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Frost Radar™: Private Multi-Access Edge Computing, 2023

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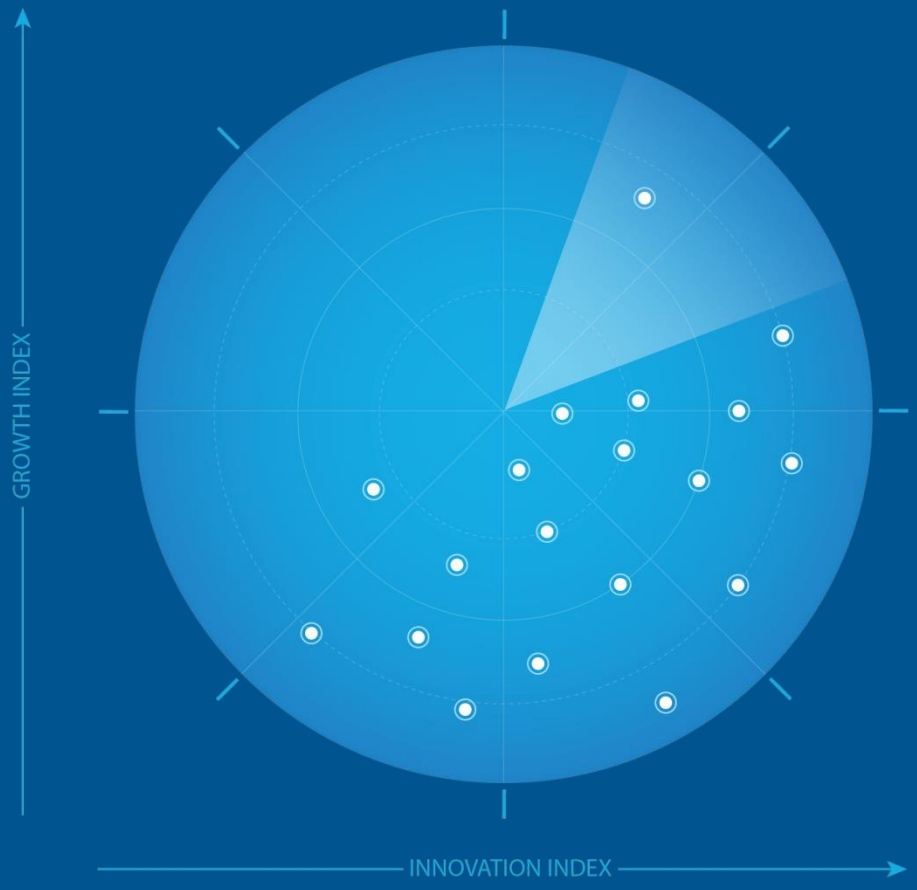
A Benchmarking System to Spark Companies to Action - Innovation That Fuels New Deal Flow and Growth Pipelines



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Strategic Imperative and Growth Environment

Strategic Imperative

Factors Creating Pressure on Growth

- Private multi-access edge computing (MEC) is a private mobile network deployment with custom-built edge computing capabilities for enterprises. It enables an infrastructure that runs mission-critical and latency-sensitive applications by offering ultralow latency levels (less than ten milliseconds).

- Enterprises usually have a choice of two models:

  - Paying upfront for the hardware and the installation charges of the macro cellular and MEC and then a lower monthly recurring charge for the services provided,

  - Paying for everything as a service with no or minimal upfront costs. Typical contracts have a duration from three to five years, but this may vary by provider. There may be additional charges for gateways, software-defined wide area networks (SD-WANs), and other add-ons.

Source: Frost & Sullivan

Strategic Imperative (continued)

Factors Creating Pressure on Growth

- Edge-as-a-service (EaaS) is a terminology for a private MEC solution that combines distributed cloud computing, storage, hardware/devices, and sophisticated networking (i.e., Wi-Fi 6, 5G, SD-WAN), enabling a platform that provides ultralow latency and high bandwidth to allow edge-native applications to run with high performance and availability. There is a high level of automation in the solution via software and artificial intelligence/machine learning (AI/ML) to allow device monitoring, smart traffic routing, application management, and other functions. A successful service provider in the private MEC space will have strong capabilities globally in terms of professional and managed services teams, technology tools, and telecommunication networks. Innovative business models are emerging in private and public sectors, leveraging the distributed cloud platform to support edge use cases in different verticals. Transformative Megatrends, including the Future of Mobility (e.g., connected cars and integrated mobility) and Bricks and Clicks (e.g., retail personalization and omnichannel marketing), are boosted by MEC, which allows for faster development and adoption of edge computing.

Source: Frost & Sullivan

Growth Environment

- According to the Global Mobile Suppliers Association (GSA), 243 commercial 5G networks operated in 96 countries as of December 2022. China is first in terms of 5G connections, with 1.10 billion as of December 2022. Edge computing is evolving rapidly in wireless networks. MEC is the term that telecom operators use for their commercial edge computing offerings in wireless networks. They partner with cloud providers such as AWS, Microsoft Azure, Google Cloud, and IBM Cloud to improve the performance of mission-critical applications in wireless networks and enable new applications. Most operators have designed their offerings for private implementations, providing the necessary infrastructure on-premises for smart factories, mining facilities, ports, and other industrial environments. Some have deployed smaller data centers closer to customers and application demand at the 5G public network edge to serve use cases such as gaming and connected cars.

- The coexistence of competition and partnerships in the private MEC market is an interesting and important aspect of the industry. It can be explained by the market's early stage, complex ecosystems, specialization, and the need for openness and standards. This phenomenon drives innovation, improves technology, and expands the market reach. Frost & Sullivan expects more vendor collaboration to benefit the industry as the market matures.

Source: Frost & Sullivan

Growth Environment (continued)

- Frost & Sullivan research conducted in Q4 2023 indicates that approximately 20% of enterprises consider edge computing their number-one technology investment priority over the next 12 months. In 2023, most MEC trials used 5G deployments, while in the 2019-2021, most implementations used 4G. Additionally, 5G will bolster MEC through minimum latency (less than 1 ms), high bandwidth (10 Gbps peak speed), and high density (1 million connections/square km). Market revenue is projected to increase from $749.3 million in 2021 to $16.28 billion in 2025 at a compound annual growth rate (CAGR) of 115.9%. Among MEC segments, software, and services present the highest CAGRs, mostly driven by the demand for latency reduction in mobile networks for mission-critical applications across customer, enterprise, and industrial use cases and that data-driven companies and governments require a significant data stream for real-time analytics. Enterprises also require network and application resiliency, which distributed computing capabilities can achieve.

- Growing adoption of the Internet of Things (IoT) also results in high demand for edge infrastructure, which can lower operational expenses (lower traffic in the backhaul and core) and help telecom operators offer a better customer experience. Edge infrastructure also helps telecom operators address rising high-definition (HD) video stream consumption on mobile devices.

Source: Frost & Sullivan

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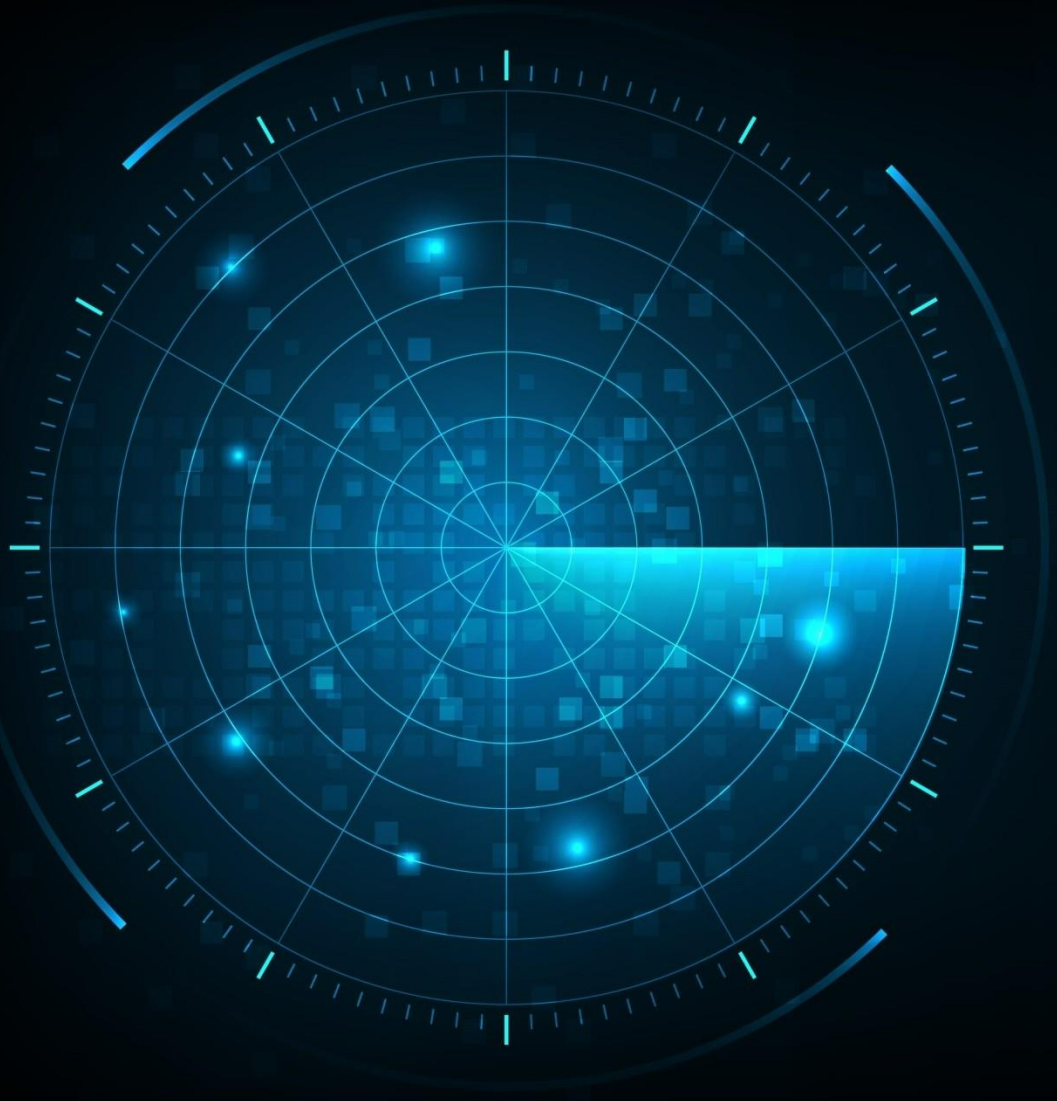
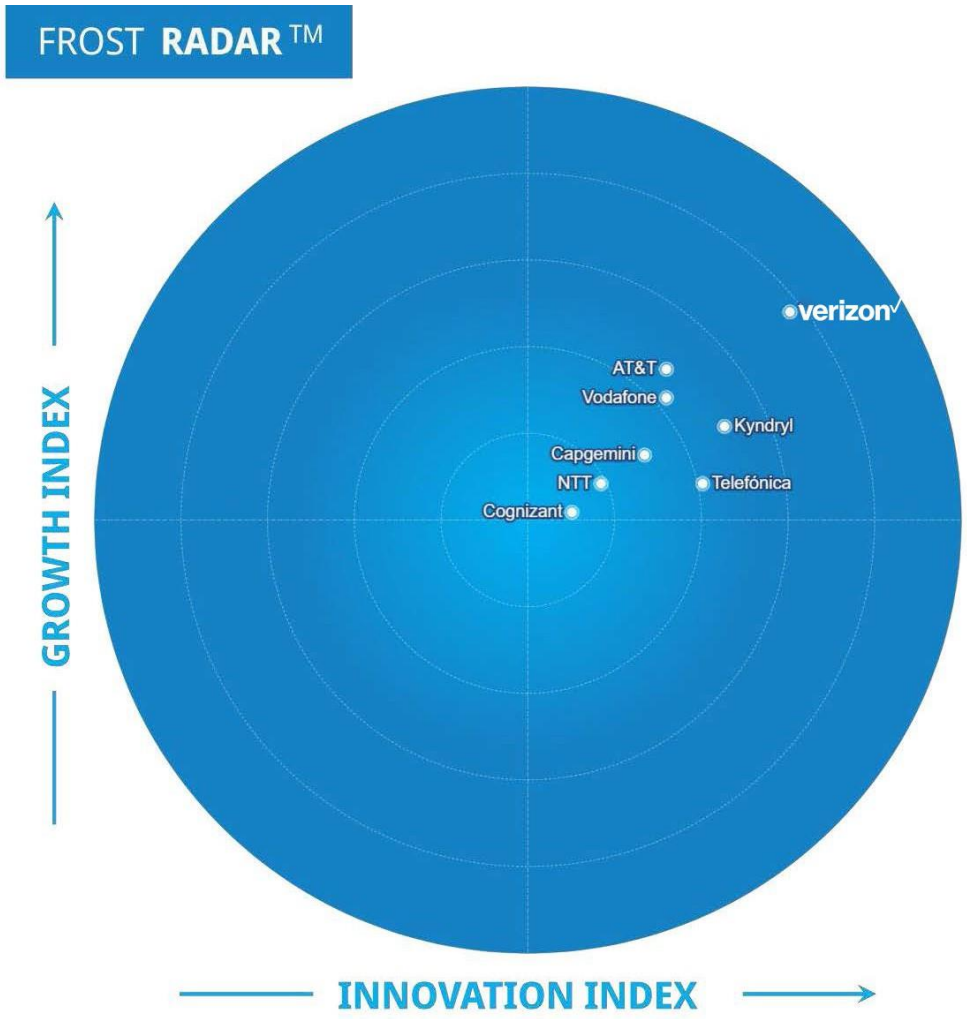


Frost Radar™

Zero Trust Browser Security, 2023

Frost Radar™: Private Multi-Access Edge Computing, 2023



Source: Frost & Sullivan

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Competitive Environment

- The edge computing ecosystem comprises telecom and IT infrastructure vendors, telecommunication companies (telcos), cloud providers, global system integrators (GSIs), edge data center support infrastructure vendors, edge data center colocation services providers, and edge application or solution developers. It includes numerous startups developing software, hardware, and data center infrastructure solutions.

- In a field of more than 100 global industry participants, Frost & Sullivan independently plotted the top eight GSIs and telcos in this Frost RadarTM analysis. Each has a different commercial approach and offers different services to businesses seeking to implement MEC solutions.

- Telcos are the traditional providers of network infrastructure and connectivity. In the private MEC market, they offer a range of market component services, including network infrastructure, connectivity solutions, security services, and orchestration tools. GSIs focus on the integration of private MECs, as well as the advisory and managed services aspects. It is important to note that the lines between telcos and GSIs are increasingly blurred. Some telcos are expanding their portfolio to include GSI-like services, while many GSIs are partnering with telcos and/or telecom vendors to provide end-to-end solutions. This collaboration is crucial for the growth of the private MEC market. It gives businesses access to a wider range of services and expertise to meet their needs.

Source: Frost & Sullivan

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Companies to Action:

Companies to Be Considered First for Investment, Partnerships, or Benchmarking

Company to Action: Verizon

Innovation

- Verizon is one of the pioneers of 5G and MEC. In December 2019, Verizon partnered with AWS to announce its public MEC solution. The Verizon 5G Edge solution extends AWS compute and storage services and tools to Verizon's public mobile network's edge. In May 2022, Verizon completed the coverage of 19 major metropolitan areas in the United States with Public MEC; according to Verizon, "75% of the US population is covered within 150 miles of one of 19 Wavelength Zones."

- In March 2022, Verizon announced a collaboration with Meta to improve the metaverse application experience using the MEC infrastructure and deliver intensive XR cloud rendering and low-latency streaming. This is an interesting bet for the future of applications.

- In private MEC, the company has consolidated a compelling offering, with options with upfront investment and as-a-service. Verizon has built its concept around the real-time enterprise, with end-to-end visibility, control and security, analytics, and ML. Its private MEC can offer a latency of less than 7 ms. Its hybrid MEC orchestration is a relevant innovation and a differentiator to the service.

Source: Frost & Sullivan

Company to Action: Verizon

Innovation

- Verizon works with enterprises and start-ups at MEC innovation centers and labs. It created the latest lab with IBM in August 2021. It has 3 5G labs in the United States (East and West coasts) and a 5G lab for international customers in London. In addition, Verizon works with customers as part of its 5G Innovation Hubs, which are spaces at startups, universities, and large enterprises where partners/ customers develop and test solutions powered by Verizon 5G Ultra Wideband.

- The company offers an innovative Verizon 5G Edge solution that combines MEC and 5G technology. The infrastructure and software development combination makes Verizon 5G Edge a powerful and comprehensive solution. Verizon has developed applications that include connected vehicles, automated manufacturing, connected healthcare, immersive entertainment, AR/VR, and cloud gaming.

Source: Frost & Sullivan

Company to Action: Verzon

Growth

- In public MEC, Verizon is the most advanced player, but the demand still has not reached a significant scale; its 5G private MEC offering has dozens of private networks deployed, and the demand is growing every quarter.
- To deliver private MEC, Verizon works with AWS Outposts and Google Cloud Platform. Its top verticals are transportation/logistics, retail, manufacturing, healthcare, entertainment, and construction. Applications are connected vehicles, automated manufacturing, AR/VR, and gaming.
- Verizon launched a network-as-a-service vehicle equipped with 5G, MEC, SD-WAN, and satellite connectivity in September 2023 for faster and cheaper implementations of private MEC.
- Verizon has planned additional MEC deployments across the United States in the coming years, implementing edge data centers to support the offering.
- In private MEC, it has grown significantly in 2023 and should increase the pace as the ecosystem grows, more applications scale, and customers expand implementations.

Source: Frost & Sullivan

Company to Action: Verizon

Frost Perspective

- Verizon leads the EaaS industry, shaping the global landscape with its innovative offerings. Verizon 5G Edge provides faster access to data, improved performance, greater efficiency, and accelerated transformation. By combining MEC and 5G technology, Verizon 5G Edge can provide businesses with the performance and capabilities they need to run demanding edge computing applications. Its 5G Ultra-Wideband offer adds superior performance and value to the solution.

- To strengthen its position in the MEC space, Verizon should continue expanding its MEC infrastructure across the United States and increasing simplicity and affordability to support a wider range of customers and applications. It should work with ecosystem participants and developers remotely and in its 5G innovation labs to facilitate collaboration and co-innovation, and engage with a diverse range of enterprises, start-ups, and partners.

- Verizon should develop MEC-based solutions in a marketplace for emerging industries and applications, including smart cities, connected vehicles, industrial automation, connected healthcare, immersive entertainment, AR/VR, and cloud gaming. Having partnered with multiple leading technology companies, Verizon provide customers with additional value. It should continue partnering with system integrators, cloud providers, and software vendors to enhance its offer.

Source: Frost & Sullivan

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Frost Radar™ Analytics

Frost Radar™: Benchmarking Future Growth Potential

2 Major Indices, 10 Analytical Ingredients, 1 Platform

VERTICAL AXIS

Growth Index (GI) is a measure of a company's growth performance and track record, along with its ability to develop and execute a fully aligned growth strategy and vision; a robust growth pipeline system; and effective market, competitor, and end-user focused sales and marketing strategies.

GROWTH INDEX ELEMENTS

- **GI1: MARKET SHARE (PREVIOUS 3 YEARS)**
  This is a comparison of a company's market share relative to its competitors in a given market space for the previous 3 years.
- **GI2: REVENUE GROWTH (PREVIOUS 3 YEARS)**
  This is a look at a company's revenue growth rate for the previous 3 years in the market/industry/category that forms the context for the given Frost Radar™.
- **GI3: GROWTH PIPELINE**
  This is an evaluation of the strength and leverage of a company's growth pipeline system to continuously capture, analyze, and prioritize its universe of growth opportunities.
- **GI4: VISION AND STRATEGY**
  This is an assessment of how well a company's growth strategy is aligned with its vision. Are the investments that a company is making in new products and markets consistent with the stated vision?
- **GI5: SALES AND MARKETING**
- This is a measure of the effectiveness of a company's sales and marketing efforts in helping it drive demand and achieve its growth objectives.

Frost Radar™: Benchmarking Future Growth Potential

2 Major Indices, 10 Analytical Ingredients, 1 Platform

HORIZONTAL AXIS

Innovation Index (II) is a measure of a company's ability to develop products/services/solutions (with a clear understanding of disruptive Mega Trends) that are globally applicable, are able to evolve and expand to serve multiple markets, and are aligned to customers' changing needs.

INNOVATION INDEX ELEMENTS

- **II1: INNOVATION SCALABILITY**
  This determines whether an organization's innovations are globally scalable and applicable in both developing and mature markets, and also in adjacent and non-adjacent industry verticals.
- **II2: RESEARCH AND DEVELOPMENT**
  This is a measure of the efficacy of a company's R&D strategy, as determined by the size of its R&D investment and how it feeds the innovation pipeline.
- **II3: PRODUCT PORTFOLIO**
  This is a measure of a company's product portfolio, focusing on the relative contribution of new products to its annual revenue.
- **II4: MEGA TRENDS LEVERAGE**
  This is an assessment of a company's proactive leverage of evolving, long-term opportunities and new business models, as the foundation of its innovation pipeline. An explanation of Mega Trends can be found here.
- **II5: CUSTOMER ALIGNMENT**
  This evaluates the applicability of a company's products/services/solutions to current and potential customers, as well as how its innovation strategy is influenced by evolving customer needs.

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