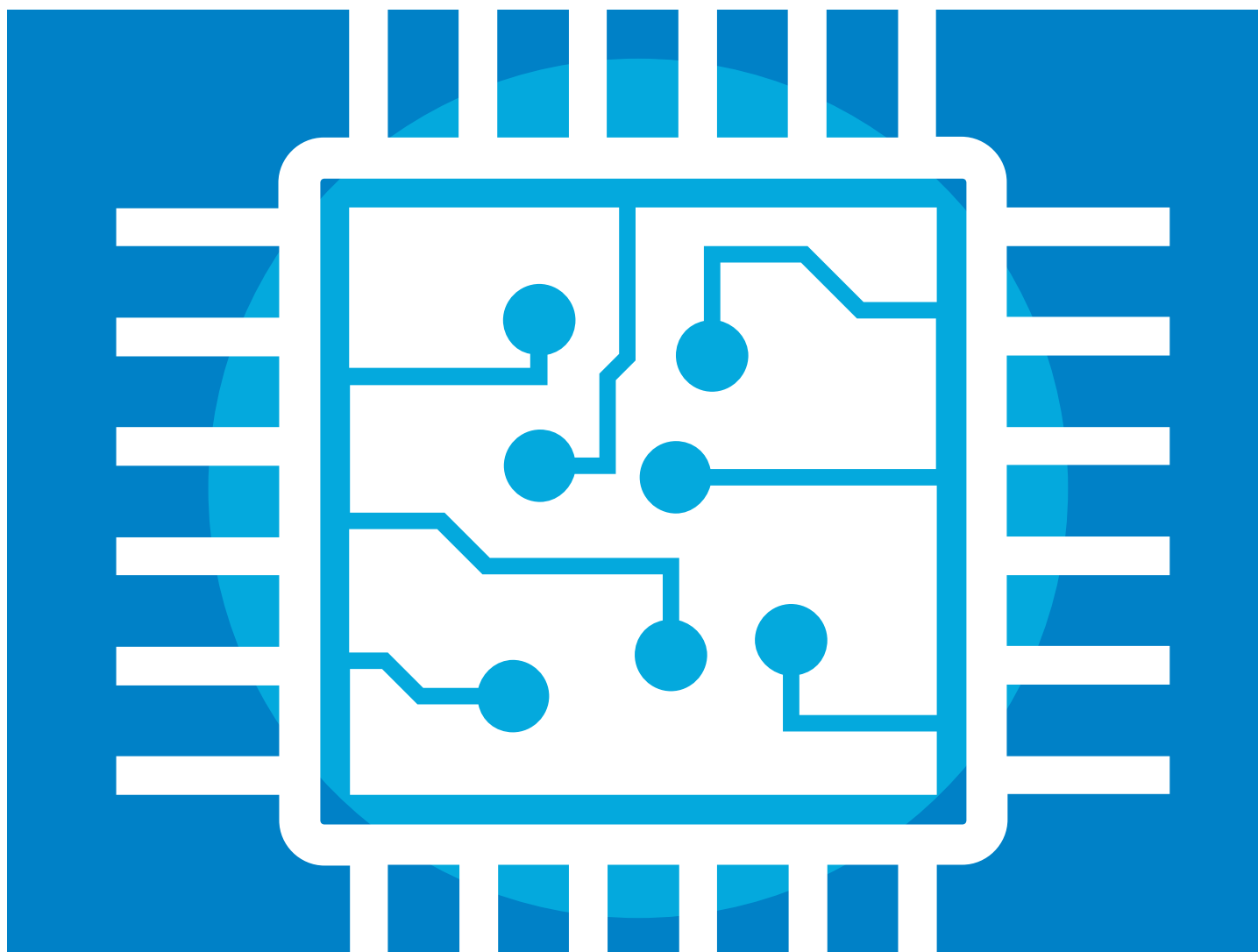Placing computation and analysis close to where data is generated offers high speed and performance for a new class of applications.

Computing at the cutting edge

The operating room is quiet as a complex and risky urological procedure begins. The surgeon works in tandem with a robot that can reach tiny areas of the patient's anatomy unattainable by human hands. The robot interacts with a powerful artificial intelligence software program, receiving second-by-second instructions on how to make the most precise incisions in real time. With the procedure complete in record time, the surgeon closes the surgical opening, satisfied that the patient will make a full recovery much faster than would have happened with traditional techniques.

This seemingly futuristic example is actually current. Driven by advancement in physical, digital, and biotechnologies, the advent of the fourth industrial revolution — the data-driven successor of steam- and semiconductor-powered work eras — means governments, industries, individual businesses, and society stand to benefit from powerful applications such as robotic surgery, self-driving cars, smart factories, advanced telemedicine, predictive analytics, and more.

But current information technology (IT) infrastructures consisting of cloud, on-premises systems, and centralized data centers are insufficient to run such applications.

Key takeaways

1 Traditional information technology can't support the incredibly fast data transmission needed for modern data-driven applications. To reap promised benefits such as smarter business decision-making and faster innovation, businesses need edge computing — which places resources closer to the applications that need them.

2 Edge computing adoption is projected to balloon in the coming years, and several industries are leading that growth. Retail, for example, is tapping edge computing to change the way people shop; health care is getting past pandemic-era enthusiasm for applications such as remote surgery and telehealth, making the capabilities mainstream; and manufacturing is happening more and more on automated factory floors that boost productivity and ensure optimal output.

3 To deliver edge computing, technology executives need to put in place different practices for cybersecurity, management, storage, and the need to scale. Aside from the challenges of assembling and securing a widely distributed network, they need to provide adequate bandwidth for edge-powered applications. And execs need to master the complexity inherent in employing edge, which can put strain on everything that makes IT tick, including computing, networking, and storage.

Traditional infrastructure is not optimized to support the vast amounts of data that need to travel back and forth to applications with lightning-fast speed.

Edge computing takes off

The global edge computing market will reach compound annual growth of more than 37% between 2020 and 2027.

$3.5billion
SIZE OF THE GLOBAL EDGE COMPUTING MARKET, 2019

$43.4billion
SIZE OF THE GLOBAL EDGE COMPUTING MARKET, 2027

Source: Edge Computing Market Analysis, Report, Million Insights

Traditional infrastructure is not optimized to support the vast amounts of data that need to travel back and forth to applications with lightning-fast speed, with virtually no delay, or latency, in the delivery of data. With edge computing, data and computational power reside closer to the data sources and applications that use them — often in the same metro areas, rather than in giant, far-flung cloud data centers — enabling high performance for cutting-edge applications that rely on real-time data.

It's now possible to distribute applications in a wide variety of locations — inside a corporation, out in the field, in a store, at a hospital, on a manufacturing production line. Tapping into real-time data capabilities with software, hardware, and storage that are physically near applications reduces latency and optimizes bandwidth, provides robust security, and cuts costs.

There is a growing realization among IT decision-makers that edge computing is vital to the future. According to a 2020 survey of 900 IT professionals by Turbonomic, nearly 50% of organizations use or plan to use edge computing in the next 18 months.[1] And Gartner reports that by 2022, 50% of business-generated data will be created and processed outside of a traditional data center or cloud, up from less than 10% in 2019.

Top executives across industries increasingly view the speed enabled by edge computing as an emerging competitive differentiator.

A soft sell in retail

IDC predicts that by 2023 more than 50% of new enterprise IT infrastructure deployed will be at the edge rather than in corporate data centers, up from less than 10% in 2020.[2] By 2024, the number of apps at the edge will increase 800%. This growth is led by host of industries: edge computing enables innovations in retail, health care, and manufacturing. For example, retailers can deploy video analytics technologies on an edge computing node, or piece of hardware with storage and networking capabilities, located near their store locations, enabling them to predict theft. "The video analytics system operates at the edge, analyzing customer movements to detect behaviors in real time that are predictive of theft," a workload that is unsuited to public cloud for speed and cost reasons, says Paul Savill, senior vice president of product management and services

"From one centralized node in one market area, say, the size of Denver, edge computing can serve many more retail locations within five milliseconds."

Paul Savill, Senior Vice President, Product Management, Lumen

at technology company Lumen, which offers an edge computing platform. There's no need to deploy edge computing at every retail location. "From one centralized node in one market area, say, the size of Denver, edge computing can serve many more retail locations within five milliseconds," says Savill.

There can be consumer privacy concerns when it comes to analytics that flag certain behaviors. But with the right practices, such as anonymization, this type of application can be an important tool in the arsenal as many retailers, pinched by the lockdowns and restrictions that followed the 2020 coronavirus pandemic, struggle to find ways to operate profitably.

A mammoth US retailer, with 2019 revenues of $16.4 billion, Gap was an early user of edge computing. One of its biggest edge use cases is at the cash registers or other points of sale at its more than 2,500 retail stores, where millions of transactions are processed. Edge computing allows Gap to get nearly up-to-the-second data on sales performance. And during the pandemic, edge helps the retailer keep track of how many people are in its stores.

"The compliance rules for the number of customers allowed in a store were changing based on how each state and each county were in the situation of the pandemic," says Shivkumar Krishnan, head of stores engineering at Gap, referring to regulations designed to limit the spread of the deadly disease. "So, to ensure capacity is not exceeded, we had to make sure we were measuring the occupancy in near real time."

Processing data on an edge node eliminates the many points of failure that exist from the store to the cloud, according to Krishnan, everything from switches, routers, the telecom circuit, and cloud providers themselves. The edge gives the retailer full capability to process all transactions at any store, and they only go to the cloud if the edge fails. Krishnan can remotely monitor and manage most of the retailer's more than 100,000 devices used for sales and other store operations.

The next level of health care

In health care, edge enables a wealth of advanced applications in addition to robot-assisted surgery, including voice-enabled electronic health records, telehealth, remote surgery, connected ambulances, and remote patient monitoring. Using consumer devices and sensors in

A matter of strategic importance
Edge computing has become a top priority for C-suite executives.
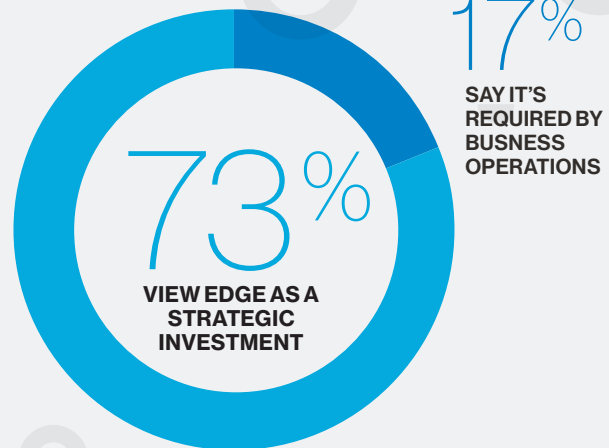
73% VIEW EDGE AS A STRATEGIC INVESTMENT

17% SAY IT'S REQUIRED BY BUSNESS OPERATIONS

Source: "Edge Computing Solutions Powering the Fourth Industrial Revolution," by IDC, sponsored by Lumen and Intel, based on a survey of 802 business decision-makers worldwide

the field running on an edge node, health-care providers can move the bulk of patient care outside the hospital and provider setting, says Arun Mirchandani, an advisor on health-care digital transformation.

"Even before covid, there was a trend to move health care out of the hospital setting because of cost pressures," says Mirchandani. C-suite executives are now prioritizing investments in digital technologies, including the network of connected devices known as the internet of things, because of the prospect of major cost efficiencies as well as an improved patient experience. According to market researchers McKinsey & Company, the pandemic accelerated the need for and adoption of digital technologies in health care, used in everything from research and development, wellness and disease prevention, screening and diagnosis, care delivery, and finance and operations.

Another example of the trend: much health care is now taking place in retail outposts such as CVS and Walmart. Routine diagnostic tests are moving to the places consumers frequent daily, allowing them to avoid a

In health care, edge enables a wealth of advanced applications, including robot-assisted surgery, telehealth, and remote surgery.

separate trip to the doctor's office. This is not expected to change post-pandemic as many consumer habits have altered permanently. Edge computing capabilities and tools enable that care to take place on-site, on a real-time basis, with no need to wait a day or longer for results to come back, says Savill.

Microsoft's recent nearly $20 billion acquisition of Nuance Communications, a software company that provides speech recognition tools, shows the technology giant is betting on voice as a game-changer for health care, for things like voice-enabled medical records. "It's a very laborious process for physicians and care providers to have to

Cloud and edge: A complementary pair

Edge computing helps overcome traditional infrastructure limitations, such as latency, bandwidth, and security. Edge, though, is not a replacement for cloud but is complementary, allowing businesses to choose edge for applications that need near-zero latency. Direct network connectivity to public cloud continues to be essential.

"Edge compute is designed to work in tandem with public cloud services," says Paul Savill, senior vice president of product management and services at Lumen, a vendor of edge computing and other technologies. Applications that exchange a high volume of real-time data require processing and analysis close to the data

source. It makes more sense to run applications that do not require real-time data on the public cloud. There's a place for on-premises, cloud, and edge computing for today's modern applications, and applications can switch back and forth among the different options.

On-premises and cloud infrastructures are often used alongside edge computing. For example, Lumen did an edge computing installation at a newly built factory incorporating 50 robotics systems. It used edge computing for the robotic control applications because they require latency of less than 5 milliseconds to maintain accuracy. But other applications related to the controls do not

require the same degree of low latency — remote monitoring and predictive analytics do not need to happen in real time, so they live on the public cloud.

"The ability to tie together the public cloud and edge compute to provide a unified technology solution for a modern, million-square-foot factory facility is very important," enabling the company to reduce costs and increase efficiency, says Savill. On such a complex project, the decisions about which workloads should reside where is made jointly with the customer's IT department in consultation with its cloud provider, based on the application's performance requirements and other factors.

manually enter all that information — every encounter, every medication, everything that happens to a patient — into a system," says Mirchandani. "Bringing voice, so the person could just speak into a device, and that information gets transcribed automatically and gets populated into the electronic health record, is going to be a huge cost savings" that will drive digital investment.

A competitive edge for manufacturing

Not surprisingly, manufacturing is also fertile ground for use of edge computing. The sector has long invested in automation and internet-of-things technologies and is hungry for analytics and robotics that can boost productivity and improve decisions made in real time. But traditional IT infrastructure is not optimized to support real-time analysis. Edge computing opens a new world of shop-floor applications, including the use of sensor-rich robotics leading to higher quality and greater output.

The fourth industrial revolution and its manufacturing-specific adjunct, "factory 4.0," depend on massive volumes of data being collected and shared automatically, lessening the need for human involvement. Sophisticated sensors, for example, can monitor the condition of factory-floor equipment, triggering maintenance that predicts an issue before it occurs — and then fixes it. Industrial robots can operate autonomously and communicate with manu-facturing systems. Augmented- or virtual-reality gear such as goggles and gloves can help improve safety and training for industrial workers. These applications need computing power located near the source of the data with low latency, making them a fit for edge. The value is not lost on manu-facturing executives, 90% of whom expect to use edge computing by 2022, according to Frost & Sullivan.

Manufacturing processes generate massive volumes of data, and not all of it deserves to be retained, says Bike Xie, vice president of engineering at Kneron, an AI technology vendor. With sensitive data, "you could even destroy the data right after it is processed. That will give you the highest privacy," says Xie. "Of course, it depends on the application. Users can also choose to store some or all of the data on the cloud if they want."

Edge computing enables manufacturers to make flexible choices about processing data to eliminate time lags and decrease bandwidth use. Processing data closer to where it's used saves bandwidth and reduces costs, and data is more secure because it's processed right away.

Why edge computing?

In a recent survey, business decision-makers who deployed edge technologies were asked what motivated them.

COST OF BANDWIDTH	**30**%
DATA PROTECTION	**27**%
LATENCY LIMITATIONS	**19**%
COMPLIANCE	**14**%
NEED FOR CONTINUOUS OPERATION	**11**%

Source: "Edge Computing Solutions Powering the Fourth Industrial Revolution," by IDC, sponsored by Lumen and Intel, based on a survey of 802 business decision-makers worldwide

Data collection and asset tracking are the most common edge computing applications in manufacturing today, according to IDC research, and that will expand rapidly — edge investments in field service and labor management will see significant growth, as well as order tracking and security systems. Edge computing is a key enabler of factories of the future.

Cybersecurity: Everywhere at once

As a new computing model, edge requires different practices for cybersecurity and management. Technology executives need to plan to deliver security as a distributed, virtualized, and dynamically scaled capability rather than as an appliance in a private data center.

"The more that you concentrate information in a location, the more you have worry about protecting that, and the riskier that becomes in terms of creating a single spot that can be penetrated and information stolen," says Savill. So, information security is one of the primary concerns of any chief information officer who wants to take advantage of this kind of technology, he adds.

> "As with the development of many different technologies, there are always challenges. Leaders should adopt edge computing while managing its risks."
>
> Landry Signé, Senior Director and Professor, Thunderbird School of Global Management

Reducing security and compliance risks requires intuitive and intelligent data protection with continuous monitoring and immediate defenses, and the ability to control the location of the data at the edge. Lumen, for example, helps its customer organizations stay secure with cybersecurity built into the network, data centers in regional proximity of data sources, and information security experts to design the network and infrastructure according to requirements.

Technology executives also need to make sure there's adequate bandwidth to the edge, enabling advanced applications to run wirelessly. Toward that end, super-fast broadband technology 5G is expected to be an enabler as it makes its way to corporate America. Savill emphasizes 5G is not necessary to run an edge computing node but is a useful wireless connectivity option in places such as the factory floor, where it is impractical to network multiple connected devices using wires.

Elegant complexity

Another key challenge is managing the complexity of edge computing. Adding connected devices at the edge drives increased scale across all IT disciplines: compute, network, storage, management, security, and licensing.

"With cloud computing, things are simple, or at least simpler because everything is centralized on the cloud,"

says Landry Signé, senior director and professor at Arizona State University's Thunderbird School of Global Management and senior fellow at the Brookings Institution. "With edge computing, complexity is connected to the need to provide cybersecurity and data privacy but also control management, backups, and scale." The expertise required for edge computing spans multiple disciplines, making it inherently more complicated than on-premises or cloud-based infrastructure.

Mastering the complexity is worth it, says Signé. Poised to take industry and the world by storm, applications fueled by real-time data are increasingly running on the edge, according to market researcher Gartner. "As with the development of many different technologies, there are always challenges. Leaders should adopt edge computing while managing its risks," says Signé.

Retail, health care, manufacturing, and other industries are looking to enable new capabilities and applications, redefining how they operate day to day, deliver value to customers, and plan for growth. Demand for low data latency, robust, built-in security, and real-time data at a lower cost will drive adoption and in turn technology advancement.

"If I take an extreme example, it's almost like the use of computers or the use of mobile devices," says Signé. "The adoption is inevitable."

"Computing at the cutting edge" is an executive briefing paper by MIT Technology Review Insights. It is based on research and interviews conducted in April and May 2021. We would like to thank all participants as well as the sponsor, Lumen. MIT Technology Review Insights has collected and reported on all findings contained in this paper independently, regardless of participation or sponsorship. Jason Sparapani and Laurel Ruma were the editors of this report, and Nicola Crepaldi was the publisher.

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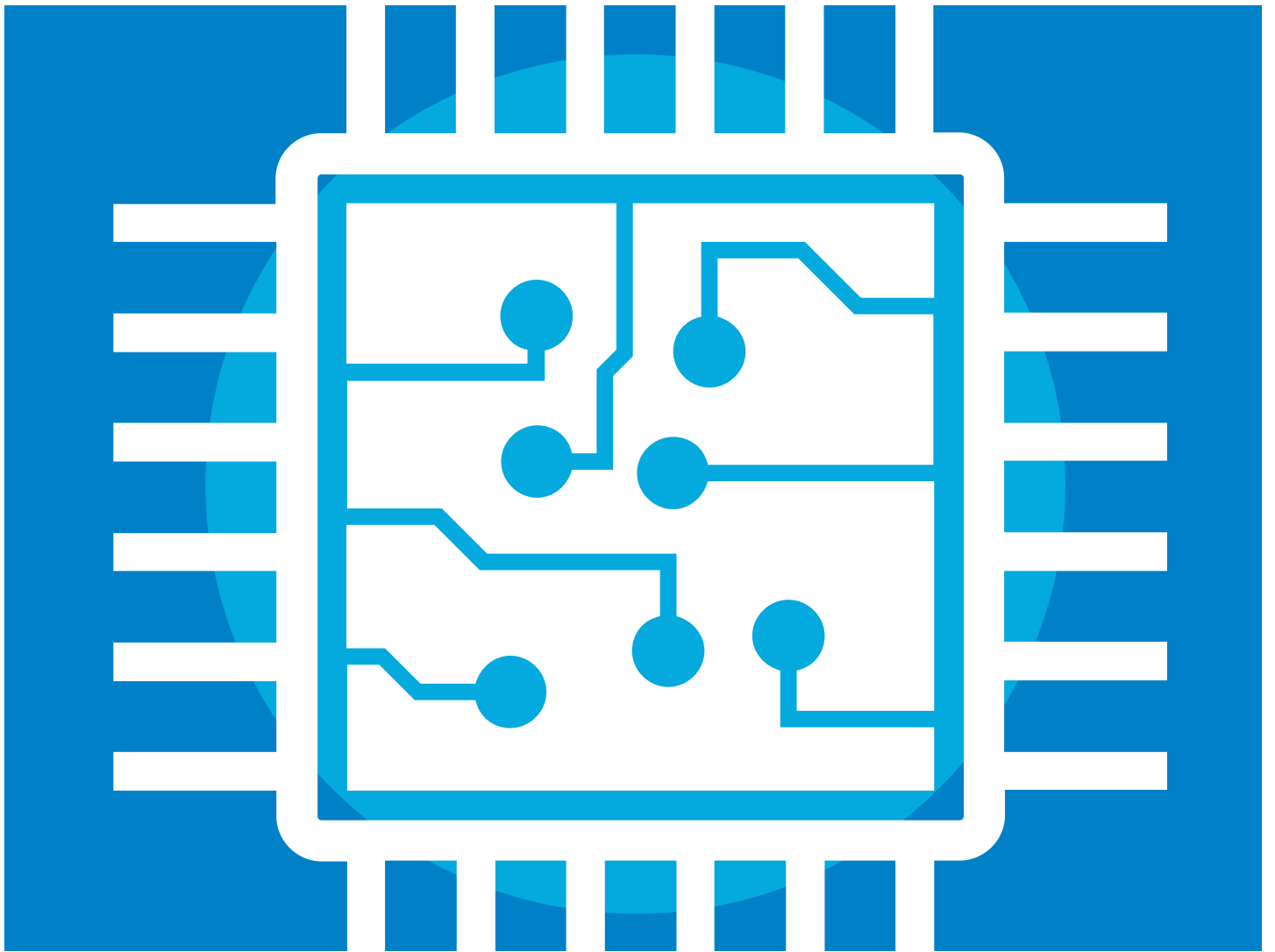2. "Edge Computing Solutions Powering the Fourth Industrial Revolution," IDC, sponsored by Lumen, January 2021.

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