McKinsey & Company

McKinsey Technology Trends Outlook 2022

Cloud and edge computing

August 2022

What is the trend about, and what are the most noteworthy technologies?

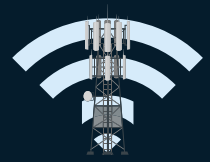
Networks of the future consist of traditional cloud data centers and a variety of computational resources located at network edge nodes closer to end users to reap the benefits of traditional cloud computing while gaining advantages such as better data latency and increased data autonomy

Tomorrow's networks will consist of devices at many locations computing simultaneously

Edge networks closer to the user | **Hybrid cloud**








	Device edge	Remote edge	Branch edge	Enterprise edge	Telecom/MEC[1] edge	Cloud
Compute location	Smartphone Camera Wearable tech	Connected vehicle Resource extraction site Remote filming locations	Branch Retail outlets Restaurants	Factories Hospitals Airports	Network aggregation points Network access points	Regional data centers Co-location data centers Hyperscale data centers
Use cases	Remote patient monitoring Real-time fleet tracking Worker safety monitoring	Remote asset management Remote content rendering	Building energy management Real-time personal promotions Immersive-content experiences	Smart construction and manufacturing Passenger analytics at airports Proactive equipment maintenance	Smart city infrastructure Air quality monitoring Media/content delivery	Streaming media delivery Real-time multiplayer gaming Local content exchange

[1]Multi-access edge computing.

Source: McKinsey analysis

Why should leaders pay attention?

Cloud has already effected change across industries and will remain an important tech disruption

Cloud computing is a huge opportunity for all organizations

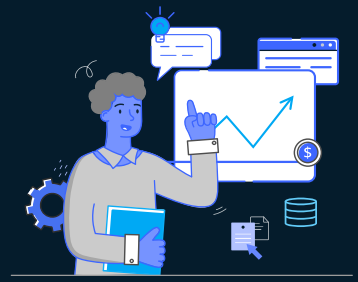
$1 trillion

Opportunity in run-rate EBITDA[1] across Fortune 500 companies in 2030 through cloud cost optimization levers and value-oriented business use cases

Cloud is no longer public or private but is increasingly hybrid

~90%

Share of **cloud users** who **have a multi-cloud strategy**, with over 80% having a hybrid mix of private and public cloud



The market for public cloud continues to grow rapidly

~$300 billion

Worldwide public cloud services market in 2020, growing at a CAGR of ~25%, driven by growth in IaaS, PaaS, and SaaS[2]

Security and access in the cloud remain a top concern for users

~75%

Share of enterprises where cloud security issues are a top concern, with the top challenges being infrastructure configuration, access, and insecure APIs

[1]Earnings before interest, taxes, depreciation, and amortization.
[2]Infrastructure as a service, platform as a service, and software as a service.

Source: "Cloud's trillion-dollar prize is up for grabs," McKinsey, Feb 2021; Flexera 2022 state of the cloud report, Flexera, Mar 2022; Worldwide Semiannual Public Cloud Services Tracker, IDC, May 2021; 2022 cloud security report, Check Point

Why should leaders pay attention? (continued)

Edge computing might soon become an operational necessity for many organizations

Data regulation is taking center stage around the world

>60

Number of countries reporting data protection localization requirements in 2021; requirements can be fulfilled by adoption of edge storage and computing

Enterprise edge computing spend is growing rapidly

~$250 billion

Projected worldwide spending on edge computing in 2025, growing at a CAGR of ~10%

Data volume and velocity are growing at an unprecedented pace

<20%

Share of data generated by enterprises that is ultimately used, due to challenges with latency and costs of moving data across environments

Distributed computing is getting more popular, unlocking real-time insights

26%

Forecast **share of servers** shipped in 2024 that will be **deployed at the edge**—up from 20% in 2019

Edge computing provides flexibility for organizations to achieve **greater data sovereignty, greater autonomy, better security, and better latency** while unlocking a variety of use cases that rely on real-time data processing

Source: IDC; Omdia

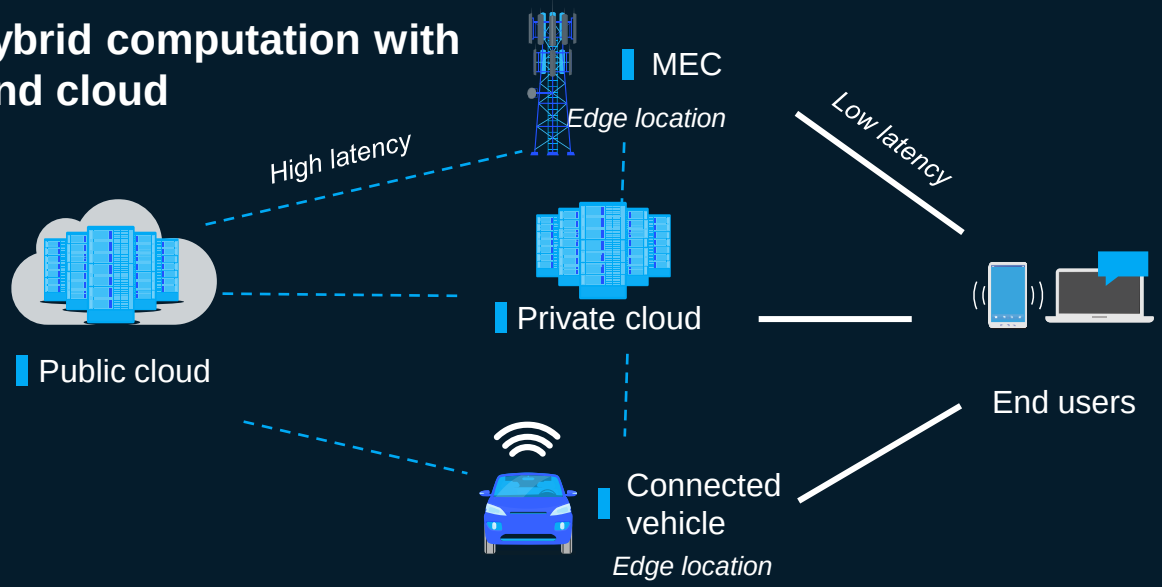
What distinguishes edge computing from traditional cloud?

From multi-cloud-based centralized computation …

Computational resources

Fully **centralized core** with **computation and storage** done **in the cloud**, leading to high latency and network congestion

… to hybrid computation with edge and cloud



Selected **core functions moved toward the edge**, where **computing infrastructure** is deployed to run latency-intensive apps

Edge computing will leverage many types of networking technology to connect end users to a decentralized core of **computing infrastructure located closer to the end user**

Reduced distance to end users will **shrink data transmission delays and costs,** as well as provide **faster access** to a smaller, more relevant set of data, which helps companies **comply with data residency laws**

Traditional public cloud will continue to play a critical role in the networks of the future by **performing non-time-sensitive computing use cases** at better **economies of scale** at a distance from the end user

Source: McKinsey analysis

What disruptions could the trend enable?

Disruptions from edge computing will have impact on almost all industries and functions

The impact can be described in terms of 2 broad categories:

Network service improvements

Improvements in the **performance of the network** and in the **quality of experience** for users

Content/CDN[1] caching

Mobile backhaul optimization

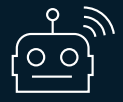
Media delivery optimization

New services unlocked by improved quality of experience

B2B services that usually do not benefit the end user directly

Active-device location tracking

Real-time personal promotions



Drones/smart robots

Connected cars

B2C services that generally benefit the end user directly

Cloud gaming

Remote desktop applications

Cognitive assistance

Augmented and assisted reality

[1]Content delivery network.

Source: McKinsey analysis

What should a leader consider when engaging with the trend?

Benefits

Data latency: Edge will enable use cases that had been challenging to implement effectively, due to data latency (eg, cloud gaming, smart factories, autonomous vehicles)

Data residency compliance: Edge will ensure compliance with local data residency laws necessary to experience the benefits of both cloud and edge

Data autonomy: Edge will ensure much more granular control over individual and enterprise data by limiting reliance on public cloud

Data security: Edge provides a security advantage over public cloud infrastructure, which is often susceptible to breaches enabled by the infrastructure-sharing model and misconfigurations

Risks and uncertainties

Business model: Telecom companies and IT service providers need to figure out partnership, services, and infrastructure management approaches to unlock cost-efficiency and avoid major cost increases resulting from greater technical complexity

Technical challenges: Cloud and edge involve managing resources over networks that require interoperability among a wide variety of devices and sensors to deliver value

Scaling hurdles: The growing number of edge nodes and devices will be challenging, since edge doesn’t benefit from the same economies of scale as traditional cloud computing

Source: McKinsey analysis

What industries are most affected by the trend?

Edge computing is **quickly approaching maturity;** several players have successfully used it to create impact in their operations and services

Synergetic technologies (**5G, MEC, SD-WAN,**[1] and other advancements in networking) are **driving adoption for edge** to create major impact across many industries

Industry affected	Implications of technology trend
Telecommunications	Increase in revenue streams from technologies such as MEC, given the telecom company role as the primary owner of the networking infrastructure required for distributed computing
Automotive and assembly	Increase in overall efficiency of transportation routes through schedule management, route optimization, etc; reduced reliance of connected/autonomous vehicles on large, distant data centers for access to compute
Electric power, natural gas, and utilities	Increase in employee safety and efficiency at work sites through real-time tracking and optimization; improvements in equipment efficiency through condition monitoring, real-time data processing, and predictive maintenance
Manufacturing	Improvements in networking and data latency, increasing effectiveness of other Industry 4.0 technologies, leading to better overall productivity
Financial services	Sensors and monitors in vehicles, helping insurance players reduce collision and theft
Retail	Improvements in advanced analytics use cases (eg, personalization, staff allocation, theft detection)
Healthcare systems and services	Improvements in most digital use cases (eg, remote diagnostics, active drug tracking, fitness trackers)

[1]Software-defined wide-area network.

Source: McKinsey analysis

What industries are most affected by the trend? (continued)

Edge computing is **quickly approaching maturity;** several players have successfully used it to create impact in their operations and services

Synergetic technologies (**5G, MEC, SD-WAN,**[1] and other advancements in networking) are **driving adoption for edge** to create major impact across many industries

Industry affected	Implications of technology trend
Aerospace and defense	Better networking and data latency, which make automated manufacturing technologies more effective, leading to higher overall productivity for aerospace players, while flowing data to cloud platforms for efficient analytics
Aviation, travel, and logistics	More effective demand forecasting, schedule management, and route optimization; well-orchestrated data decentralization can also provide resilience against data loss
Information technology and electronics	Increase in products and services the industry can offer, spanning cloud and edge environments
Media and entertainment	Maximizing streaming performance and delivery of large volumes of digital content with minimal delays and downtime; enabling flexible server capacity to meet unpredictable consumer demand while maintaining high quality of service
Pharmaceuticals and medical products	Accelerated drug discovery by enabling better use and storage of AI/ML models; continuous monitoring of equipment that improves quality, safety, and yield of drugs and formulations.

[1]Software-defined wide-area network.

Source: McKinsey analysis

Who has successfully created impact with cloud and edge computing?

Industry	Case example
 **Telecommu-nications**	**AT&T** has created a new service line providing customers with multi-access edge computing by partnering with system integrators to connect customers' enterprise data centers with LTE and 5G infrastructure
 **Automotive and assembly**	**Tesla's** vehicles are powered by homegrown full self-driving (FSD) processors that act as edge nodes to run machine learning algorithms trained in the cloud to unlock self-driving capabilities
 **Retail**	**Walmart** is planning to use edge computing not only to improve its own Internet of things (IoT), real-time analytics, and customer experiences but also to leverage its nationwide coverage of supercenters to provide edge computing services to customers near these locations

What are some topics of debate related to the trend?

Cloud and edge computing will undoubtedly create tremendous change, but experts are still debating several key questions

1 Impact of edge computing

Will edge truly be more disruptive than cloud?

- Edge is **extremely flexible** and supports a **wide array of devices** while lying in a **business and regulatory sweet spot**
- However, traditional cloud enables economies of scale that would **be impossible for edge computing** networks that require a **high level of interoperability and commonality of standards** currently absent in networking

2 Outlook

Will hyperscale cloud providers win the edge race?

- Public cloud providers have already **created services and partnership ecosystems** to provide seamless edge and cloud connectivity to their customers
- **Telecom companies with 5G-enabled MEC** can choose to either contend or partner with hyperscalers
- **OEMs and networking and edge service providers** will be important as edge networks scale up and customers require custom solutions

3 Security vulnerabilities

Will the increase in number of storage and processing units lead to security vulnerabilities?

- Keeping **sensitive data at edge locations** away from centralized servers helps restrict access and minimize risks in the event of a major attack
- However, increasing the number of edge locations increases the **attack vectors for malicious actors;** if proper precautions aren't taken, security vulnerabilities may arise

4 Energy consumption

How will cloud and edge evolve in line with the sustainable IT paradigm?

- Data centers are increasingly relying on green IT measures such as **sustainably sourced energy** and **energy-efficient cooling systems**
- Edge computing further reduces overall energy requirements, as **less data is transmitted across the network** and more is processed and stored locally
- However, as networks expand, the amount of critical infrastructure and number of devices, data centers, and **related energy requirements will continue to increase**

5 Meeting demand

How will cloud and edge resources cope with growing demand?

- As sensor costs drop and performance increases, will new technological advances in the space be able to meet the growing demand for data movement and AI-enabled analytics which rely heavily on the cloud?
- Increase in network capacity and performance may increase demand for cloud-based workloads and reduce the need for specialized edge services

Source: Expert interviews; McKinsey analysis

Additional resources

Knowledge center

Cloud Insights

Related reading

New demand, new markets: What edge computing means for hardware companies

Cloud foundations: Ten commandments for faster—and more profitable—cloud migrations

The cloud transformation engine