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

With over 100 edge use cases identified, the fast-growing need to power connected devices demands a custom response from vendors.

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As connected devices proliferate and their capabilities expand, so does the need for real-time decision making untethered from cloud computing's latency, and from connectivity in some cases. This movement of computational capacity out of the cloud—to the edge—is opening up a new sector: edge computing.

By circumventing the need to access the cloud to make decisions, edge computing provides real-time local data analysis to devices, which can include everything from remote mining equipment and autonomous vehicles to digital billboards, wearable health appliances, and more.

IoT devices tend to operate under different conditions from those of the controlled environments of offices and factories, driving demand for a whole new set of technologies that can allow computing in those situations. Take the scenario of a military drone deployed on a tactical surveillance mission in a high-intensity combat zone. It is essential for the drone to be able to collect, process, and transmit high-quality data in real time, despite numerous challenges, including remote location, limited connectivity, and extreme environmental conditions.

While the drone can use mobile satellite connectivity to access the secure military cloud, it's much faster if it does the computing onboard, using lightweight data storage and compute power. This way of computing—on the edge of the cloud—lets the drone stay in sync with both the command center and troops on the ground, without the latency that computing in the cloud involves. Once the job is done, the drone returns to base and can connect with the larger system, now transferring its data to the cloud, where it can be used to feed algorithms and other advanced analytics activities.

In considering the sheer variety and volume of edge use cases, it becomes clear that the demand for the edge computing technologies that enable them will in turn create myriad opportunities in a vast number of industries. In this article, we map out more than 100 edge computing use cases across 11 sectors that we believe could create more than $200 billion in hardware value in the next five to seven years (Exhibit 1).

What drives edge computing?

To understand what effect edge computing will have, it is important to know what causes its evolution. Edge computers have an infinitely wide range of uses; however, the conditions in which they operate form the driving factors for this new field and the technologies that serve it. These are:

Varied connectivity and data mobility. Edge technologies can operate in places that might limit or require intermittent connectivity to the cloud for services like computing, storage, backup, and analytics.

Need for real-time decision making. Edge use cases often require data to be processed instantly, for self-driving cars or automatic picking machines, for example. These devices and platforms need to be able to do analytics locally, without first sending data to the cloud, so decisions can be made rapidly.

Localized compute power. Edge computers need to be lightweight devices that can make fast, secure decisions without the support of bigger computing power.

New storage and security needs. As the numbers of sensors generating data on remote and mobile devices grow, so does the need for

Exhibit 1 Edge computing represents a potential value of $175B–$215B in hardware by 2025.

Industry	% of total edge use cases	2025 hardware value[1]
Travel, transport, and logistics	24%	~$35B–$43B
Cross-vertical	9%	~$32B–$40B
Retail	10%	~$20B–$28B
Media and entertainment	1%	~$17B–$25B
Public sector and utilities	10%	~$16B–$24B
Global energy and materials	13%	~$9B–$17B
Advanced industries	10%	~$5B–$13B
Healthcare	10%	~$5B–$13B
Infrastructure	6%	~$4B–$11B
Chemicals and agriculture	5%	~$4B–$11 B
Banking and insurance	1%	~$2B–$7B
Consumer	4%	~$1B–$5B
		Total: ~$175B–$215B

[1]Hardware value includes opportunity across the tech stack (ie, the sensor, on-device firmware, storage, and processor) and for a use case across the value chain (ie, including edge computers at different points of architecture).

efficient storage that can be secured in a variety of environments.

Intermittent power. Power and infrastructure variations at the edge are pushing the boundaries of performance and capabilities of edge solutions. Especially in industrial applications, edge computers need to be able to operate with a power supply that might be sporadic.

What opportunities will edge computing open?

Unlike recent technological advances such as cloud computing, where most gains were captured by just a few major players in the technology sector, edge computing creates opportunities across a breadth of industries. In addition, while much of today's technical infrastructure is sector-agnostic—the same cloud that powers an ecommerce engine also powers the workflow of a bank—edge computing technologies need to be more specialized. For example, the data storage and computing power needed for precision agriculture will be different from that needed to run mobile, durable medical appliances or safety equipment in a mine.

In our research we identified 107 edge computing use cases (Exhibit 2). These applications are not conceptual: we identified 3,000 companies deploying these use cases today to understand the potential opportunities across sectors and the technology stack. Our calculation of the value they could generate focused on hardware, but of course the opportunity extends to software too. We considered the hardware stacks (the value of the sensor, on-device firmware, storage, and processor, for example) and use cases across the edge value chain (including edge computers at different points in the architecture).

Exhibit 2

A comprehensive market analysis revealed 107 concrete use cases for edge computing. (1 of 2)

Sector	#	Use case
Advanced industries	1	Condition-based maintenance in airplanes
	2	Condition-based management for defense equipment
	3	Use sensor data and compute to cross-sell items to user in manufacturing
	4	Use sensor data to design better next generation of manufacturing equipment
	5	Satellites performing functions such as telecom communications, weather patterns
	6	Connected ships to help navigation
	7	Tracking of shipping containers for improved utilization and route optimization
Banking & insurance	8	Insurance solution aimed at reduction of collision and theft using automated braking systems
Chemicals and agriculture	9	Condition-based maintenance for after-sales improvement for farm equipment
	10	Activity monitoring and transparency to increase human productivity on farms
	11	HR redesign to improve human productivity on farms
	12	Health monitoring of livestock to improve sustenance
	13	Location tracking of livestock to reduce lost / stolen livestock
	14	Use of precision farming and soil condition sensors to improve yield
Consumer	15	Energy management to help conserve energy at homes
	16	Pre-sales analytics to help target the most relevant customers for home appliances
	17	To reduce the instances of break-ins and to minimize risk on the home with early alerts
	18	Usage based design for homes to provide manufacturers with feedback on usage
Cross – vertical	19	Use drones to enable monitoring requirements in defense, mining, and agriculture
	20	Energy management in offices using sensors and compute on-premises
	21	Use connected sensor data and compute on edge to auto-adjust equipment in case of employee safety hazard possibilities
	22	Augmented reality that enables workers to be fed with continuous information and remove the need to remain bound to the desk
	23	Real-time inventory management using edge sensors in plant warehouse
	24	Cross-sell other products based on usage pattern of equipment
	25	Task automation across industries
	26	Design next generation of products based on analytics on usage patterns for offices
	27	Use CCTV, cameras, and audio monitoring system to enable real-time response
	28	Video consumed by end users, eg, through Alexa, YouTube, Facebook live, eSports
Global energy and materials	29	Real time tracking of work-site safety conditions in mines
	30	Real time tracking of work-site safety conditions at oil rigs
	31	Activity monitoring & transparency to increase human productivity at mines
	32	Activity monitoring to increase human productivity at oil rigs
	33	Allow companies to use of streams of data collected on employees' interaction with the physical world to redesign their organizations
	34	Real-time information on employee activity and location at oil rigs
	35	Perform maintenance by tracking equipment condition at mines
	36	Perform maintenance by tracking equipment condition at oil rigs
	37	Use usage data generated by devices to improve product R&D for mines
	38	Use usage data generated by devices to improve product R&D for oil rigs
	39	Use edge computing to centrally or remotely optimize the operations at mines
	40	Use edge computing to centrally or remotely optimize the operations at oil rigs
	41	Use edge computing to better identify equipment needs on mines
	42	Use edge computing to better identify equipment needs on an oil rig
Healthcare	43	Counterfeit drug reduction in hospitals through active drug tracking
	44	Building energy management in hospitals using connected devices
	45	Activity monitoring to increase human productivity in hospitals
	46	HR redesign to improve human productivity in hospitals
	47	Improved medical devices by tracking mobile durable equipment
	48	Inventory optimization and management at hospitals using RFID tracking
	49	Increased nursing efficiency from better remote asset tracking
	50	Condition based management of hospital equipment
	51	Pre-sales analytics in hospitals to improve cross-selling of products
	52	Help improve fitness and wellness for users of edge/wearable devices using accountability, advice, and incentives
	53	Track patient condition in real time and improve treatment through better patient treatment compliance and early identification of health complications

A comprehensive market analysis revealed 107 concrete use cases for edge computing. (2 of 2)

Infrastructure	54	Real-time tracking of work-site safety conditions in construction
	55	Activity monitoring and transparency to increase human productivity in construction
	56	HR redesign in construction that uses employee data to increase human productivity
	57	Improved, proactive equipment maintenance in construction
	58	IoT enabled R&D in construction that leverages usage data from edge equipment
	59	Operations management in construction to centrally or remotely optimize operations
	60	Sales analytics in construction to better identify equipment needs on a work-site
Public sector and utilities	61	Air quality monitoring using sensors to monitor particulate matter
	62	Congestion lanes using demand-based pricing to manage traffic
	63	Distribution and substation automation to reduce distribution line losses
	64	Surveillance, coordination, and transport tech to better manage/mitigate emergencies
	65	Smart meters reduce meter reading OPEX and prevent theft
	66	Smart parking meters to offer real-time insight and enable dynamic pricing
	67	Smart solid waste pickup to enable automatic billing and optimized collection routes
	68	Smart water meters to reduce OPEX and enable real-time water consumption data
	69	Structural monitoring (streetlights & bridges)
	70	Water leak identification across pipes, pumps, etc. to manage water loss
	71	Water quality monitoring in water pipes, rivers, lakes, etc.
Retail	72	Activity monitoring and transparency to increase human productivity in retail
	73	HR redesign in retail that uses employee data to increase human productivity
	74	Improved staff allocation based on consumer behavior and crowding analytics
	75	Inventory optimization using connected RFID
	76	Layout and staff deployment optimization based on analytics on consumer behavior
	77	Real-time personalized promotions based on user history and location data
	78	After sales service improvements in retail (e.g., condition based maintenance)
	79	Retail store energy management
	80	Improved billing / material handling in self-checkout
	81	Improved payment systems in self-checkout
	82	Smart CRM based on data about customer preferences and needs
Travel, transport, and logistics	83	Autonomous vehicles and trucks that don't require human attention
	84	Bus / train schedule management to optimize route planning
	85	Courier, express, and parcel (CEP), last-mile package tracking in logistics
	86	Condition-based monitoring of public transportation
	87	Track and support relief efforts in disaster situations
	88	Equipment efficiency improvement from data collection on the road
	89	Flight navigation improvement using tracking and remote monitoring
	90	Activity monitoring and transparency to increase human productivity outside
	91	HR redesign in outside use cases that uses employee data to increase human productivity and redesign the organization
	92	Location-based advertising in public transport through ads on vehicles
	93	Logistics routing based on delivery plans and schedules
	94	Warehouse package tracking to improve logistics
	95	Activity monitoring & transparency to increase human productivity in mfg.
	96	HR redesign in manufacturing using employee data to increase human productivity and redesign the organization
	97	Monitoring of packages through condition-based management of logistics
	98	Operations mgmt. in defense through equipment tracking & remote mgmt.
	99	After-sales service improvements of passenger vehicles and trucks via condition-based maintenance
	100	Pre-sales analytics in transportation equipment
	101	Railways condition-based maintenance (trains, tracks, navigation systems)
	102	After-sales service improvements in shipping via condition-based maintenance
	103	Usage-based design of next-generation product in transportation equipment
	104	Activity monitoring and transparency to increase human productivity
	105	Better performance management and activity monitoring in cities
	106	Organizational improvements & HR redesign in cities enabled by real-time data
	107	HR redesign in vehicle use cases that uses employee data to increase human productivity and redesign the organization

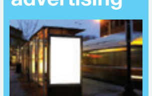
To chart each particular opportunity, we adopted an industry lens to conduct our analysis, identifying edge use cases and quantifying the potential resulting hardware value. Based on the percentage of edge use cases in each vertical, the top three verticals are:

- Travel, transportation, and logistics
- Global energy and materials
- Public sector and utilities

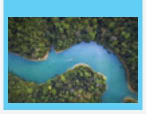
The benefits of past technology revolutions were concentrated in sectors with heavy tech users, such as financial services. For edge computing, sectors that have traditionally been less tech-intensive, such as energy and materials, stand to make substantial improvements in human productivity and safety from edge computing.

Given the central theme of edge computing—that a majority of the computing is done closer to where the data is being generated, and so real-time decision making can't rely on the traditional cloud or massive on-premises data centers, the varying conditions that each use case involves drive the technology needed for it. Looking at this through the lens of specific use cases gives a sense of the range of technologies that will be needed. For example, autonomous vehicles rely on visual processing, among other technologies, and these systems have to be able to withstand rugged environments that involve variations in weather, vibration, and connectivity. (Exhibit 3).

Exhibit 3 **Individual use cases have specific operating conditions and customer needs that shape technology requirements.** (1 of 2)

		Overview	Computing needs	Edge computer	Ecosystem	Environment
Travel, transport, and logistics	**Autonomous vehicles** 	Autonomous vehicles must make instantaneous driving decisions based on data collected via LIDAR, RADAR, and video cameras Once the car returns to its garage, data may be offloaded to edge computer for further analytics	**Real-time decision-making:** To avoid fatal consequences, data must be processed in real-time for immediate decisions to turn, brake, or accelerate	• Autonomous vehicle • Garage-based data center[1]	• Autonomous vehicle OEMs and integrators • Automotive OEM suppliers • LIDAR, RADAR, and video camera vendors	Rugged, mobile outdoor environment with broad variations in temperature, vibration, and connectivity
	Location-based advertising 	Location-based advertising in public transportation uses the location of a vehicle to customize display advertisements near consumers The advent of 5G could make location-based advertising possible at scale	**Localized computing power:** Displays must function independently with limited connectivity **Compact form factor:** Devices must be lightweight, small, and low-power	Processor embedded in display systems on vehicle	• Local, state, and national transit authorities • Advertising agencies	Semi-outdoor environment with intermittent connectivity that varies by route (eg, urban, rural, aboveground, and underground

Individual use cases have specific operating conditions and customer needs that shape technology requirements. (2 of 2)

		Overview	Computing needs	Edge computer	Ecosystem	Environment
Global energy and materials	**Offshore drilling rigs** 	Highly digitized drilling rigs generate data from multiple sensors on equipment; the data collected by these sensors needs to be processed on the rig to avoid equipment damage and interruptions in operations	**Real-time decision-making:** With limited connectivity, data must be analyzed and acted upon in real-time to avoid damage to expensive equipment **Rugged form factor:** Device must function in harsh, at-sea conditions	Hyperconverged[2] edge appliance	• Oilfield services companies that integrate the end-to-end drilling solutions for oil and gas rigs • Hyper-con verged solution vendors	Harsh external environment with drastic temperature variations and limited connectivity.
	Health and safety in mining 	Sensors on monitoring equipment, in the environment and on employees, generate data that is processed in real time to improve workforce productivity, workplace safety, and operational efficiency	**Real time decision-making:** With limited connectivity, data must be processed and acted upon in real time to prevent dangerous or fatal accidents **Rugged form factor:** Computer must withstand harsh mine environment	Hyperconverged edge appliance	• Mining corporations • Hyper-converged solution vendors	Harsh outdoor and underground environments, with limited or no connectivity
Public sector and utilities	**Water quality monitoring** 	Sensor modules with integrated compute are deployed in aquifers, treatment plants, and pipes; modules or hyper-converged appliances process data on-site to monitor water quality in real-time, and in areas with strong connectivity, data will be intermittently transferred to the cloud for centralized analytics	**Real-time decision-making:** In remote settings with no connectivi-ty, information must be processed locally in real time **Rugged form factor:** device must withstand outdoor environments	Hyperconverged appliance	• State utility companies • Electronic equipment manufacturers • Hyper-con verged solution vendors	Outdoor environment with varying tempera-ture ranges, and indoor factory environment, such as central water treatment plants
	Congestion lanes 	Sensors and video cameras deployed on roads and at traffic lights capture data on traffic flow; information is transmitted to a hyper-converged appliance2 hosted at intermittent street locations to monitor traffic patterns and implement demand- based pricing	**Real time decision-making:** data must be processed in real time to respond to congestion quickly **Efficient storage:** large volumes of video data must be quickly accessed for analytics **Rugged form factor:** device must withstand outdoor environments	Hyperconverged appliance	• State infrastructure companies • Third-party toll operators • Hyperconverged solution vendors	Outdoor environment exposed to the elements, with varying temperature and moisture ranges

[1] Mobile micro data center deployed at telecommunications network edge.
[2] A hyperconverged appliance combines compute, storage, and networking resources in a single piece of hardware.

The edge will soon be everywhere

Very soon edge computers will be all around us performing distributed computing across a multitude of devices in homes and factories, on farms, and throughout public infrastructure. The forces fueling the demand for these devices and the technologies enabling them are advancing rapidly. For tech companies, the development of edge technology will revolutionize industry with solutions customized for diverse use cases. This will create a paradigm shift from the device and original equipment makers all the way through to how such products are sold, installed, and serviced. The changes that result will affect all players in the tech stack, consumers in a vast array of sectors, and any companies and leaders looking to have a role in it. ■

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