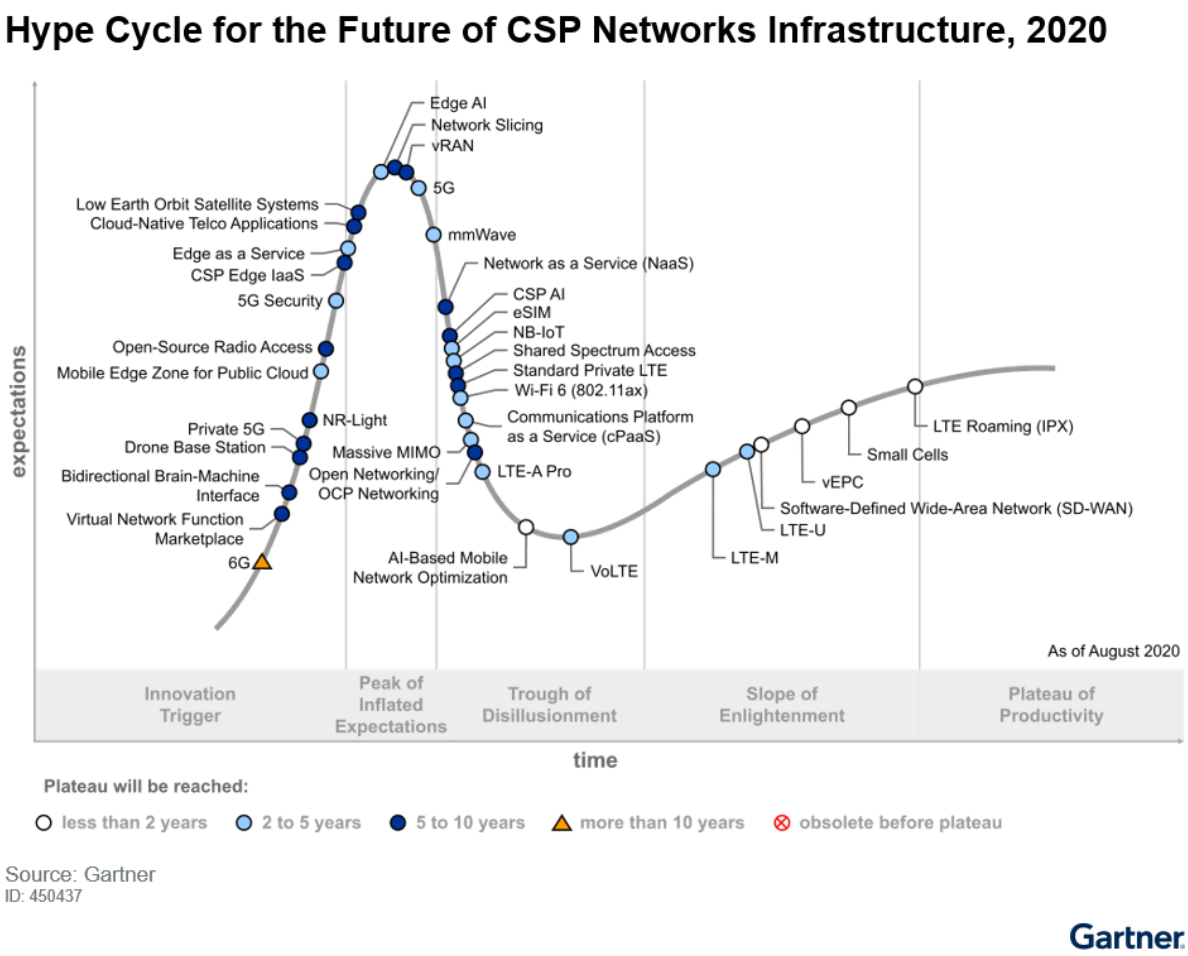
Gartner Recommended Reading

Magic Quadrant for 5G Network Infrastructure for Communications Service Providers

Changing CSPs' NFV and SDN Budgets and Implications for Technology SuppliersAssessing 5G Mobile Technology for Organizations

Appendixes

Figure 2. Hype Cycle for the Future of CSP Networks Infrastructure, 2020



Source: Gartner (August 2020)

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 2: Hype Cycle Phases

(Enlarged table in Appendix)

Phase ↓	*Definition* ↓
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant media and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the innovation is pushed to its limits. The only enterprises making money are conference organizers and content publishers.
Trough of Disillusionment	Because the innovation does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the innovation's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the innovation are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the innovation to reach the Plateau of Productivity.

Source: Gartner (July 2021)

Table 3: Benefit Ratings

Benefit Rating	*Definition*
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (July 2021)

Table 4: Maturity Levels

(Enlarged table in Appendix)

Maturity Levels	*Status*	*Products/Vendors*
Embryonic	In labs	None
Emerging	Commercialization by vendors Pilots and deployments by industry leaders	First generation High price Much customization
Adolescent	Maturing technology capabilities and process understanding Uptake beyond early adopters	Second generation Less customization
Early mainstream	Proven technology Vendors, technology and adoption rapidly evolving	Third generation More out-of-box methodologies
Mature mainstream	Robust technology Not much evolution in vendors or technology	Several dominant vendors
Legacy	Not appropriate for new developments Cost of migration constrains replacement	Maintenance revenue focus
Obsolete	Rarely used	Used/resale market only

Source: Gartner (July 2021)

Document Revision History

Hype Cycle for the Future of CSP Networks Infrastructure, 2020 - 7 August 2020

Hype Cycle for the Future of CSP Wireless Networks Infrastructure, 2019 - 7 August 2019

Hype Cycle for the Future of CSP Wireless Networks Infrastructure, 2018 - 8 August 2018

Hype Cycle for the Future of CSP Wireless Networks Infrastructure, 2017 - 2 August 2017

Hype Cycle for Communications Service Provider Infrastructure, 2016 - 25 July 2016

Hype Cycle for Communications Service Provider Infrastructure, 2015 - 4 August 2015

Hype Cycle for Communications Service Provider Infrastructure, 2014 - 23 July 2014

Hype Cycle for Communications Service Provider Infrastructure, 2013 - 29 July 2013

Hype Cycle for Communications Service Provider Infrastructure, 2012 - 31 July 2012

Hype Cycle for Communications Service Provider Infrastructure, 2011 - 27 July 2011

Hype Cycle for Communications Service Provider Infrastructure, 2010 - 30 July 2010

Hype Cycle for Communications Service Provider Infrastructure, 2009 - 31 July 2009

Hype Cycle for Network Service Provider Infrastructure, 2008 - 9 July 2008

Hype Cycle for Network Service Provider Infrastructure, 2007 - 19 July 2007

Hype Cycle for Network Service Provider Infrastructure, 2006 - 18 July 2006

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Create Your Own Hype Cycle With Gartner's Hype Cycle Builder

Infographic: AI Use-Case Prism for Telecommunications CSP Networks

Grasp the Opportunity of a Communication Service Provider-Led Edge Computing

Routes to the Future for CSPs — Technology Strategy

Market Guide for 5G Network Ecosystem Platform Providers

Table 1: Figure 2: Priority Matrix for the Future of CSP Networks Infrastructure, 2021

Benefit	*Years to Mainstream Adoption*			
↓	***Less Than 2 Years*** ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Transformational	vEPC	400G Transport Edge AI eSIM	Cloud-Native CSP Infrastructure Composable Networks LEO Satellite Systems Network Slicing	6G
High	Network AI and Automation	5G 5G Small Cell Edge as a Service LTE-A Pro Massive MIMO Private LTE Public Cloud for Mobile Edge XGS-PON	5G-Advanced 800G Transport Open RAN Private 5G RedCap Shared Spectrum Access vRAN	All Photonics Network
Moderate		5G Network Security CDN Developer Edge Node LPWA Open Core Network Software-Defined Cloud Interconnect	50G PON Active-Passive Antenna FMC Core Open Networking	

Benefit	*Years to Mainstream Adoption*			
↓	***Less Than 2 Years*** ↓	***2 - 5 Years*** ↓	***5 - 10 Years*** ↓	***More Than 10 Years*** ↓
Low			NaaS	

Source: Gartner (July 2021)

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Source: Gartner (July 2021)

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