EAGLE GLOBAL ADVISORS

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Innovation: Cloud Computing Is "On The Edge"

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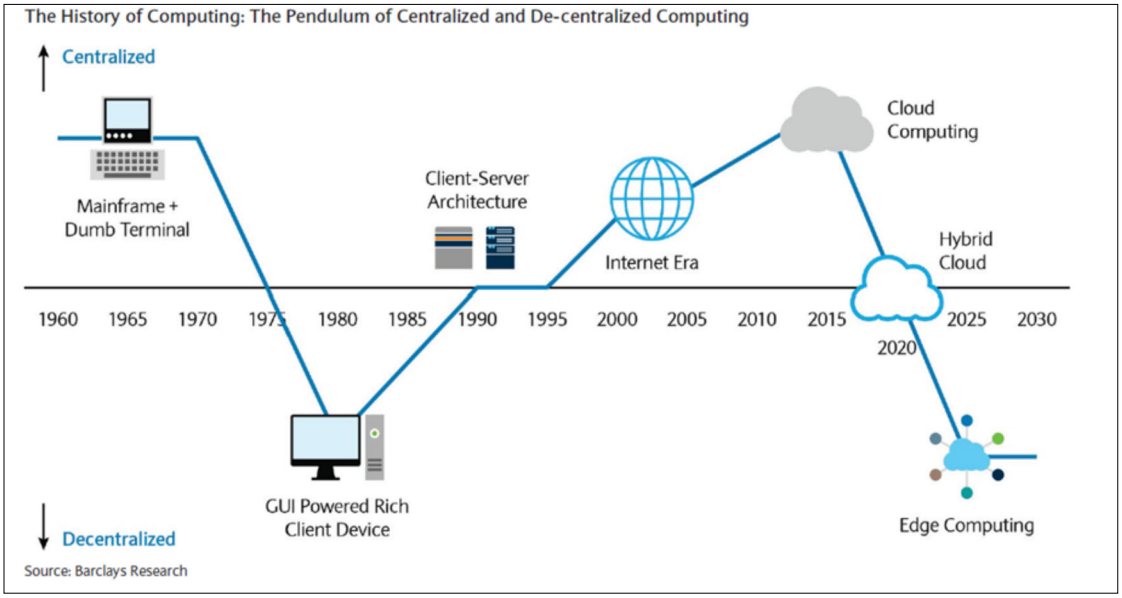
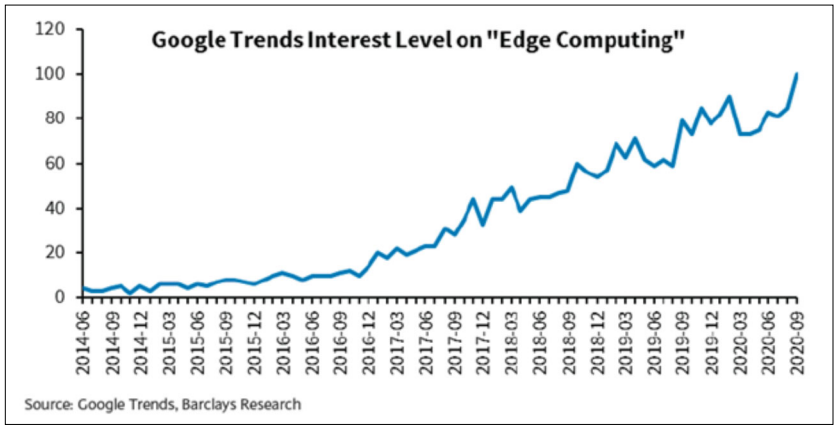
Innovation: Cloud Computing Is "On The Edge"

The Big Picture: A Historical Perspective of Cloud Computing

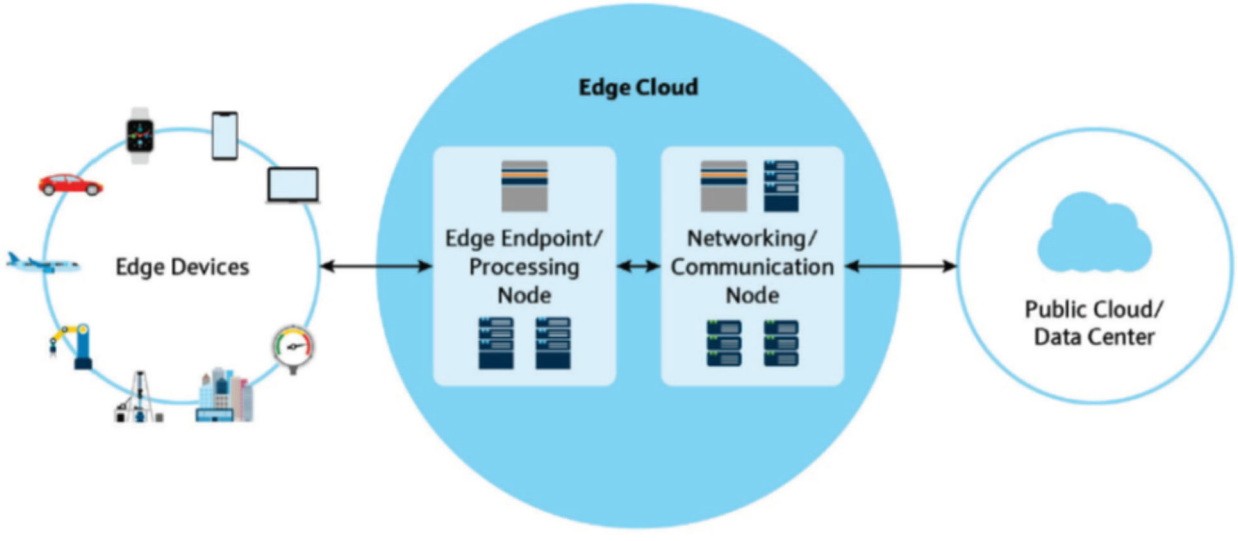
Cloud concepts began their gradual evolution dating back to the 1950's with mainframe computing as companies used prohibitively expensive mainframe computers to process their data. By the 1970's, computing development accelerated with the concept of the virtual machine where two distinct computing operations could operate at the same time on one piece of hardware, virtually eliminating mainframe computers. Fast forward to the 1980's, companies invested and maintained their own hardware as new, less expensive, more compact hardware components were invented. With the introduction of client/server architecture, companies could also purchase systems that functioned like traditional mainframe systems at a fraction of the cost. By the time we reached the 1990's, the idea of cloud computing became a reality and the cloud symbol started being used. The virtual private network (VPN) replaced the point to point data circuit previously offered by telecommunications companies. During the later part of the 1990's, companies gained a better understanding of the usefulness of cloud computing and its ability to provide top-notch services and solutions to their customers, while also improving internal efficiencies. After the dot-com bubble burst, companies such as Amazon played a key role in the further development of cloud computing. Additionally, internet power increased due to high-speed broadband. Most recently, the availability of high-capacity networks and low-cost computers as well as the widespread use of virtualization and service-oriented architecture has led to the cloud computing we know today, a technology on the forefront of transformation over the coming decade as Edge Computing makes its entrance.



What is Edge Computing?



It's clear from the chart to the right, interest in learning about Edge Computing has been on a steady climb since 2016. So, what is it? The short answer is Edge Computing decentralizes or brings data storage and computing power closer to the device or data source where it's most needed. The long answer according to the Open Glossary of Edge Computing published by the Linux Foundation* is Edge Computing is "the delivery of computing abilities to the logical extremes of a network in order to improve the performance, operating cost and reliability of applications and services. Its architecture has new resources and software stacks along the path between today's centralized data centers and an increasingly large number of devices in the field." The diagram below illustrates how Edge Computing is an extension of the Cloud. The "Edge Cloud" provides additional computing power, storage, networking and software capabilities to the "Edge Devices." For example, this additional computing power could be a data center attached to a cell tower or near a power plant. It could also take the form of a computing device inside an autonomous vehicle. Moving forward, a significant portion of worldwide traffic and workload will be processed and stored on the "Edge" or at locations close to the user versus at centralized data centers. This distribution eliminates lag-time and saves bandwidth.



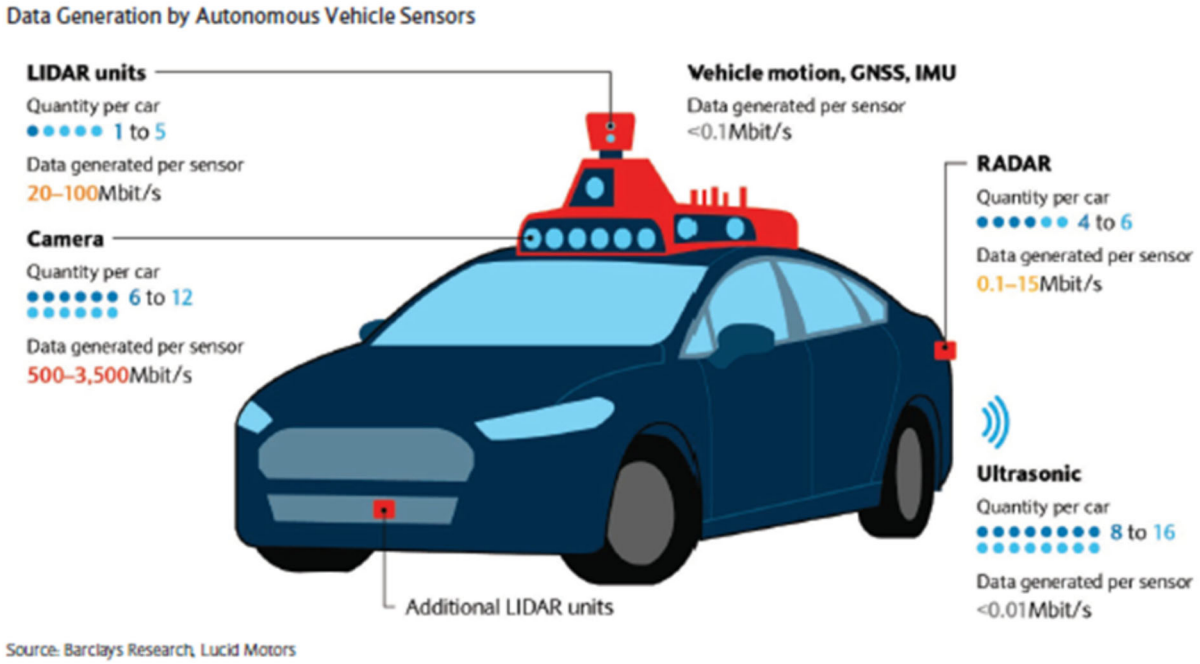
Source: Barclays Research

*Source: State of Edge Glossary, Barclays

Why is Edge Computing Needed?

Jeffrey Ricker of Hivecell*, the premiere platform as a service for edge computing notes six key reasons for Edge Computing:

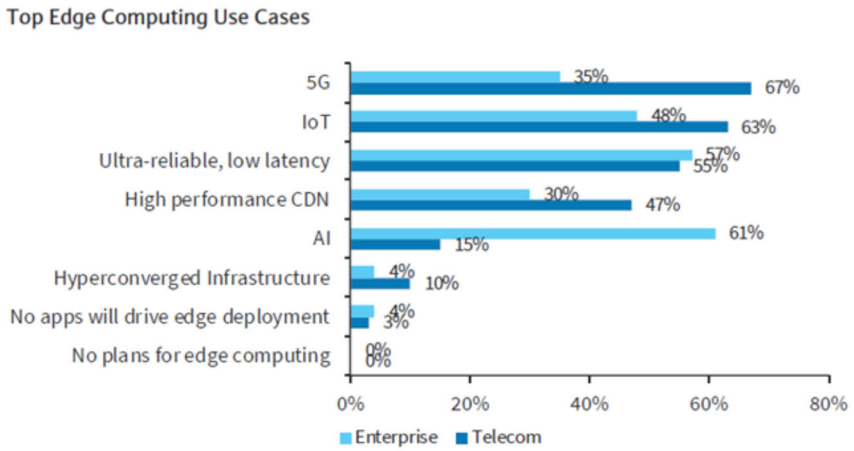
- Bandwidth: The volume of data generated by the Internet of Things ("IoT") to be sent to a centralized cloud will be too burdensome, so it will need to be analyzed down to key data elements.
- Cost: Similar to bandwidth, a large portion of the data is unusable, so Edge Computing can reduce costs to identify data with value.
- Reliability: Safety of data from inevitable network outages is essential.
- Security: Some data can be too sensitive to send over some networks.
- Compliance: Data sovereignty and nationalistic laws will prevent some data from going across national borders.
- Latency/Performance: Data distance and movements through networks can add latency and reduce performance quality. For applications like the autonomous vehicle or mobile robots where instantaneous information is a critical safety requirement Edge Computing is essential. The chart below provides prospective on the volume of data generated by AV's.



*Source: Jeffrey Ricker, "Six Reasons for Edge Computing", UBS

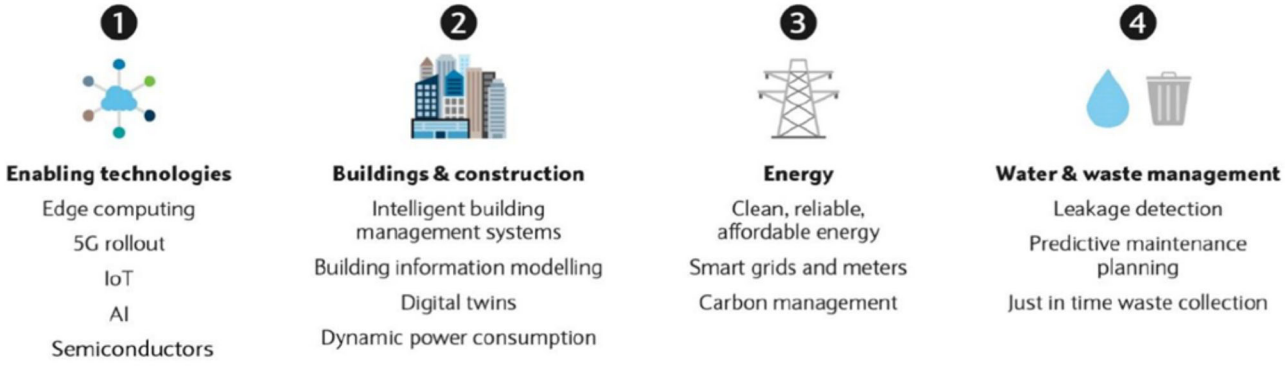
Edge Computing in the Real World

According to global research and advisory firm Gartner, ~90% of enterprise data is currently processed in centralized data centers despite the fact the data is generated hundreds of miles away from the data centers. As shown in the chart below, Edge Computing is expected to be a key building block for many of the "next big things" including 5G, "IoT" and autonomous driving.



Source: Heavy Reading survey[3], Cisco Internet Report, Barclays Research

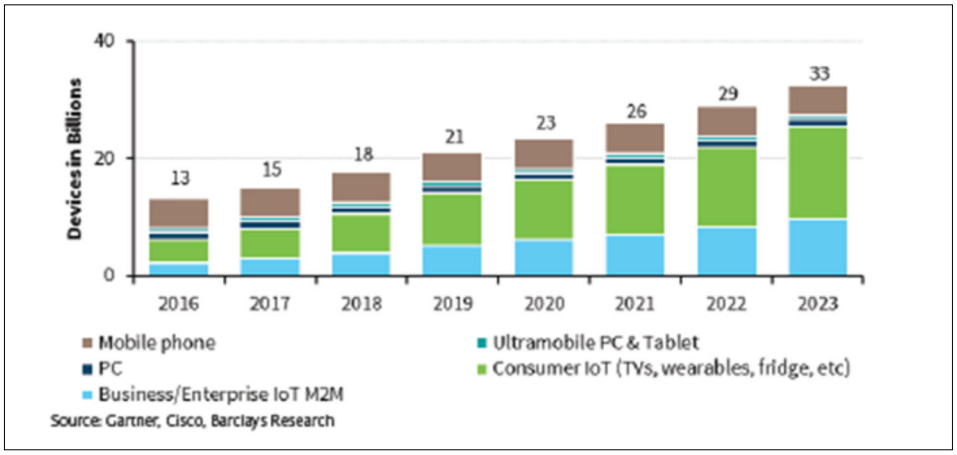
One interesting application is the role Edge Computing and 5G will play to further accelerate the growth of "Smart Cities." As we emerge from the challenges presented by COVID-19, escalating sustainability commitments and future urban growth will require ongoing infrastructure investment and innovation. In combination with Edge Computing, 5G is an essential ingredient because "Smart Cities" are only as good as their connectivity. 5G enables a new kind of network designed to connect virtually everyone and everything together including machines, object and devices. 5G wireless technology is meant to deliver higher multi-Gbps peak data speeds, ultra-low latency, more reliability, massive network capacity, increased availability and a more uniform user experience to more users.



Source: Barclays Research, UN, World Bank, McKinsey

Accessing the Investment Opportunity

Because we are still in the early stages of what is expected to be profound change to the industry, it is difficult to access the size of this market, which to date has generated little revenue. However, it is estimated that ~$20 Billion in opportunities will exist across hardware, software, power management and services that could be deployed "On the Edge" by 2023. This number will likely grow as more applications are developed to take advantage of Edge's ultra-low latency. The chart below shows the expected growth of connected devices, which will cause the amount of data generated to grow exponentially. More specifically, industry groups that are likely to be impacted by this move to decentralization include Communications Infrastructure, IT Hardware/Communications Equipment, Semiconductors, Telecom Services and Security Applications. Interestingly enough, hyper-scalers like Amazon, Facebook and Google recognize the issues centralized clouds present with regard to latency, reliability, and security. The likelihood they prohibit constant communication may require their adoption to a decentralized model.



The investment opportunities will likely be significant as the trend shifts away from the centralized nature of Cloud Computing to decentralized Edge Computing. This shift represents a disruptive innovation because it is "an innovation that creates a new market and value network and eventually disrupts an existing market and value network, displacing established market leading firms, products and alliances."*

*Source: Clayton M. Christensen and co-workers at Harvard Business School (1995)

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