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# Edge Computing:

## Everything You Need to Know

by Bharat Bhooshan Tyagi

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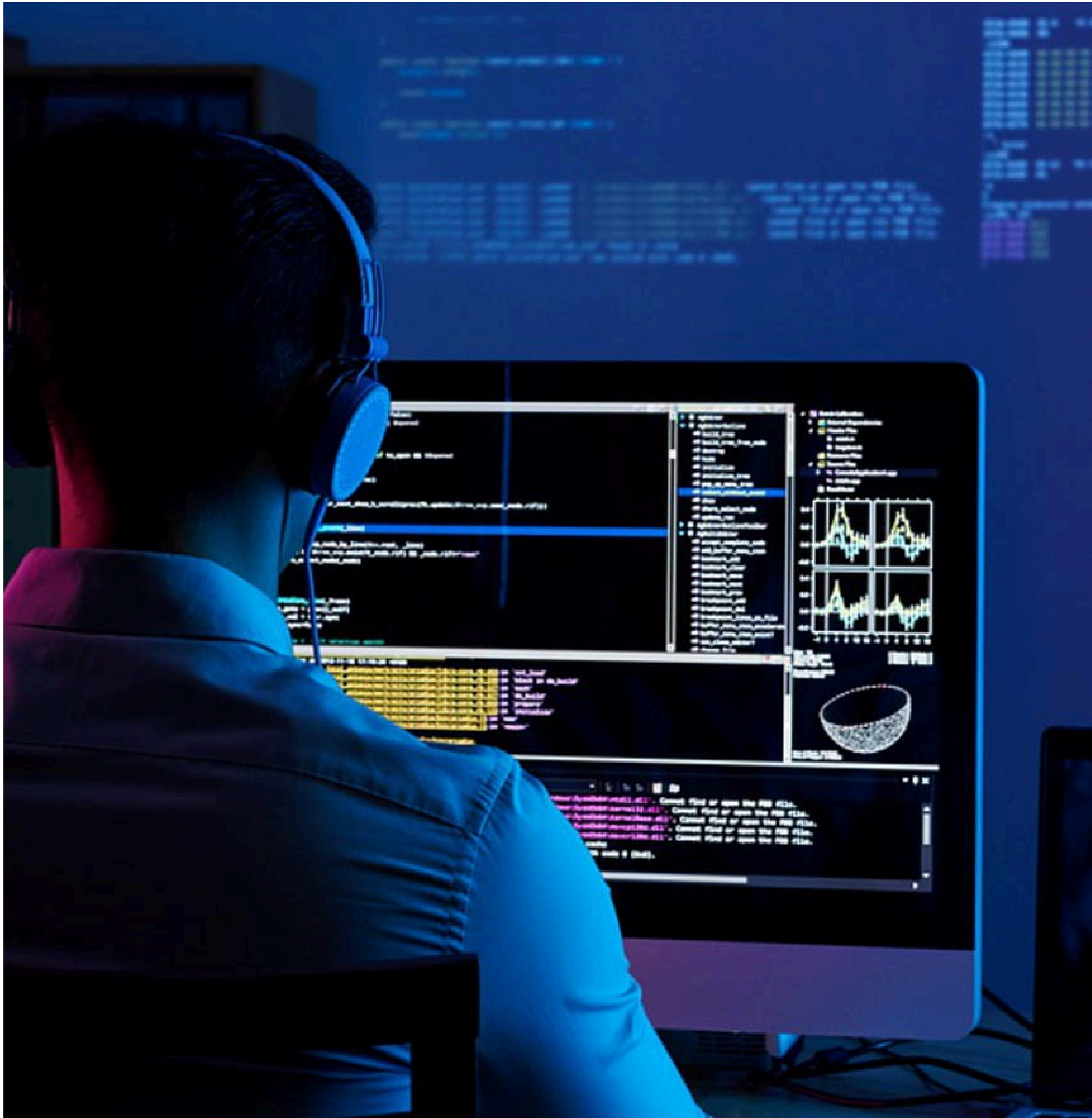
# What is Edge Computing?

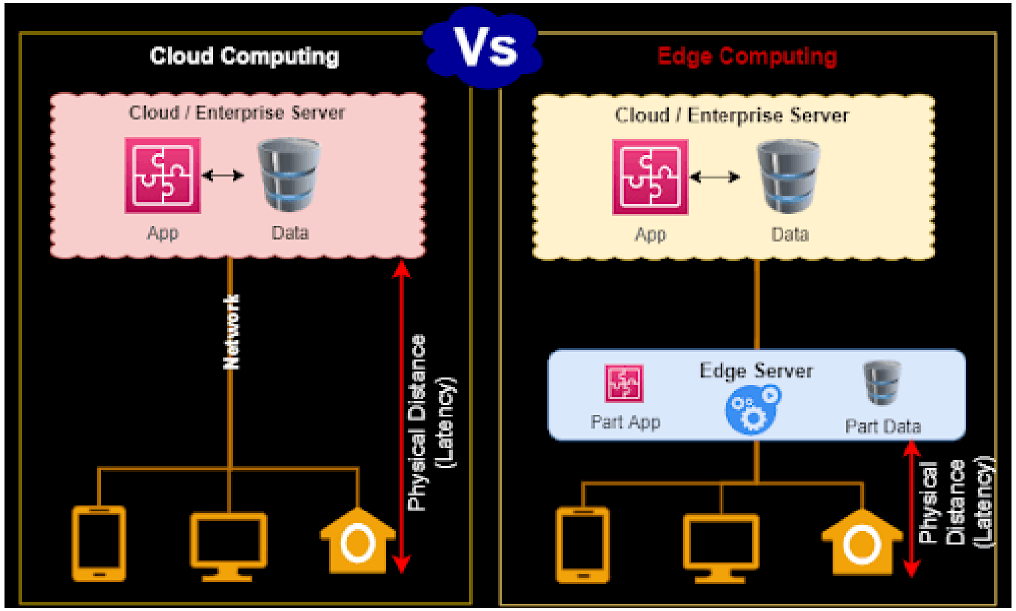
We live in a world where the volume of data produced is growing exponentially, and the need for faster processing or computation is increasing.



**Edge Computing** is a distributed computing paradigm focused on bringing computation close to the data source, yielding faster processing and higher quality insights while reducing latency and bandwidth.

Data is of the utmost importance for modern businesses; different analytics on data provide insights and help businesses decide on their strategies, investments, expansion plans, etc. IoT devices are generating an enormous amount of data, and at the current rate, world data is expected to grow 61% to 175 zettabytes by 2025.

Despite the advancements in network technology, the traditional computing paradigm cannot guarantee the processing, transfer rate, and response times critical to many businesses. Endlessly growing rivers of real-world data and networking challenges of latency, bandwidth limitations, and unpredictable network disruptions call for a new approach – and one is shaping up in edge computing.




Edge computing aims to **move or reduce computation responsibilities** away from centralized servers and leverage the computing and storage power of smart devices such as user computers, mobile phones, network gateways, edge servers, and a variety of IoT devices, etc. These lie on the network's edge, minimizing long-distance communication and providing real-time processing.

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# How Does Edge Computing Work?

The underlying principle of edge computing architecture is “Bring the storage and computation closer to the point where data is generated.”

In a traditional client-server architecture, data is generated at the client endpoint, such as the user's computer.

It travels through WAN, LAN, and ultimately reaches data centers where enterprise applications work upon it. Then, the results of the process are sent back to the client endpoint.

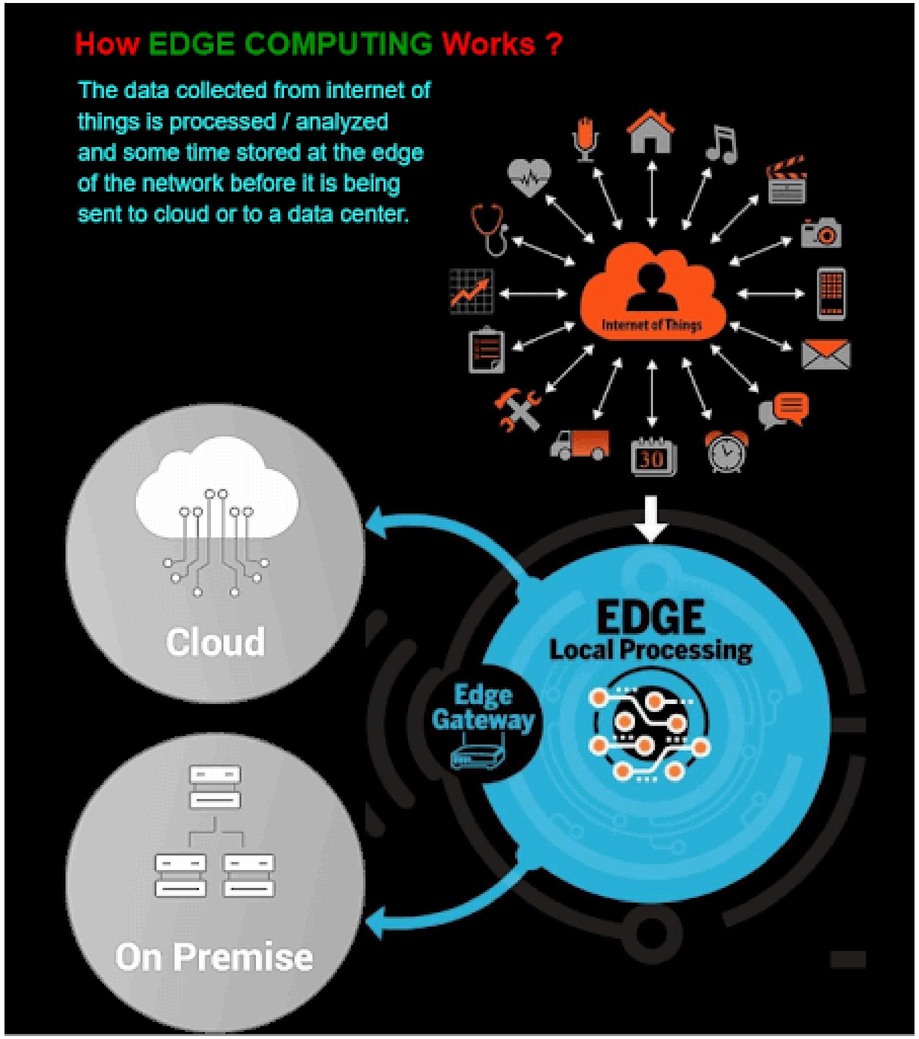
Though this is a tested and proven architecture, the traditional data center finds it difficult to accommodate the exceptional growth in data volume. According to Gartner's predictions, 75% of enterprise data will be generated outside centralized data centers by 2025.

Moving and handling this vast amount of data will put incredible pressure on the internet, which often suffers disruption and congestion even with the best network technology. The edge computing principle is simple: if you cannot take the data to the data center efficiently, bring the data center closer.

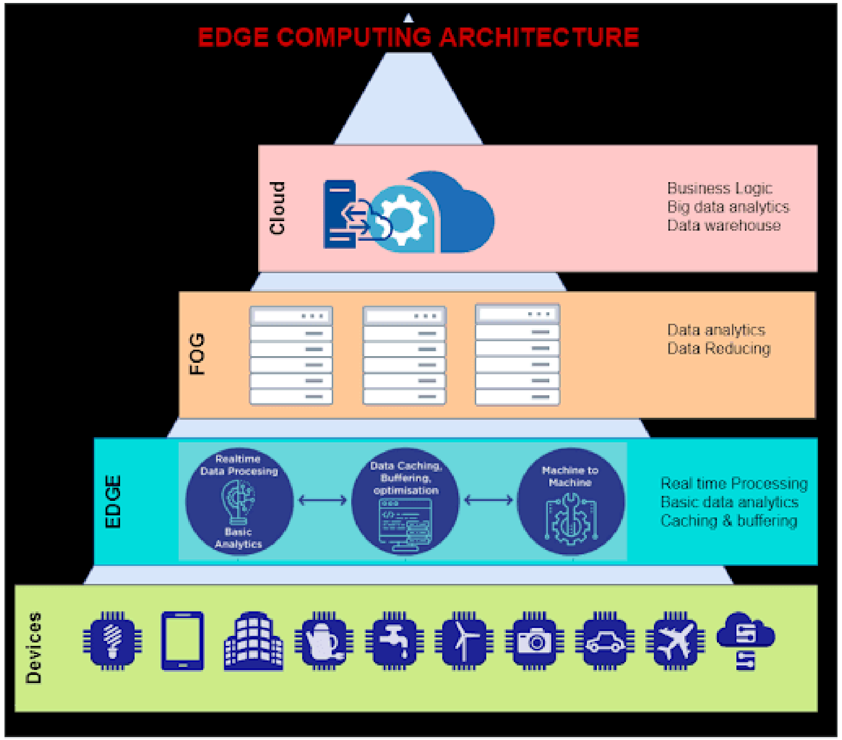
This architecture helps boost application performance by negating the chances of network latency and is also cost-efficient, leveraging local computation power.

Edge computing services and hardware equipment such as edge gateway and IoT sensors help solve issues with traditional client-server architecture by utilizing or providing local storage and computation.

The edge device may also include a user's computer, smartphone, security camera, and even internet-connected devices such as air conditioners, microwave ovens, etc.



# Edge Computing Architecture




Edge computing architecture can be visualized as a pyramid consisting of multiple layers with edge devices at the bottom.

## Edge Devices

The edge and IoT devices can collect data, run analytics, apply artificial intelligence rules to collected data, and even store some data locally. These edge devices can handle real-time decision-making and analysis without the involvement of the edge server or the enterprise server.

## Edge Server or Gateway

Responsible for monitoring and maintaining millions of devices and deploying or upgrading apps on these devices, the edge server remains connected with the devices.

It does so with the help of agents installed on each of these IoT devices. If a device doesn't have enough analysis capabilities, then the device sends data to the edge server for further analysis.

## Fog Computing Layer

This bridge between the edge and the cloud usually has more processing power than the edge servers. This layer has IoT gateways or fog nodes that generally execute additional filtering and analysis.

There is no strict rule to have this layer; it is optional, and many edge systems can be set up without the Fog layer.

## Cloud Computing Layer

This layer is responsible for accumulating data received from all edge devices and fog nodes and storing it in data warehouses. This layer has ultimate processing capabilities and runs Big Data analytics.

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# Edge Computing Use Cases

Explore real-world examples.

Conceptually, edge computing targets data collection, filtering, massaging, processing, and analysis at the closest location to where it is needed, i.e., at the network edge. Collecting and moving huge amounts of data to a centralized location may not be technically feasible or cost-effective or may otherwise violate standard data compliances such as GDPR or data sovereignty.

Edge computing also brings hardware and software solutions and networking architecture together to address the vast number of use cases pursued across several industry verticals. Here are a few examples.

## Industrial Manufacturing

The combined power of IoT, edge computing, and machine learning have taken industrial manufacturing to the next level. Computation and data storage enable real-time analytics and machine learning at the edge, allowing for predictive maintenance, energy efficiency, cost reduction, reliability, productive uptime, etc.

## Autonomous Transportation

Autonomous/driverless vehicles produce and consume around 5-12 TB of data daily. To operate safely, these vehicles gather massive data about location, weather conditions, vehicle conditions, road conditions, directions, traffic, etc. This data must be collected, aggregated, and analyzed at runtime. Any minor lag in processing could lead to a severe outcome; hence it needs robust computation and data storage onboard, making the vehicle in motion an "edge."

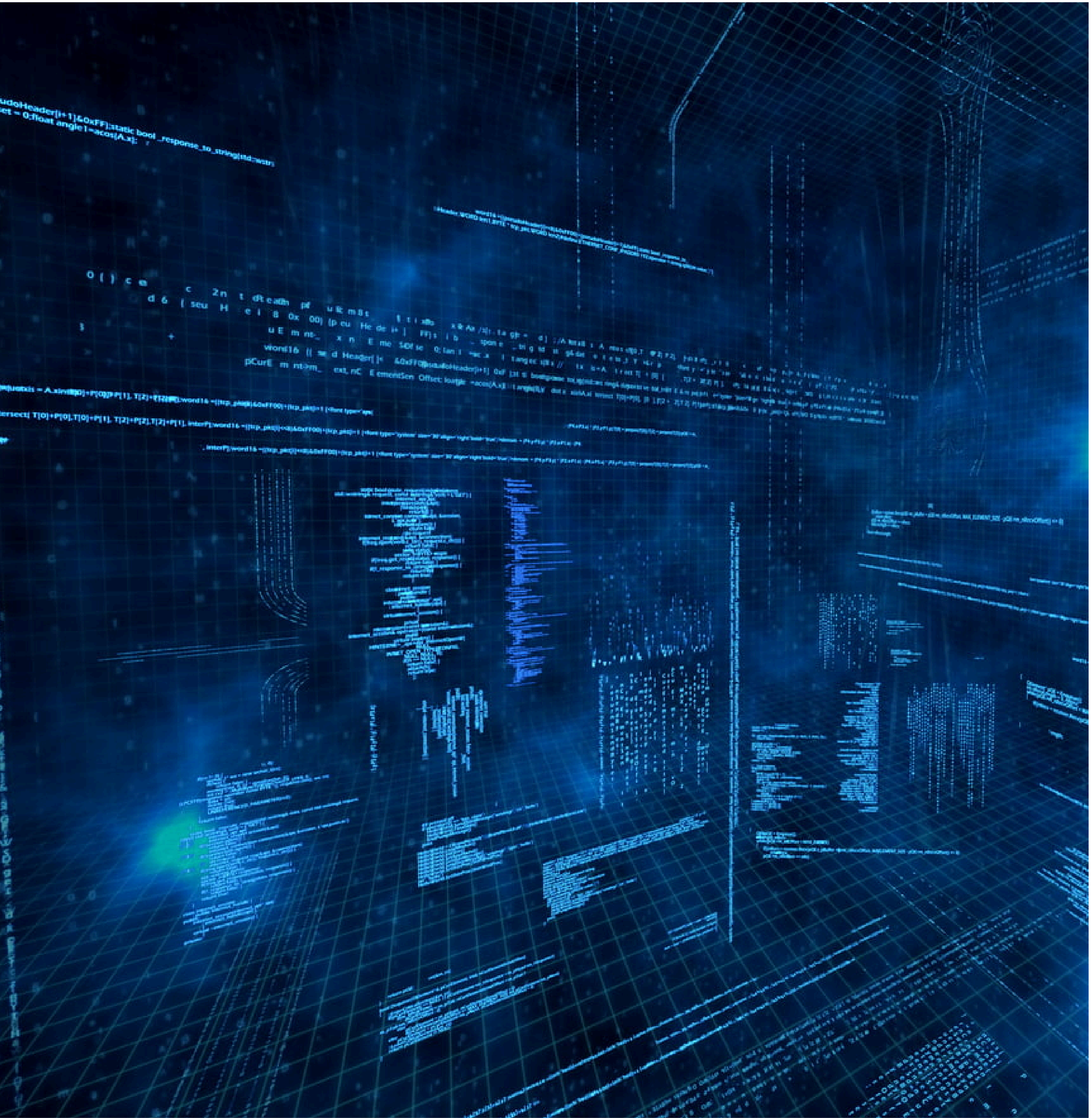
With edge computing architecture, autonomous vehicles can collect, analyze, and share details among vehicles and networks in real time with no latency. These vehicles can leverage the network of geographically positioned edge data centers to relay critical data to auto manufacturers and businesses, helping improve vehicle management.

## Healthcare

The enormous volume of patient data collected through various medical equipment, sensors, etc. requires real-time processing and analysis to identify critical diseases which may need immediate intervention to help patients avoid health incidents. Edge computing is helping healthcare by applying automation and machine learning to access the data, ignoring "normal" data, and identifying problems in real-time.

## Smart Cities

Smart urban locations heavily rely on automated systems utilizing IoT, sensors, etc. to collect a wealth of data on traffic, weather, roads, utility usages, and many more critical infrastructure data daily. The collected information must be stored and processed before it can be used for predictive, immediate, or deferred actions. Citing the magnitude of devices, network constraints, etc., traditional cloud-based solutions may fail to provide immediate processing and response hence making room for edge computing.

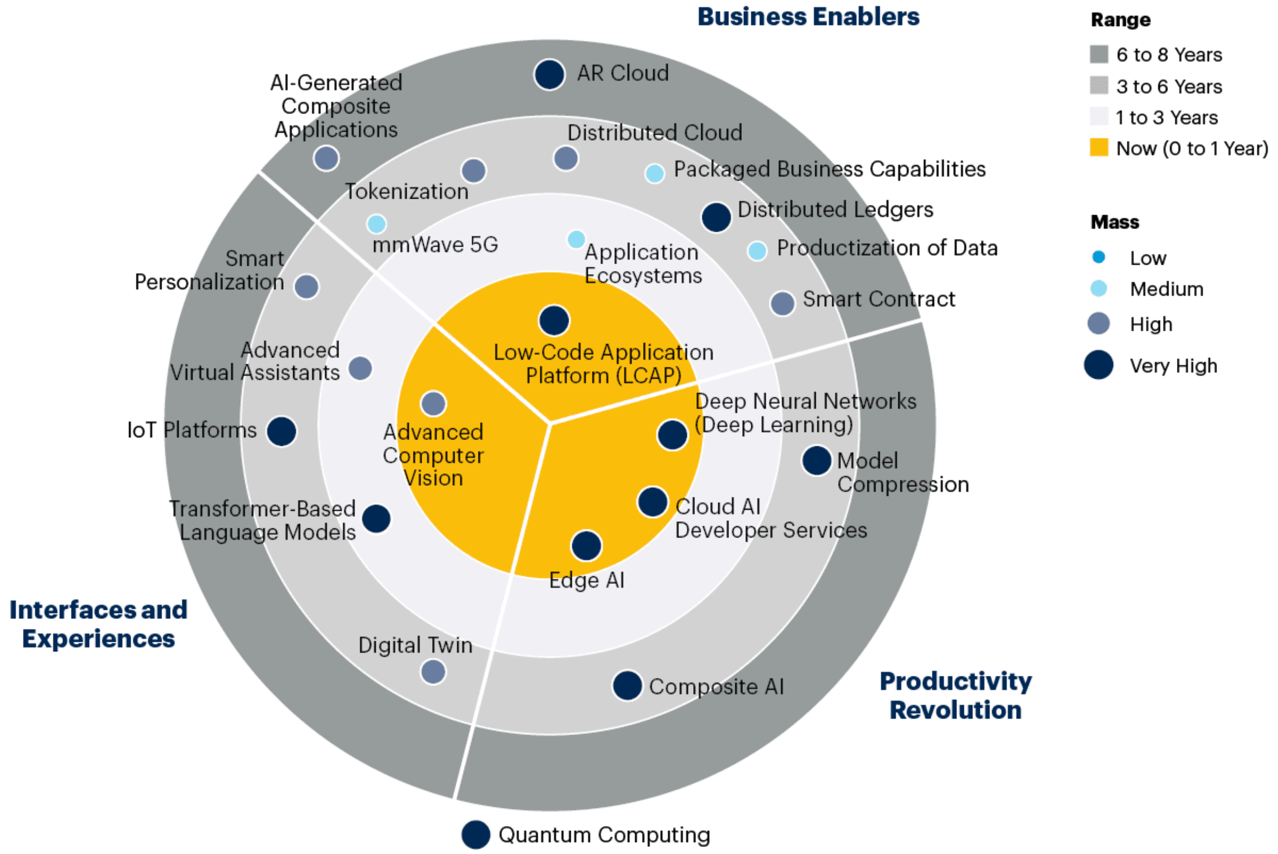


# The Future of Edge Computing

With several advantages over traditional network architecture, edge computing will continue to emerge as a highly focused technology along with IoT.

It will continue to play an important role in an organization's business with growing IoT devices hitting the global market daily. To date, only a fraction of edge computing's capabilities has been realized.
*Image source: Gartner*

## Emerging Technologies and Trends Impact Radar




Source: Gartner

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# Edge Computing Adoption & Market Growth

Edge technology is quite new and complex, requiring research, infrastructure, connectivity, and management. It is in the early stage of development; maturity at implementation and operations haven't been achieved so far. Only 27% have adopted this technology, but many are looking forward to the edge growth opportunities offered soon.

The global edge computing market is expected to grow at a compound annual growth rate of 19%, from USD 36.5 billion in 2021 to USD 87.3 billion by 2026.

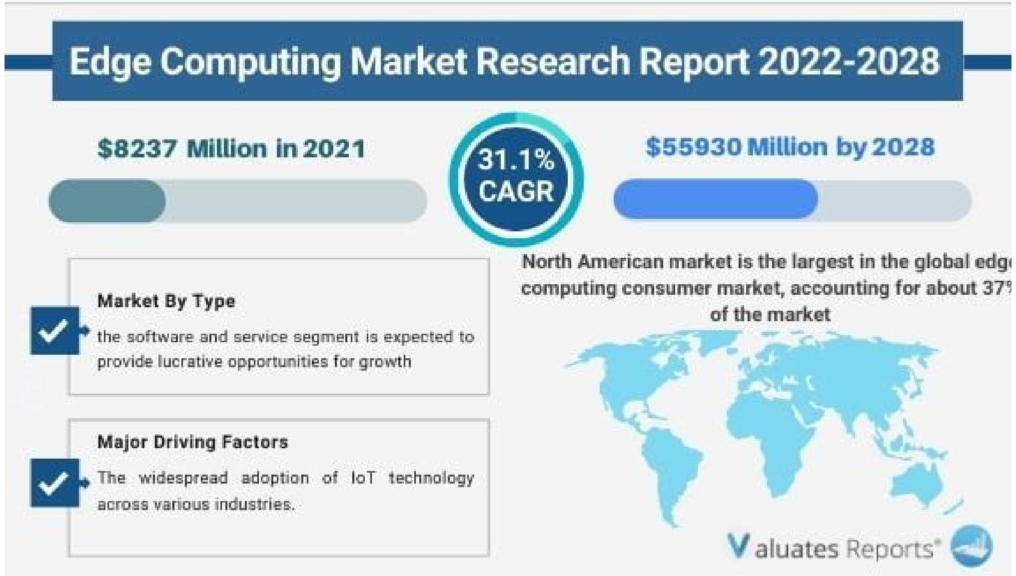


*Image source: Valuates Reports*

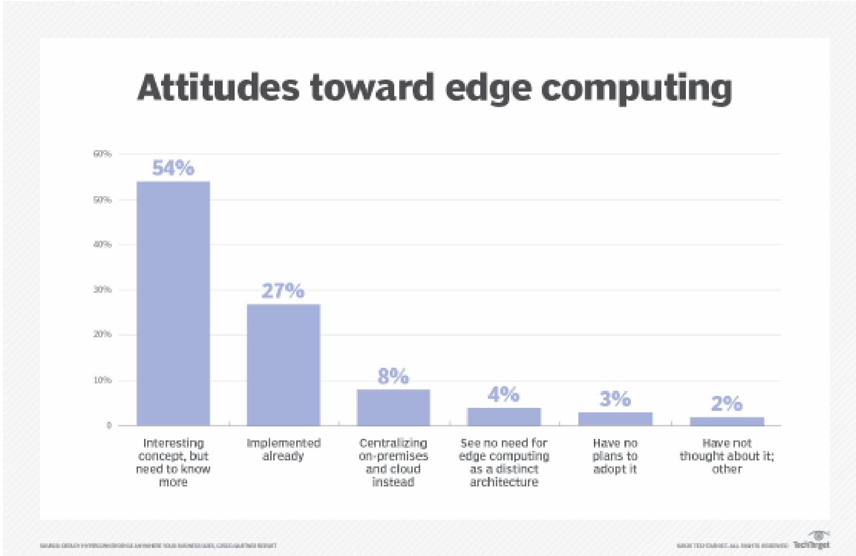


*Image source: TechTarget.com*

Growth in IoT devices, large-scale investments, rising demand for latency connectivity, and increasing use of BYOD in modern business practices have given the necessary boost to this sector. The APAC region, being home to many SMEs, has been a major contributor to edge computing growth. The emerging market of autonomous vehicles and lightweight edge computing frameworks is projected to grow exponentially in the edge computing sector.

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# Edge Computing Benefits

Edge computing addresses infrastructure challenges such as network reliability, latency, congestion, or bandwidth limitations, but many additional benefits make it more appealing.

## Fast Response

Fast processing and results are key to some businesses, such as autonomous vehicles, high-frequency trading, or the healthcare industry, where minor delays could result in expensive consequences.

Even with the latest network technology, such as fiber optic, which allows data to travel at 2/3 the speed of light, enormous data volumes lead to traffic congestion and latency.

Edge computing increases network performance by reducing latency as data is not required to travel the long distances inherent to a traditional client-server architecture.

Since minimal latency or downtime may cost thousands of dollars, gains in speed with edge computing are impactful.

## Reliability

With the availability of IoT edge computing devices and edge data centers closer to data generation, dependency on continuously strong networks and bandwidth has been dramatically reduced.

Reliability is improved, especially where internet connectivity or bandwidth is limited or unreliable, for example, on oil rigs, ships, or in rainforests and deserts.

With a great network of edge computing devices and edge data centers, there is no single point of failure, negating the chances of complete service failure.

As a result, reliability is improved, especially when internet connectivity or bandwidth is limited or unreliable, for example, on oil rigs, ships, rainforests, and deserts.

## Compliance

Many different compliance laws across the world apply to data security and sovereignty. Transmitting data across regions, countries, and continents may fall under different legalities, which could be an additional problem than transmitting large volumes of data across WAN and LAN.
One such example is the European Union's GDPR, which defines the guidelines for data storage, processing and exposing the data, etc.

By leveraging edge computing architecture, the data can be processed locally, and any sensitive information could be filtered out before transmission, complying with local laws.

## Cost Effective

Transmitting, processing, storing, managing, and securing large volumes of data is not cheap.

Data generated by IoT devices may not be critical to the operation. They can be filtered out at/or near the source before moving to centralized data centers, resulting in excellent cost cutting on bandwidth use.
In this way, edge computing helps to optimize the data flow, reduce redundancy costs, and maximize the organization's profit.

## Security

Despite the increased attack network surface (because of the number of IoT edge devices), edge computing provides some important security advantages.

Because of their "centralized processing" nature, traditional architectures have been vulnerable to DDoS (Distributed Denial of Service) attacks and power outages.

However, edge computing minimizes the chances of disruption and network outage by distributing computation, storage, and applications across a wide range of data centers and edge devices.

An IoT edge device could also become an entry point for an attack. Still, it can easily be identified and secured by implementing security measures in the affected area without taking down the entire network.

Since a lower volume of filtered data is transmitted to the centralized server because of local data storage and processing, the risk of data interruption reduces greatly.

Even if a device is compromised, only data available to that device is exposed for attack rather than the entire centralized server.

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# Edge Computing Adoption Challenges

Edge computing is multiplying in all sectors, including industrial and commercial. There are many use cases, but as operations become more geographically distributed, organizations face various roadblocks on the path to full-scale adoption of edge computing. Most IoT projects fail because of various challenges, which can broadly be categorized as follows:

### Standards & Benchmarking

• No defined industry standards for legal, social, and ethical aspects of using edge intelligence.
• Immature benchmarking tools and practices require deep research.

### IT Infrastructure

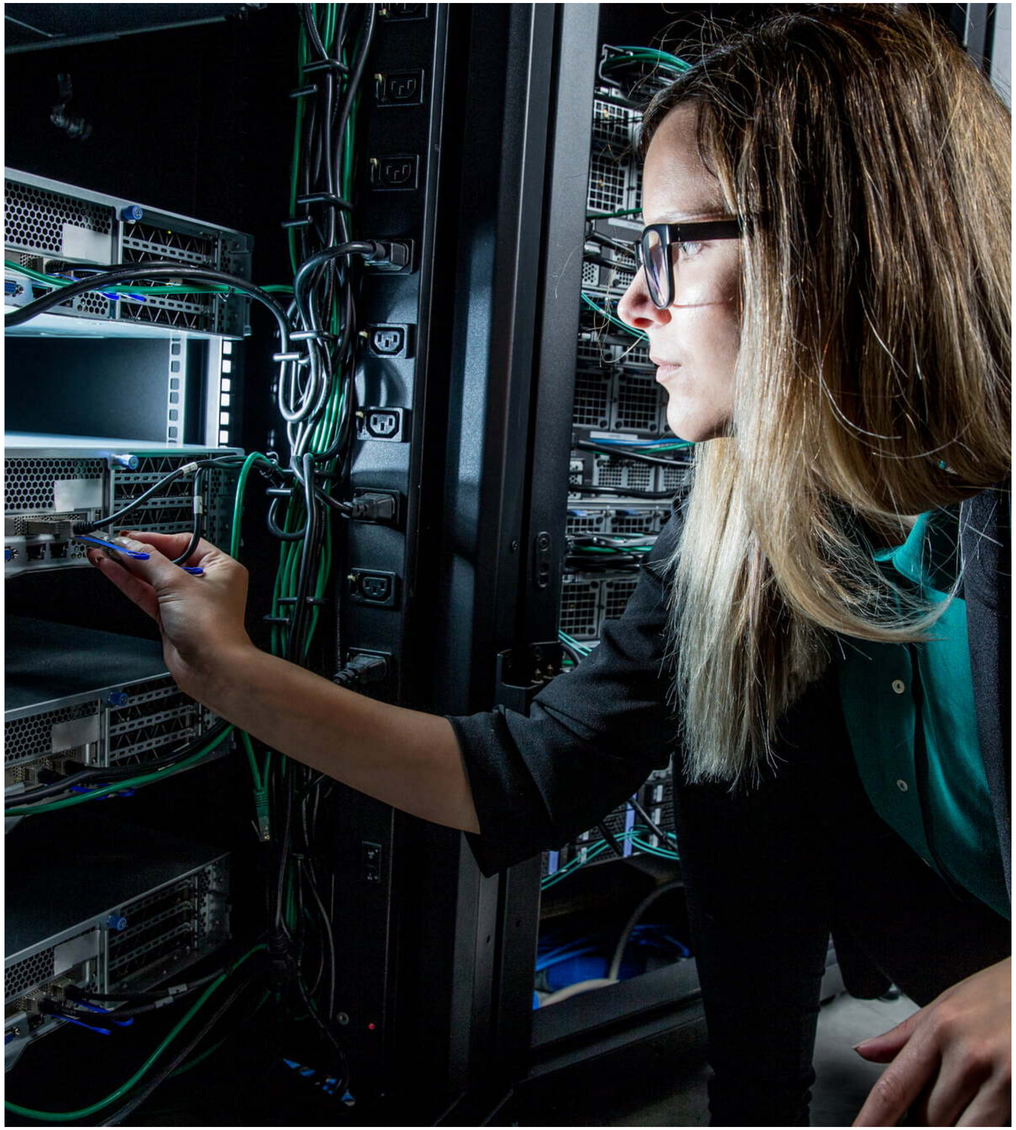
• A mix of legacy and modern solution makes cause integration challenges.
• Information security constraints with the latest technology.

### Security & Privacy

• Multitudes of harmful industrial environments affect the usage of mobile devices.
• Lack of comprehensive, secure data flow from edge to core network.

### Software Frameworks

• Lack of standard software framework and toolkits for edge intelligence workflows.
• Hetrogeneity or hardware and platform, and resources in the workflow.



## Undiscovered Security Threats

Many IoT devices collecting sensitive information, including personal, health, and financial data, are not designed with security. The primary focuses of the manufacturer are typically ease of use, low cost, and speedy deployment.

***However, security comes at the cost of all three, making IoT devices the weakest link and providing an easy-to-exploit attack surface.***

There is a need for a standard security framework as a precondition for large-scale edge computing projects. Managing the security of a centralized or cloud data center is far easier than managing the security of thousands of remote and sometimes less accessible edge locations.

## Scale

In an edge computing network, scaling is not simply adding more servers. It requires increasing all sectors, including computation, network, bandwidth, storage, security, licensing, etc.

## Data Accumulation

While collecting, processing, and storing data at the edge brings a lot of advantages to the business, it also presents new challenges and liabilities.
Growing needs for data storage, computation, and – most importantly – handling of data per defined rules is difficult to manage.

An edge network with millions of connections needs a robust system to handle and accumulate data correctly.

## Heterogeneity

A variety of deployment environments, software, hardware, etc. creates fragmented visualization. Managing an edge network requires more skills, resources, and resolution time as each new custom edge location adds complexity to the system.

Monitoring, managing, viewing, and processing data from multiple edge sources to provide holistic management without creating equipment or domain silos present new technological challenges.

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# References & About the Author

## About the Author

Bharat Bhooshan Tyagi is a software solution architect, designer, and developer with special interests in cloud computing, robotics, and machine learning. Bharat has more than 16 years of experience in software development in different domains including healthcare, finance, and security.

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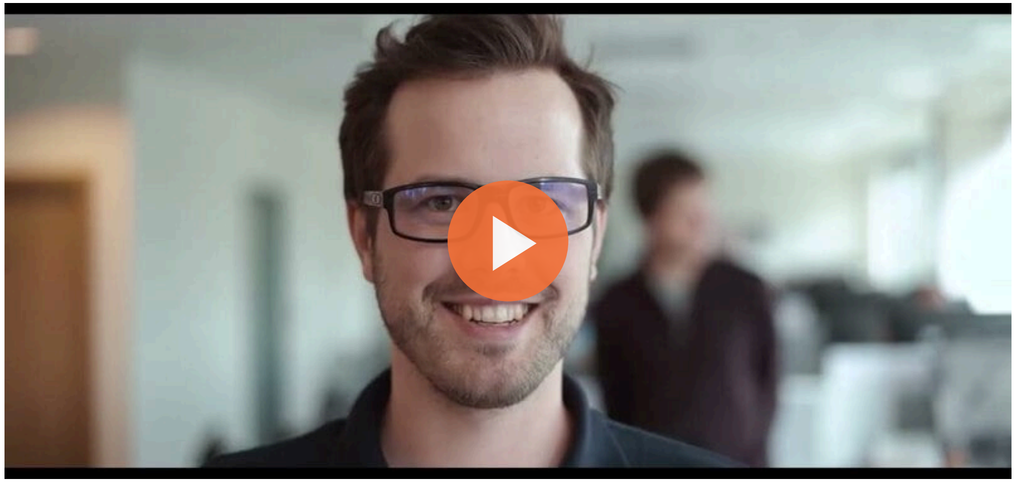

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