




## What you need to know before implementing edge computing

These are the questions your firm should ask before going down the route of edge analytics and processing.



By [Nick Heath](#) | October 1, 2018 -- 15:02 GMT (08:02 PDT) | Topic: [From Cloud to Edge: The Next IT Transformation](#)

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Increasing numbers of organizations are gathering and analysing data at the edge of their networks in their quest to improve day-to-day operations.

Whether it's for [predictive maintenance on lifts](#)

(<https://www.zdnet.com/article/keeping-the-worlds-elevators-running-smoothly-with-machine-learning-and-iot/>) and [aircraft](#)

(<https://www.zdnet.com/article/heres-how-boeing-is-partnering-with-microsoft-on-its-cloud-data-platform/>), or analysing data collected to keep oil rigs running smoothly, companies are using using low-powered edge devices to collect huge volumes of data.

This data was typically sent to a central data centre for analysis, but as the volume of data collected at the edge has increased, so has

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However, deploying devices to the edge of a network can pose some unique challenges for businesses.

## Why you might want to engage in edge computing

The reasons for shifting data processing and analytics to the edge of your network go beyond resolving issues of insufficient bandwidth or limited connectivity, according to [Bob Gill](#)

(<https://www.gartner.com/analyst/42807/Bob-Gill>), research VP and agenda manager in Gartner's infrastructure strategies group.

He points out that companies should consider an edge-computing setup where there is a need for devices to act upon data in real time or near-real time, so the time taken to send that data to the cloud for processing would be an issue.

"Let's say there are a whole series of traffic lights in a city, with edge computing one of the things we can do is actually provide intelligence between devices, so they can communicate between themselves without having to talk to a central locale," he says, highlighting the edge analytics carried out by the company [Swim](#) (<https://www.swim.ai/>) as an example.



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to [James Staten](https://www.forrester.com/James-Staten) (<https://www.forrester.com/James-Staten>), vice-president serving CIOs at analyst Forrester.

"While many companies think that edge analysis in the device itself is good enough, in most cases, no, it isn't," he says. "For example, in cars today with all their sensor data, to guide drivers and future autonomous cars, you must aggregate data coming from more than just the one car."

"This is best accomplished via an edge compute device deployed in proximity to where the cars are running (in each metro and in multiple metro locations optimally), so that analysis of data about the experience multiple cars are facing can be combined with weather, maps and other cloud-based data repositories," says Staten, adding that Dell, HPE, Saguna and IBM offer suitable machines for carrying out this sort of analysis near to the edge.

Conducting analysis close to where data is gathered can also be necessary to comply with strict rules on where data is processed -- to comply with data sovereignty stipulations under the [European General Data Protection Regulation](https://www.zdnet.com/article/gdpr-an-executive-guide-to-what-you-need-to-know/) (<https://www.zdnet.com/article/gdpr-an-executive-guide-to-what-you-need-to-know/>), for example.

**SEE: IT pro's guide to GDPR compliance** (<https://www.techrepublic.com/resource-library/whitepapers/it-pro-s-guide-to-gdpr-readiness/>) **(free PDF)**

## Factors to consider before embarking on an edge computing project

- **How secure are your edge devices?**

Gartner's Gill highlights the problems with many edge devices running insecure software platforms that are unpatched against known exploits, citing the ease with which CCTV cameras were hijacked by [Mirai](https://www.zdnet.com/article/mirai-botnet-adds-three-new-attacks-to-target-iot-devices/) (<https://www.zdnet.com/article/mirai-botnet-adds-three-new-attacks-to-target-iot-devices/>) malware as just one example.

"There are a lot of devices out there that have pretty marginal security, and if what we're talking about is building a critical application that relies on thousands or even millions of devices, we've got to ensure some kind of end-to-end security all the way back into the core," he says.

"This brings up fascinating questions when dealing with edge device manufacturers about 'How do we gauge the extent to which their security meets our enterprise security? How do we gauge how it fits in with our overall identity and access management scheme?'," Gill adds.

[Eric van Hensbergen](https://about.me/ericvh) (<https://about.me/ericvh>), who leads the software and large-scale systems research at chip designer Arm, says: "Historically at the extreme edge there's tonnes of gadgets that you buy that are a couple of bucks and the companies that are making these don't put an investment into security."

He expects the situation to improve, and says that Arm is trying to build a certain level of integrity into devices running on Arm-based processors.

- **Should you let a hyperscale cloud provider take care of security and maintenance?**

One such example is Microsoft's [Azure Sphere](https://www.techrepublic.com/article/microsoft-says-its-new-linux-based-os-will-secure-iot-devices-for-a-decade/) (<https://www.techrepublic.com/article/microsoft-says-its-new-linux-based-os-will-secure-iot-devices-for-a-decade/>), which aims to secure connected microcontrollers -- of which there are 9 billion shipping every year -- at both the board level and network level.

Azure Sphere has three components. The first is customised microcontroller units for IoT devices, which are authenticated using certificates encoded in on-board chips.

The second component is the Azure Sphere OS, which runs on the IoT devices and helps secure and authenticate the hardware, and which is based on a custom version of the Linux kernel.

The third is the Azure Sphere Security Service, a cloud-based offering that keeps devices patched with the latest security updates and detects threats to these connected devices for 10 years after their rollout.

**SEE: [Cybersecurity in an IoT and mobile world](https://www.zdnet.com/topic/cybersecurity-in-an-iot-and-mobile-world/)** (<https://www.zdnet.com/topic/cybersecurity-in-an-iot-and-mobile-world/>) **(ZDNet special report)** | **[Download the report as a PDF](http://www.techrepublic.com/resource-library/whitepapers/special-report-cybersecurity-in-an-iot-and-mobile-world-free-pdf/)** (<http://www.techrepublic.com/resource-library/whitepapers/special-report-cybersecurity-in-an-iot-and-mobile-world-free-pdf/>) **(TechRepublic)**

Amazon offers similar services via AWS IoT Core and AWS Greengrass, and Gartner's Gill says this route is a viable option for firms considering an edge deployment.

"This points to the advantage of perhaps using a hyperscale cloud provider and their whole cloud-to-edge portfolio," he says.

Both firms are also offering [digital twin](https://en.wikipedia.org/wiki/Digital_twin) ([https://en.wikipedia.org/wiki/Digital\\_twin](https://en.wikipedia.org/wiki/Digital_twin)) systems, which [allow firms to model the relationship between edge devices and a physical space](https://www.zdnet.com/article/microsoft-readies-previews-of-azure-digital-twins-azure-sphere-secure-edge-service/) (<https://www.zdnet.com/article/microsoft-readies-previews-of-azure-digital-twins-azure-sphere-secure-edge-service/>).

- **Don't forget about physical security**

Unlike the multiple layers of physical security in a data centre, edge devices will often be in public spaces or other locations that are difficult to secure, points out Arm's van Hensbergen, so firms will need to factor how they will factor that insecurity into their plans.

"There's a number of really important considerations, particularly security, that they just have to get right or there will be problems," he says.

- **Consider if any analytics should be carried out centrally**

Although the term 'edge computing' suggests a certain amount of data processing will take place at the edge of the network, there may still be benefits in handling some analysis centrally, particularly where it requires a level of computing power that's not available locally.

which also send data back to Google's cloud platform for use in training more accurate machine-learning models.

- **Minimise maintenance**

The remote nature and long lifespan of many edge devices means that firms are going to want devices and supporting infrastructure to be robust enough to minimise hands-on maintenance, says Gartner's Gill.

"As much as possible we're trying to make these devices have a greater longevity," he says, adding many edge device manufacturers are working towards five to 10-year lifecycles.

The key is engineering systems that can be secured and receive new features via software, rather than hardware updates, he says.

"When we start getting into the billions of devices, the task of managing all those becomes a mess," he says.

"That's exactly one of the things that Microsoft was pushing with the whole Azure Sphere concept...we could do system updates on devices like we do with Windows Update."

- **Be ready to set up an edge computing centre of expertise**

Due to the nature of edge devices, staff with the relevant expertise to manage the devices' deployment are likely to be spread across different operations, line-of-business and IT departments, according to Gartner's Gill.

For this reason he recommends the management of edge deployments be handled by a "centre of excellence", composed of staff from across the organization with the relevant expertise.

"It mirrors the shift from IT to the business unit with cloud deployment," Gill says.

"We have the same thing here when it comes to who owns the devices at the edge, when it comes to things like maintenance and ownership of the data, that has to be specified and agreed to."

- **Ensure a degree of compatibility between different edge deployments**

Although it makes sense to trial a number of different technology platforms when piloting edge-computing deployments, you also want to ensure a level of compatibility and interoperability between these deployments in different parts of the business once they go live, says Gartner's Gill.

"Within a retail organization do you really want four completely independent trials that don't speak to each other, using different types of technology?" he asks.

## RECENT AND RELATED COVERAGE

### Juniper unveils Contrail Edge Cloud for managing services at the edge

(<https://www.zdnet.com/article/juniper-unveils-contrail-edge-cloud-for-managing-services-at-the-edge/>)

The new orchestration product is designed to address the physical and power constraints of the network edge.

### Where's the 'edge' in edge computing? Why it matters, and how we use it

(<https://www.zdnet.com/article/where-the-edge-is-in-edge-computing-why-it-matters-and-how-we-use-it/>)

Just as cloud computing seemed to be settling down into a standardized set of platforms, the drive for service differentiation results in new use cases for a faster, more flexible premium service tier. But will those use cases make sense in practice?

### VMware looking towards IoT and the edge (<https://www.zdnet.com/article/vmware-looking-towards-iot-and-the-edge/>)

As the world of edge computing and IoT becomes more distributed, billions of connected devices require increasing levels of compute at the edge. This needs to be secured, managed, and automated, and VMware wants to look after that on behalf of the enterprise.

### Microsoft Azure gets new tools for edge computing and machine learning

(<https://www.techrepublic.com/article/microsoft-azure-gets-new-tools-for-edge-computing-and-machine-learning/>)

(TechRepublic)

Announced at the Microsoft Ignite conference today, these new features are designed to streamline the collection, processing and analysis of large volumes of data.

### Dell's new IoT surveillance solution prepping for 'holy grail' of edge computing

(<https://www.zdnet.com/article/dells-new-iot-surveillance-solution-prepping-for-holy-grail-of-edge-computing/>)

The first release of its computer vision play, the surveillance appliance is the beginning of Dell Technologies' push for an open approach to IoT and edge computing.

### Volkswagen and Google get in to quantum computing together

(<https://www.cnet.com/roadshow/pictures/volkswagen-and-google-get-into-quantum-computing-together/>) (CNET)

The two goliaths will use cutting-edge computing power to research traffic flow, EV batteries and artificial intelligence.

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## Edge computing: The state of the next IT transformation

The combination of billions of IoT devices and 5G networks is set to drive a profound change in the way computing workloads are deployed.



By [Charles McLellan](#) | October 1, 2018 -- 15:05 GMT (08:05 PDT) | Topic: [From Cloud to Edge: The Next IT Transformation](#)







Image: metamorworks, Getty Images/iStockphoto

In recent years, computing workloads have been migrating: first from on-premises data centres to the cloud and now, increasingly, from cloud data centres to 'edge' locations where they are nearer the source of the data being processed. The goal? To boost the performance and reliability of apps and services, and reduce cost of running them, by shortening the distance data has to travel, thereby mitigating bandwidth and latency issues.

That's not to say that on-premises or cloud centres are dead -- some data will always need to be stored and processed in centralised locations. But digital infrastructures are certainly changing. According to [Gartner](https://www.gartner.com/doc/reprints?id=1-4WDVFD0&ct=180417&st=sb) (<https://www.gartner.com/doc/reprints?id=1-4WDVFD0&ct=180417&st=sb>), for example, 80 percent of enterprises will have shut down their traditional data centre by 2025, versus 10 percent in 2018. Workload placement, which is driven by a variety of business needs, is the key driver of this infrastructure evolution, says the analyst firm:

With the recent increase in business-driven IT initiatives, often outside of the traditional IT budget, there has been a rapid growth in implementations of IoT solutions, edge compute environments and 'non-traditional' IT. There has also been an increased focus on customer experience with outward-facing applications, and on the direct impact of

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This ebook, based on the latest ZDNet / TechRepublic special



placement of certain applications based on network latency, customer population clusters and geopolitical limitations (for example, the EU's General Data Protection Regulation [GDPR] or regulatory restrictions).

capabilities.

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There are challenges involved in edge computing, of course -- notably centering around connectivity, which can be intermittent, or characterised by low bandwidth and/or high latency at the network edge. That poses a problem if large numbers of smart edge devices are running software -- machine learning apps, for example -- that needs to communicate with central cloud servers, or nodes in the intervening 'fog'. Solutions are on the way, however.

With edge computing sitting at the peak of Gartner's 2018 [Hype Cycle for Cloud Computing](https://www.gartner.com/doc/3884671/hype-cycle-cloud-computing-) (<https://www.gartner.com/doc/3884671/hype-cycle-cloud-computing->), there's plenty of scope for false starts and disillusionment before standards and best practices are settled upon, and mainstream adoption can proceed. This introduction to ZDNet's special report looks to set the scene and assess the current state of play.

## Definitions

Edge computing is a relatively new concept that has already been associated with another term, 'fog computing', which can lead to confusion among non-specialist observers. Here are some definitions that will hopefully clarify the situation.

*Futurum Research* (<https://futurumresearch.com/edge-computing-from-edge-to-enterprise/>)

Unlike Cloud Computing, which depends on data centers and communication bandwidth to process and analyze data, Edge Computing keeps processing and analysis near the edge of a network, where the data was initially collected. Edge Computing (a category of Fog Computing that focuses on processing and analysis at the network node level)...should be viewed as a de facto element of Fog Computing.

*State of the Edge 2018* (<https://www.stateoftheedge.com/>)

The delivery of computing capabilities to the logical extremes of a network in order to improve the performance, operating cost and reliability of applications and services. By shortening the distance between devices and the cloud resources that serve them, and also reducing network hops, edge computing mitigates the latency and bandwidth constraints of today's Internet, ushering in new classes of applications. In practical terms, this means distributing new resources and software stacks along the path between today's centralized data centers and the increasingly large number of devices in the field, concentrated, in particular, but not exclusively, in close proximity to the last mile network, on both the infrastructure and device sides.

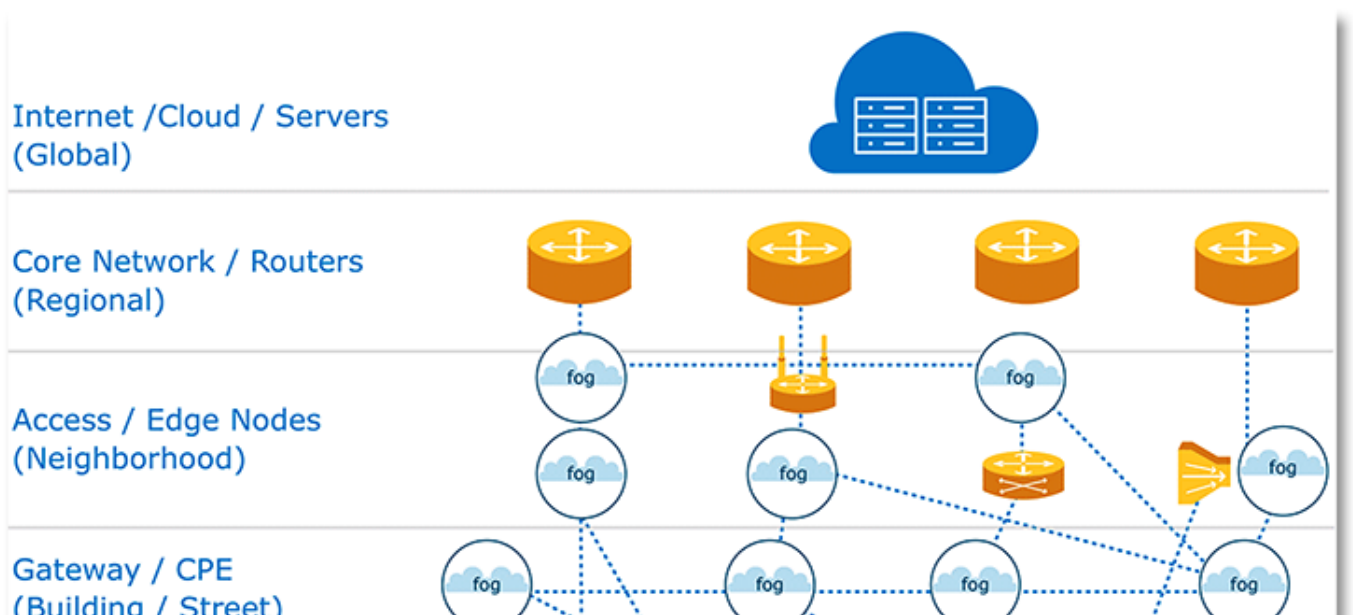
[Fog] begins on one 'end' with edge devices (in this context, we define edge devices as those devices where sensor data originates, such as vehicles, manufacturing equipment and 'smart' medical devices) that have the requisite compute hardware, operating system, application software and connectivity to participate in the distributed analytics Fog. It extends from the edge to 'near edge' functions, such as local datacenters and other compute assets, multi-access-edge (MEC) capabilities within an enterprise or operator radio access network, intermediate computing and storage capabilities within hosting service providers, interconnects and colocation facilities, and ultimately to cloud service providers. These locations have integrated or host 'Fog nodes', which are devices capable of participating in the overall distributed analytics system.

*David Linthicum (Chief Cloud Strategy Officer at Deloitte Consulting)*

(<https://www.cisco.com/c/en/us/solutions/enterprise-networks/edge-computing.html>)

"With edge, compute and storage systems reside at the edge as well, as close as possible to the component, device, application or human that produces the data being processed. The purpose is to remove processing latency, because the data needn't be sent from the edge of the network to a central processing system, then back to the edge...Fog computing, a term created by Cisco, also refers to extending computing to the edge of the network. Cisco introduced its fog computing in January 2014 as a way to bring cloud computing capabilities to the edge of the network...In essence, fog is the standard, and edge is the concept. Fog enables repeatable structure in the edge computing concept, so enterprises can push compute out of centralized systems or clouds for better and more scalable performance."

Here's how the [OpenFog Consortium](https://www.openfogconsortium.org/) (<https://www.openfogconsortium.org/>) visualises the relationship between data-generating 'things' at the network edge, cloud data centres at the core, and the fog infrastructure in between:



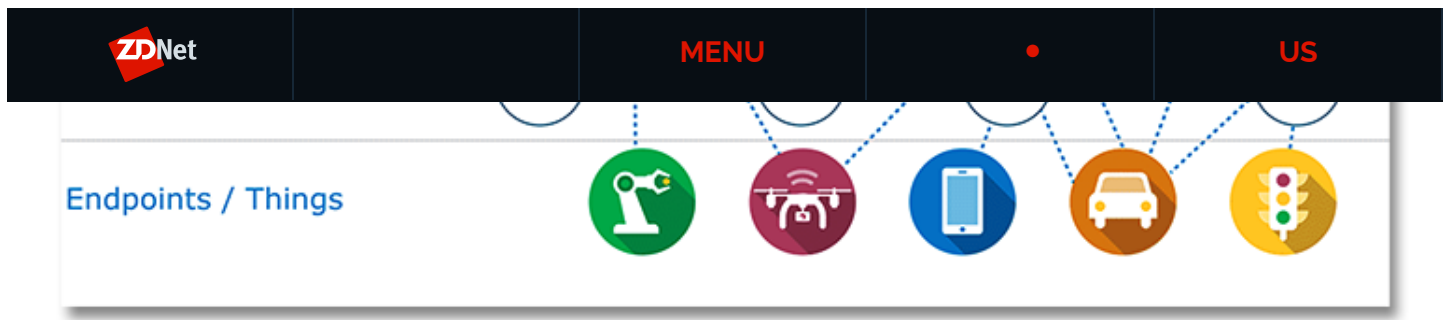


Image: OpenFog Consortium


## Market estimates

According to B2B analysts [MarketsandMarkets](https://www.marketsandmarkets.com/PressReleases/edge-computing.asp) (<https://www.marketsandmarkets.com/PressReleases/edge-computing.asp>), the edge computing market will be worth \$6.72 billion by 2022, up from an estimated \$1.47bn in 2017 -- a CAGR (Compound Annual Growth Rate) of 35.4 percent. Key driving factors are the advent of the IoT and 5G networks, an increase in the number of 'intelligent' applications, and growing load on cloud infrastructure:



### Edge computing market dynamics

<b>Drivers</b>	<ul style="list-style-type: none"> <li>• Growing load on cloud infrastructure</li> <li>• Wide range of applications in different industries</li> <li>• Increase in the number of intelligent applications</li> </ul>
<b>Restraints</b>	<ul style="list-style-type: none"> <li>• Security and privacy concerns related to edge computing</li> </ul>

	<b>MENU</b>	•	<b>US</b>
<b>Challenges</b>	<ul style="list-style-type: none"><li>• Inadequate industry standards and interoperability issues</li></ul>		

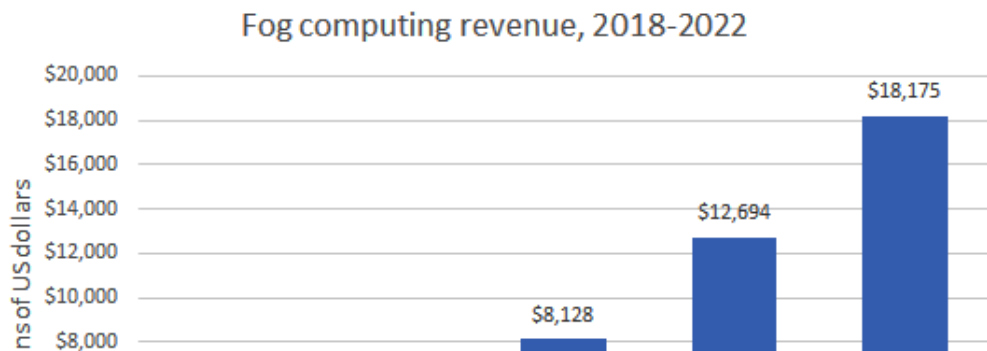
[Data: MarketsandMarkets]

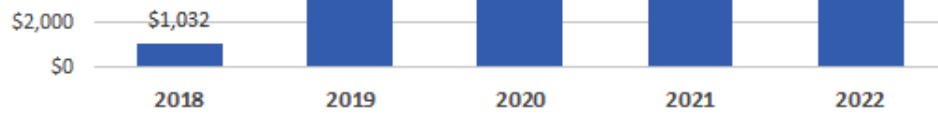
Among the vertical segments considered by MarketsandMarkets, Telecom and IT is expected to have the biggest market share during the 2017-2022 forecast period. That's because enterprises faced with high network load and increasing demand for bandwidth will need to optimise and extend their Radio Access Network (RAN) in order to deliver an efficient Mobile (or Multi-access) Edge Computing (MEC) environment for their apps and services.

The fastest-growing segment of the edge computing market during the forecast period is likely to be [retail](https://www.zdnet.com/topic/data-ai-iot-the-future-of-retail/), (<https://www.zdnet.com/topic/data-ai-iot-the-future-of-retail/>) says MarketsandMarkets: high volumes of data generated by IoT sensors, cameras and beacons that feed into smart applications will be more efficiently collected, stored and processed at the network edge, rather than in the cloud or an on-premises data centre.

[Grand View Research](https://www.grandviewresearch.com/press-release/global-edge-computing-market) (<https://www.grandviewresearch.com/press-release/global-edge-computing-market>) takes a more conservative view, estimating that the edge computing market will be worth \$3.24 billion by 2025, although that's still a 'phenomenal' CAGR of 41 percent over the 2017-2025 forecast period. Regionally, North America will lead the market due to increasing penetration of IoT devices in the US and Canada, said the research firm, while the vertical segment with the highest CAGR will be healthcare and life sciences, thanks to "storage capabilities and real-time computing offered by edge computing solutions". SMEs will witness the highest CAGR (46.5%) over the forecast period, said Grand View Research, thanks to the ability of edge computing solutions to reduce operating costs.

The most optimistic growth estimate comes from [451 Research](https://451research.com/) (<https://451research.com/>), in an October 2017 study -- [Size and Impact of Fog Computing Market](https://www.openfogconsortium.org/wp-content/uploads/451-Research-report-on-5-year-Market-Sizing-of-Fog-Oct-2017.pdf) (<https://www.openfogconsortium.org/wp-content/uploads/451-Research-report-on-5-year-Market-Sizing-of-Fog-Oct-2017.pdf>) -- commissioned by the OpenFog Consortium. This wide-ranging research puts the market opportunity for fog computing at \$18.2 billion by 2022, up from \$1.03bn in 2018 and \$3.7bn in 2019 -- a CAGR of 104.9 percent between 2018 and 2022.





Data: 451 Research & OpenFog Consortium / Chart: ZDNet

According to 451 Research, the leading verticals for fog computing in 2022, in terms of market share, will be utilities, transportation, healthcare, industrial and agriculture.

### Growth of Fog opportunity by vertical market

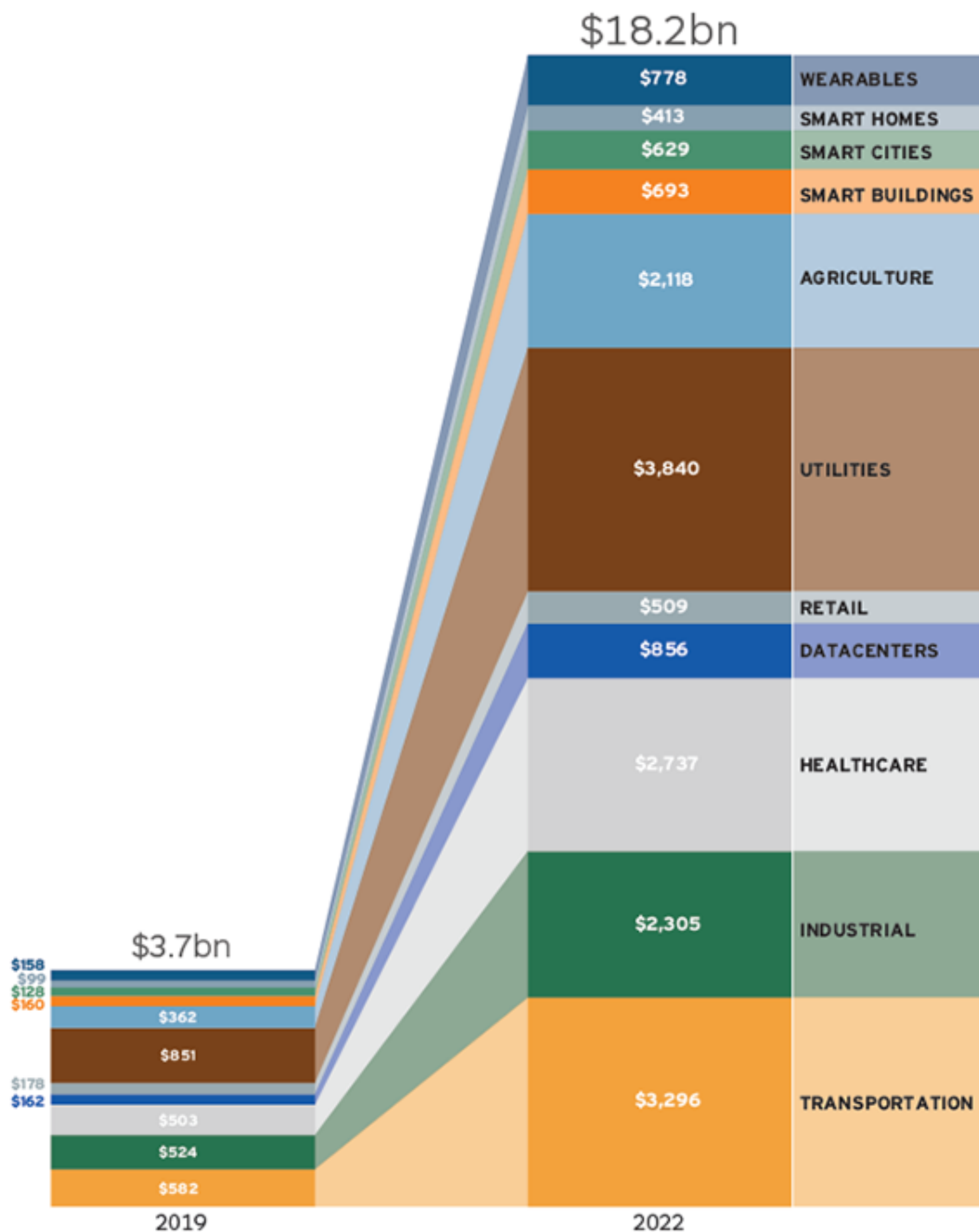
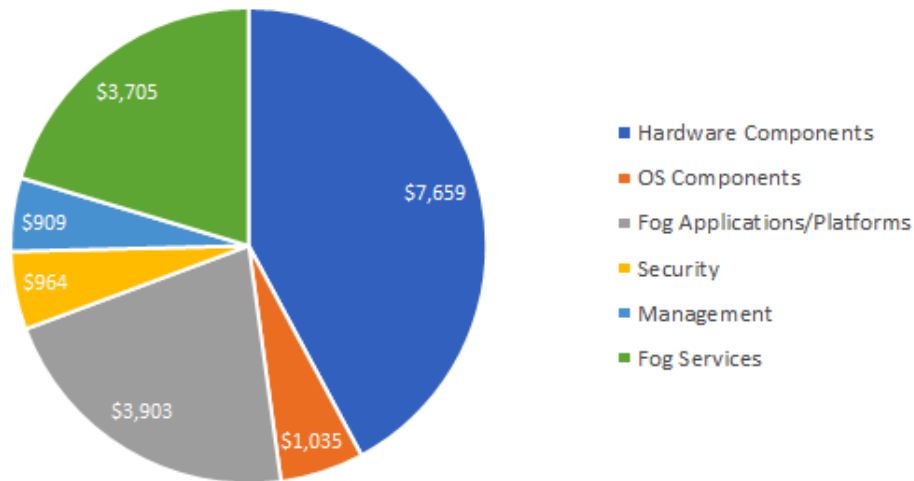


Image: 451 Research & OpenFog Consortium

## Fog computing revenue by component, 2022 (\$m)

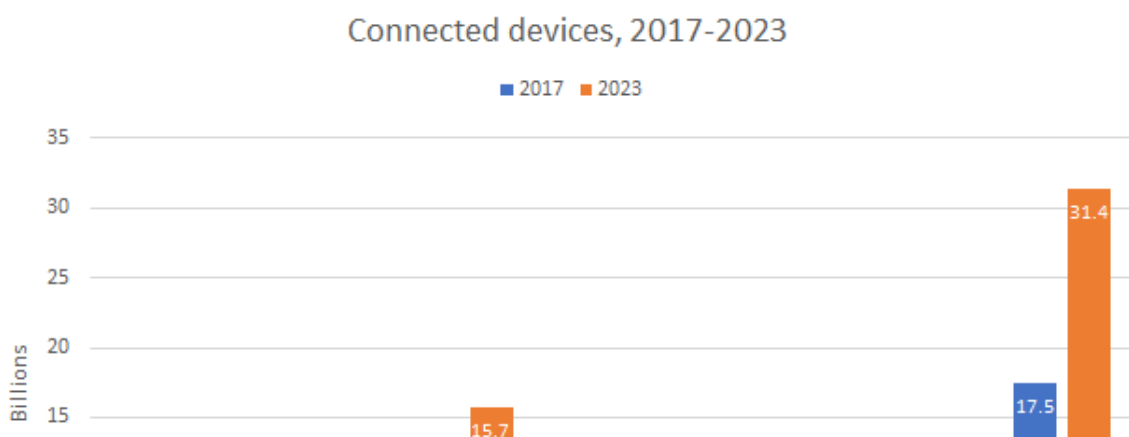


Data: 451 Research & OpenFog Consortium / Chart: ZDNet

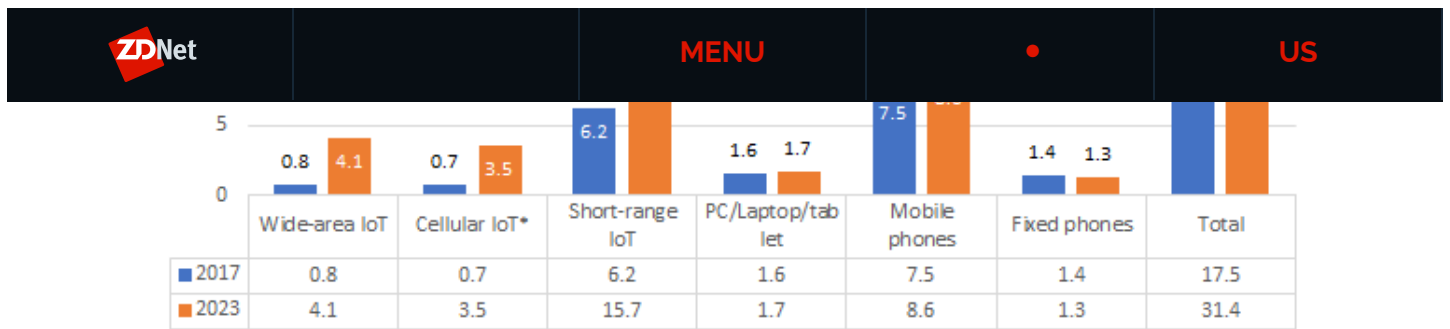
Hardware components are well out in front, with a 42.1 percent slice of the 2022 pie, followed by fog applications/platforms (21.5%) and fog services (20.4%). No wonder hardware vendors and cloud application/services providers are queueing up to get involved in the fast-developing edge/fog market.

Despite their different emphases, these forecasts make it clear that the 'perfect storm' for edge computing is being created by a rapidly increasing number of internet-connected devices and the imminent advent of high-bandwidth, low-latency 5G networks. Ericsson's [June 2018 Mobility Report](https://www.ericsson.com/en/mobility-report/reports/june-2018) (<https://www.ericsson.com/en/mobility-report/reports/june-2018>) summarises the expected developments in these areas.

Whereas PCs, laptops, tablets and (to a lesser extent) mobile phones show flat growth between 2017 and 2023, IoT devices are taking off: those with wide-area connections will see 30 percent CAGR, with short-range IoT devices showing significant but slower growth (17% CAGR). This results in an almost 80 percent (79.4%) increase in the number of connected devices between 2017 (17.5 billion) and 2023 (31.4 billion):





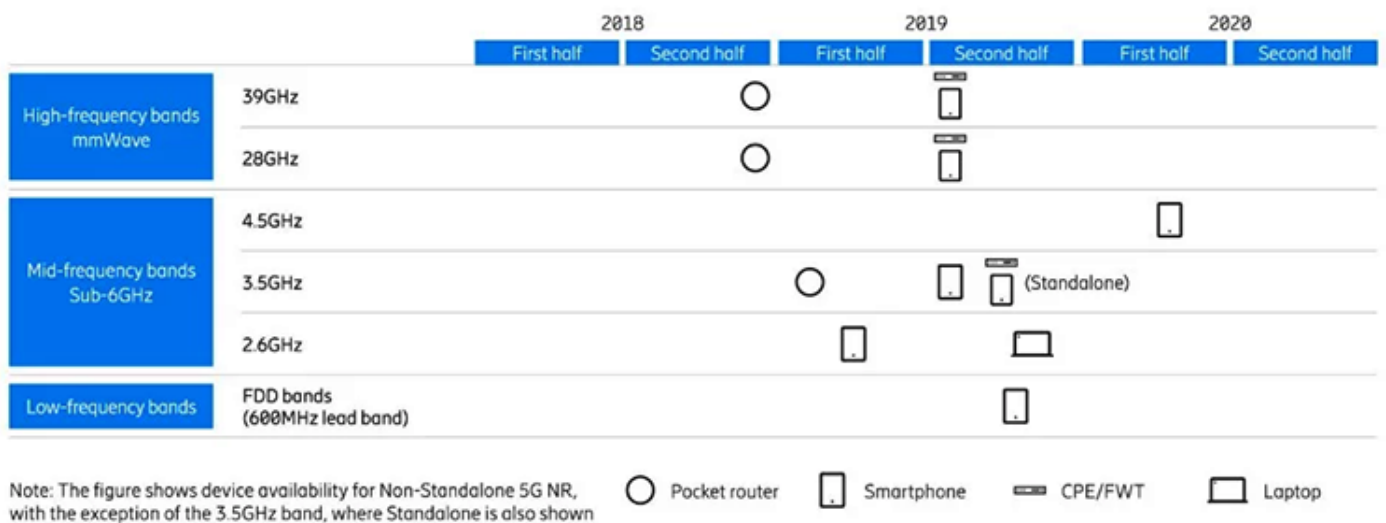


\* Cellular IoT devices are a subset of Wide-area IoT devices.

Data: Ericsson Mobility Report, June 2018 / Chart: ZDNet

As far as 5G is concerned, Ericsson expects the first data-only devices from the second half of 2018 and the first 5G smartphones in 2019. By 2023, following the advent of third-generation chipsets in 2020, the company forecasts that 1 billion 5G devices will be connected worldwide.

### 5G device availability (3GPP)



CPE/FWT: Customer-Provided Equipment/Fixed Wireless Terminal

Image: Ericsson Mobility Report, June 2018

The first module-based 5G IoT devices, supporting ultra-low latency communications for industrial process monitoring and control, are expected during 2020, says Ericsson.

## Standards & organisations

Any new IT initiative requires standards and best practices, and the early stages are often characterised by multiple groups and consortia with different agendas (despite often significant overlap in membership). Edge/fog computing is no exception.

Fog computing, a term coined by Cisco, is backed by the [OpenFog Consortium](https://www.openfogconsortium.org/)

(<https://www.openfogconsortium.org/>), which was founded in 2015 by Arm, Cisco, Dell, Intel, Microsoft and the

Our efforts will define an architecture of distributed computing, network, storage, control and resources that will support intelligence at the edge of IoT, including autonomous and self-aware machines, things, devices, and smart objects. OpenFog members will also identify and develop new operational models. Ultimately, our work will help to enable and drive the next generation of IoT.

Edge computing is promoted by the [EdgeX Foundry](https://www.edgexfoundry.org/) (<https://www.edgexfoundry.org/>), an open-source project hosted by The Linux Foundation. EdgeX Foundry's goals include: building and promoting EdgeX as a common platform unifying IoT edge computing; certifying EdgeX components to ensure interoperability and compatibility; providing tools to quickly create EdgeX-based IoT edge solutions; and collaborating with relevant open-source projects, standards groups and industry alliances.

According to EdgeX Foundry, "The project's sweet spot is edge nodes such as embedded PCs, hubs, gateways, routers, and on-premises servers to address key interoperability challenges where 'south meets north, east, and west' in a distributed IoT fog architecture".

EdgeX Foundry's technical steering committee includes representatives from IOTech, ADI, Mainflux, Dell, The Linux Foundation, Samsung Electronics, VMWare and Canonical.

There are two other industry bodies in this area: the Japan-focused [EdgeCross Consortium](https://www.edgexcross.org/en/) (<https://www.edgexcross.org/en/>), which was founded in November 2017 by Omron Corporation, Advantech, NEC, IBM Japan, Oracle Japan and Mitsubishi Electric; and the [Industrial Internet Consortium](https://www.iiconsortium.org/) (<https://www.iiconsortium.org/>), founded in 2014 by AT&T, Cisco, General Electric, Intel, and IBM.

## What the surveys say

*Edge Computing Index: From Edge to Enterprise* (<https://futuresresearch.com/edge-computing-from-edge-to-enterprise/>)

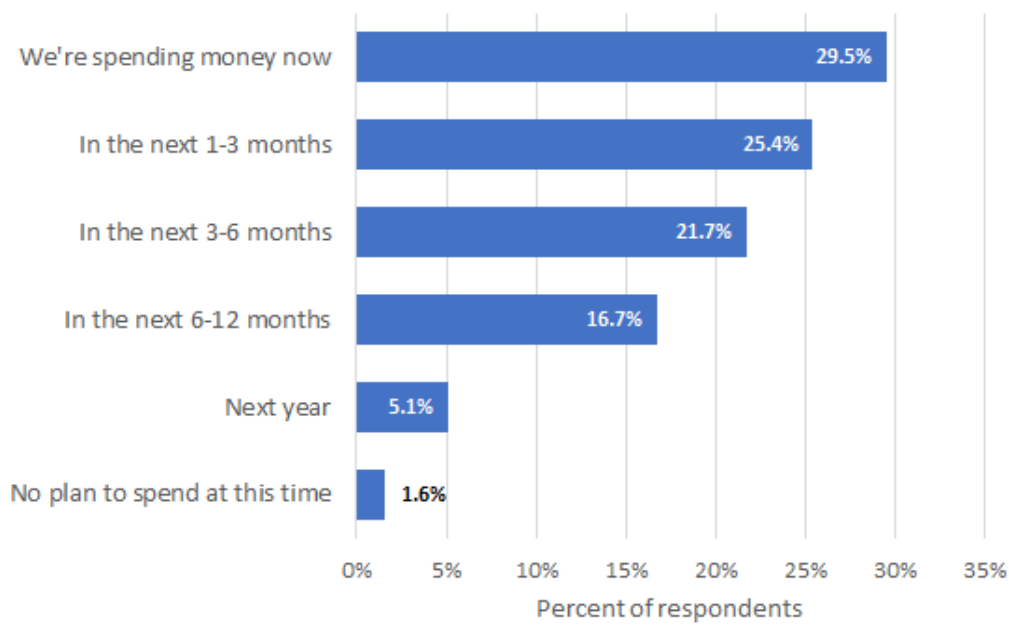


(<https://futuresresearch.com/edge-computing-from-edge-to-enterprise/>)

Futurum Research (<https://futuresresearch.com/>) surveyed over 500 North American companies (ranging from 500 to 50,000 employees) in late 2017 to discover their position on edge computing -- adoption and deployment, investment intent, and more. All respondents exerted influence on edge computing investment decisions, said Futurum, with 41.8 percent being 'operational staff' and 25.6 percent at 'director, manager, team lead' level; only 8.6 percent were classed as 'executive, C-suite, owner, partner' though.

Futurum reported that nearly three-quarters (72.7%) of companies had already implemented an edge computing strategy, or were in the process of doing so. Furthermore, almost all (93.3%) intended to invest in edge computing in the next 12 months:

## computing infrastructure and/or analytics solutions?

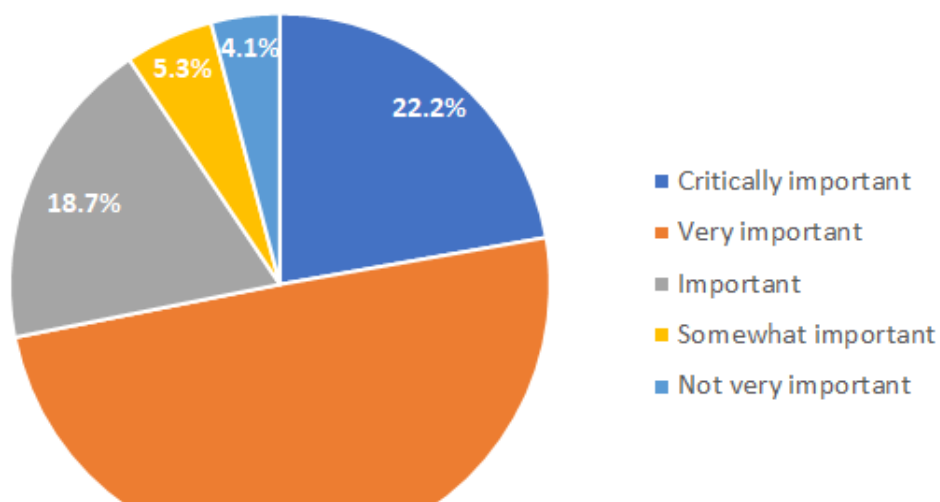


Data: Futurum Research / Chart: ZDNet

Futurum also curates a general [Digital Transformation Index](https://futurumresearch.com/futurum-2018-digital-transformation-index/) (<https://futurumresearch.com/futurum-2018-digital-transformation-index/>), which in 2018 put 68 percent of companies in the 'leaders' and 'adopters' categories. So the fact that 72.7 percent of respondents are already investing in edge computing shows that this is a hot topic for tech-savvy businesses. However, Futurum also noted that "the eagerness of 93.3% of businesses to invest in edge computing in the next 12 months does not speak to the size of their investment".

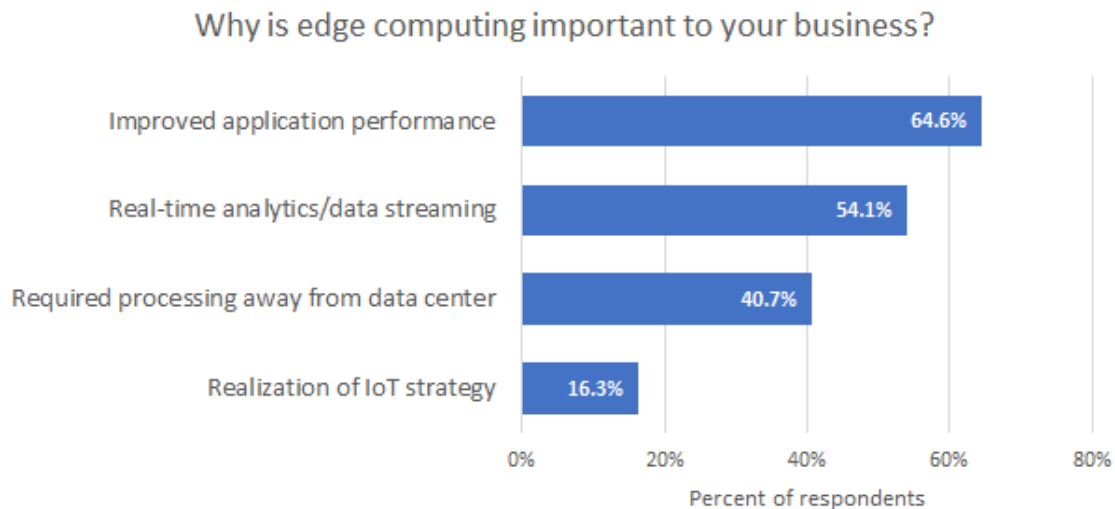
The positive vibes among Futurum's respondents continued when they were asked about the importance of edge computing data streams in their business processes, with 71.8 percent describing these as 'critically' (22.2%) or 'very' (49.6%) important:

How important is your edge computing strategy to obtaining and utilizing data streams to improve business processes and productivity?



Data: Futurum Research / Chart: ZDNet

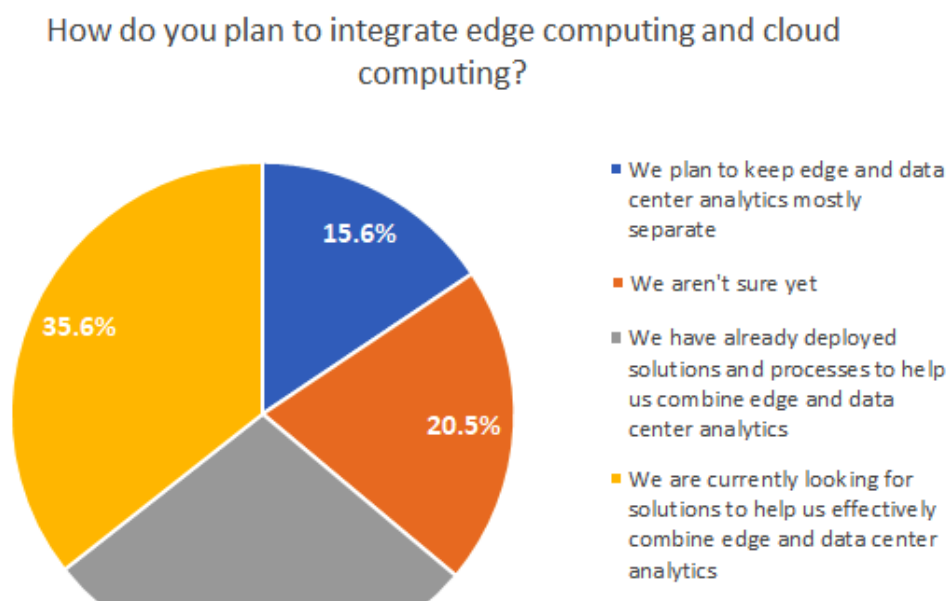
What were the key drivers of this enthusiasm for edge computing? For Futurum's respondents, it was 'improved application performance', followed by 'real-time analytics/data streaming':



Data: Futurum Research / Chart: ZDNet

The analyst firm interpreted these priorities as a reflection of the need for operational efficiency, suggesting that the relatively low ranking for IoT strategy -- often quoted as a canonical edge computing use case -- "will likely increase in the coming years".

Only 15.6 percent of Futurum's respondents aimed to keep edge computing and cloud computing separate -- a decision often driven by data and system security concerns, and a focus on compartmentalised operations, the research firm said. That leaves nearly 64 percent (63.9%) who had already deployed (28.3%) or were seeking (35.6%) combined edge/data centre analytics solutions, plus 20.5 percent who were unsure whether to combine these functions or keep them separate:



Data: Futurum Research / Chart: ZDNet

The 'unsure' and 'seeking' responses amount to 56.1 percent of the survey sample, which clearly represents a significant opportunity for edge computing providers.

*2018 Outlook for Fog Computing* (<https://www.openfogconsortium.org/wp-content/uploads/Fog-survey-of-OpenFog-members-January-2018.pdf>)



The OpenFog Consortium surveyed its 61 member organisations on the state of fog computing in December 2017, finding that an impressive 70 percent of CEOs were aware of the fog computing initiatives happening on their watch.

Budgets for fog computing in 2018 were generally increasing (40%) or staying the same (51%), with just 5 percent of respondents reporting a decrease. Initiatives were primarily based in the R&D department (51%) and overwhelmingly had IoT applications as their primary focus area (70%).

Security was the number-one concern among OpenFog respondents (32%), followed by worries about early/unproven technology, interoperability and unclear ROI. The main drivers of interest in fog computing were latency and bandwidth issues. Respondents expected manufacturing, smart cities and transportation to be the top industry segments adopting fog computing, followed by energy, healthcare and smart homes.

## Key vendors

Edge/fog computing can pull workloads away from cloud data centres, so it's no surprise to see the cloud giants taking steps to prevent those workloads from escaping their orbit.

### Amazon

Introduced at Amazon's [2016 re:Invent](http://phx.corporate-ir.net/phoenix.zhtml?c=176060&p=irol-newsArticle&ID=2226603) developer conference, [AWS Greengrass](https://aws.amazon.com/greengrass/) builds on the company's existing IoT and Lambda (serverless computing) offerings to extend AWS to intermittently connected edge devices.

"With AWS Greengrass, developers can add AWS Lambda functions to a connected device right from the AWS Management Console, and the device executes the code locally so that devices can respond to events and take actions in near real-time. AWS Greengrass also includes AWS IoT messaging and synching capabilities so devices can send messages to other devices without connecting back to the cloud," said Amazon. "AWS Greengrass allows customers the flexibility to have devices rely on the cloud when it makes sense, perform tasks on their own when it makes sense, and talk to each other when it makes sense -- all in a single, seamless environment."

### Greengrass Group

A defined group of Greengrass Cores and other devices that are configured to communicate with one another. A Greengrass Group may represent one

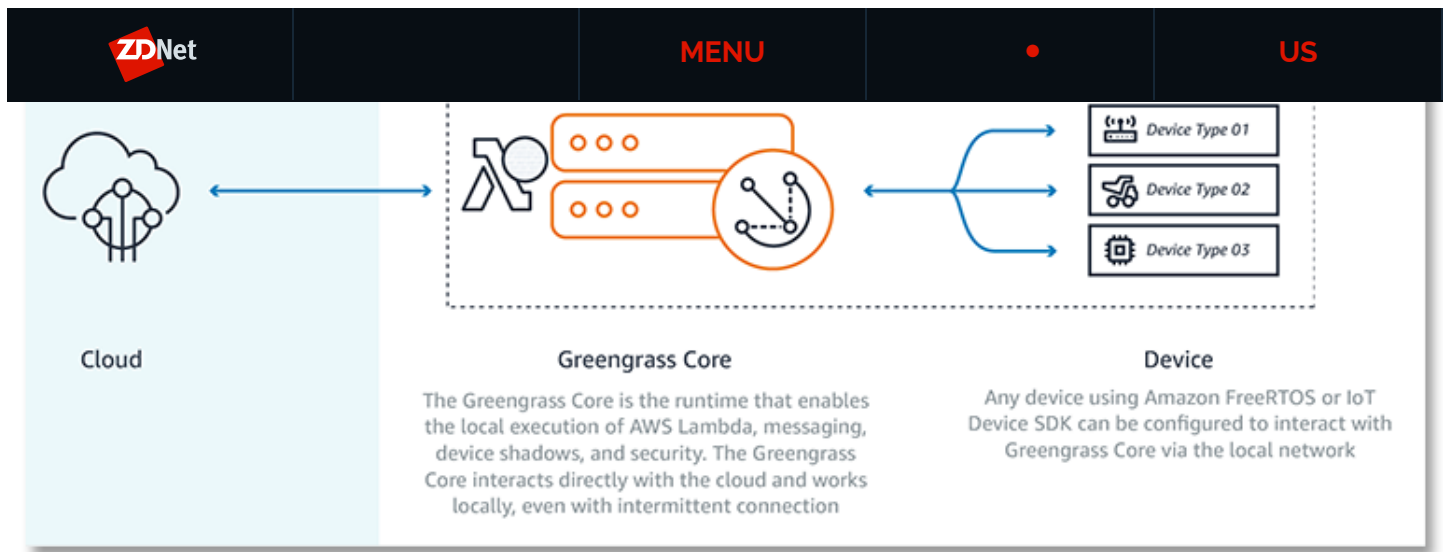


Image: Amazon Web Services

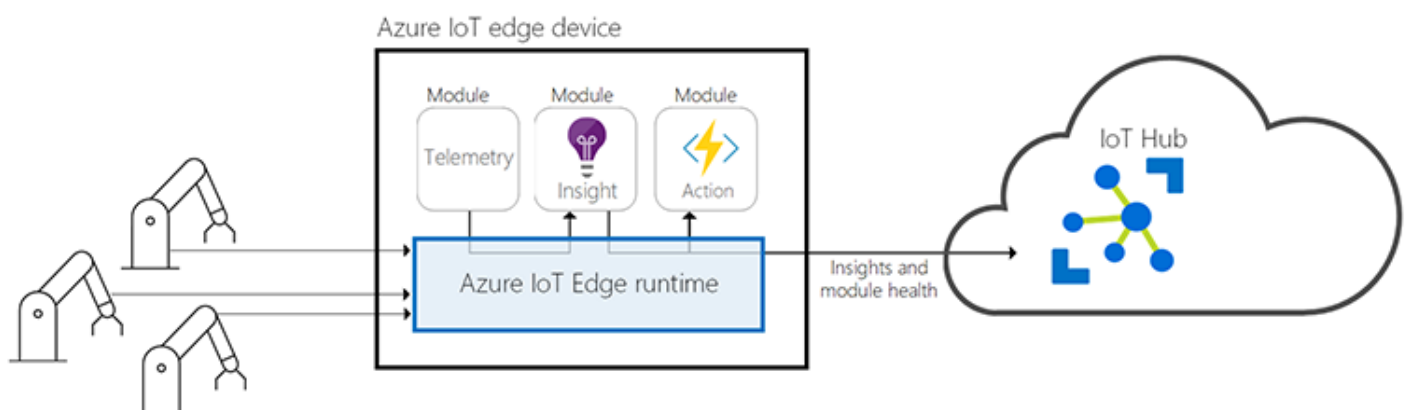
These are 'smart' edge devices, of course: Greengrass requires at least 1GHz of compute (either Arm or x86), 128MB of RAM, plus additional resources for OS, message throughput and AWS Lambda execution. According to Amazon, "Greengrass Core can run on devices that range from a Raspberry Pi to a server-level appliance".

#### Microsoft

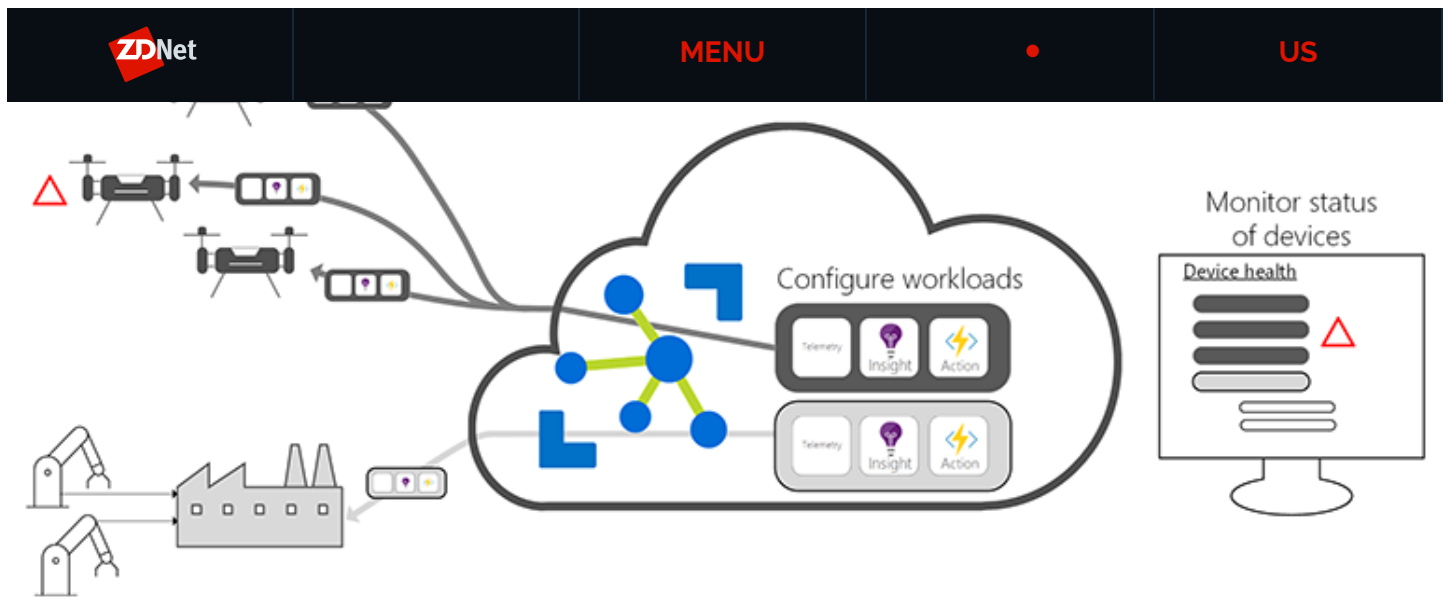
Introduced at Microsoft's BUILD 2017 (<https://azure.microsoft.com/en-gb/resources/videos/build-2017-enabling-intelligence-at-the-edge-with-azure-iot-edge/>) developer conference and generally available since June 2018, [Azure IoT Edge](https://azure.microsoft.com/en-gb/services/iot-edge/) (<https://azure.microsoft.com/en-gb/services/iot-edge/>) allows cloud workloads to be containerised and run locally on smart devices ranging from a Raspberry Pi to an industrial gateway.

Azure IoT Edge comprises three components: IoT Edge modules; the IoT Edge runtime; and IoT Hub. IoT Edge modules are containers that run Azure services, third-party services or custom code; they are deployed to IoT Edge devices and execute locally. The IoT Edge runtime runs on each IoT Edge device, managing the deployed modules, while IoT Hub is a cloud-based interface for remotely monitoring and managing IoT Edge devices.

Here's how the different Azure IoT Edge elements fit together:





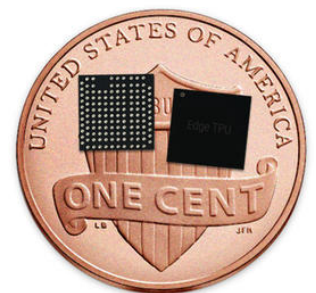


Images: Microsoft

With [general availability](https://azure.microsoft.com/en-gb/blog/azure-iot-edge-generally-available-for-enterprise-grade-scaled-deployments/) (<https://azure.microsoft.com/en-gb/blog/azure-iot-edge-generally-available-for-enterprise-grade-scaled-deployments/>), Microsoft added new capabilities to Azure IoT Edge, including: open-source support; device provisioning, security and management services; and a simplified developer experience.

### Google

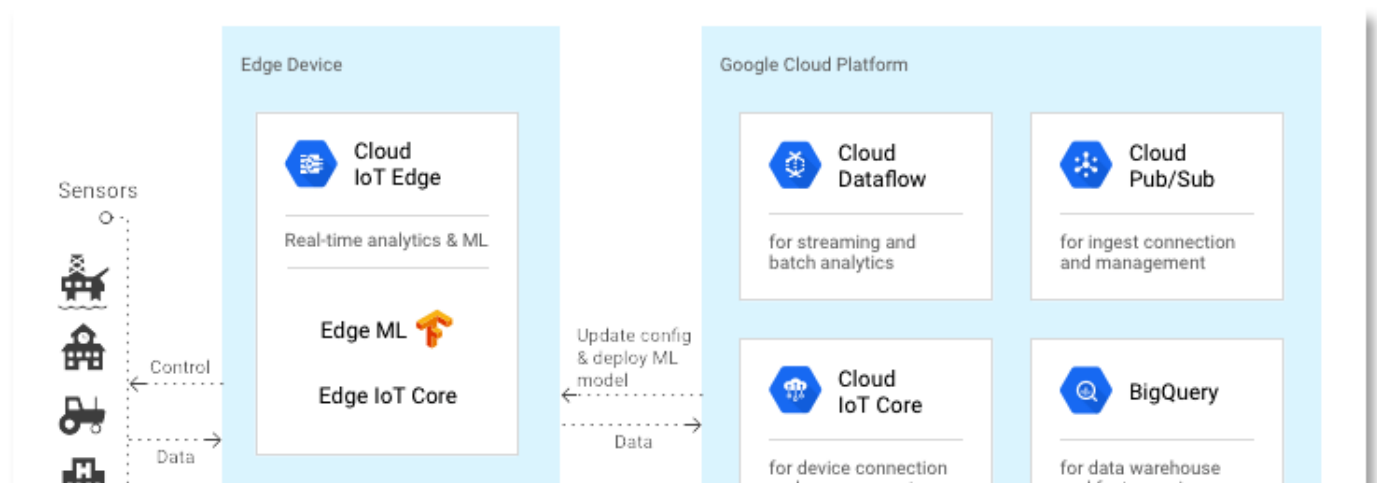
In July 2018, Google announced two products for developing and deploying smart connected devices at scale: [Edge TPU](https://cloud.google.com/edge-tpu/) (<https://cloud.google.com/edge-tpu/>) and [Cloud IoT Edge](https://cloud.google.com/iot-edge/) (<https://cloud.google.com/iot-edge/>). Edge TPU is a purpose-built small-footprint ASIC chip designed to run TensorFlow Lite machine-learning models on edge devices. Cloud IoT Edge is the software stack that extends Google's cloud services to IoT gateways and edge devices.



Google's Edge TPU ASIC, compared to a 1 cent coin.

Cloud IoT Edge has three main components: a runtime for gateway-class devices (with at least one CPU) to store, translate, process and extract intelligence from edge data, while interoperating with the rest of Google's Cloud IoT platform; the Edge IoT Core runtime that securely connects edge devices to the cloud; and the Edge ML runtime, based on TensorFlow Lite, that performs machine-learning inference using pre-trained models.

Image: Google



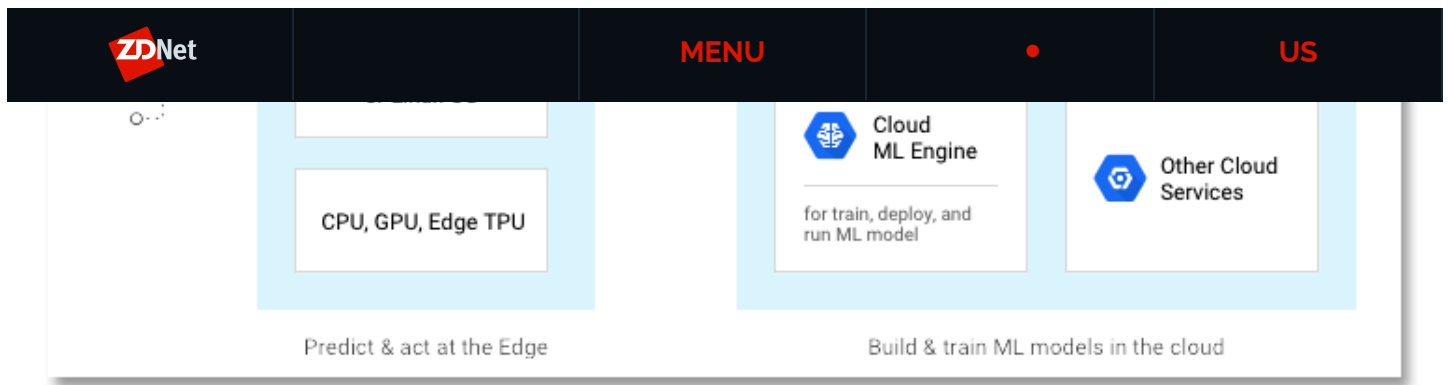


Image: Google

Both Edge TPU and Cloud IoT Edge are at the alpha testing stage at the time of writing (September 2018).

## Outlook

The edge/fog computing transformation is one of those shifts in focus that happen periodically in computing -- from mainframes to desktop PCs, to on-premises data centres, to cloud data centres, for example. Now we're looking at a mix of existing elements, along with billions of smart IoT devices, bound together by an intervening 'fog' of gateways and nodes. Device connectivity has been a bottleneck holding back this transformation, but that's about to get a huge boost with the advent of 5G mobile networks.

Any industry sector that can derive benefit from the timely analysis of IoT data streams -- and that's pretty much all of them -- will be interested in edge/fog computing. That's why there are huge opportunities for vendors at all levels of the technology stack -- standards, networking, compute, storage, applications and services.

With ever more data being generated, processed and stored in ever more locations, issues surrounding infrastructure management and data security, privacy and governance will become even more important than they are today. Let's hope those issues are addressed sooner rather than later.

## RECENT AND RELATED CONTENT

**Understanding Edge Computing** (<https://www.zdnet.com/topic/understanding-edge-computing/>)

The edge is that theoretical space where a data center resource can be accessed in the minimum amount of time. The location could be in the data center, on the desktop, or wherever there's a need.

**Microsoft Azure gets new tools for edge computing and machine learning**

(<https://www.techrepublic.com/article/microsoft-azure-gets-new-tools-for-edge-computing-and-machine-learning/>)

(TechRepublic) (<https://www.techrepublic.com/article/microsoft-azure-gets-new-tools-for-edge-computing-and-machine-learning/>) Announced at the Microsoft Ignite conference today, these new features are designed to streamline the collection, processing and analysis of large volumes of data.

**VMware taps IoT to extend hybrid and multi-cloud environments to the edge**

(<https://www.techrepublic.com/article/vmware-taps-iot-to-extend-hybrid-and-multi-cloud-environments-to-the-edge/>)