



Edge Computing: Driving New Outcomes from Intelligent Industrial Machines



Executive summary

Industrial companies have used technology for decades to automate processes and streamline operations. Data from sensors, historians, SCADA systems, and similar technologies became fertile ground for cloud computing and big data analytics to extract new insights from operations. Sample benefits from these technologies include higher asset uptime, lower costs, and better production.

But even as cloud computing, mobile, and big data continue to make inroads within industrial organizations, another technology phenomenon is emerging—edge computing.

'Edge' refers to the computing infrastructure that exists close to the sources of data. In the context of Industrial Internet of Things (IIoT), where industrial machines are the “things” from which data is sourced, edge computing is where cyber (i.e. software) meets physical (i.e. machines).

Edge, in the context of the cyber-physical boundary sits in contrast with more centralized and generalized capabilities of cloud computing.

Edge computing can include sources of data such as controllers, gateways, and distributed controls systems, and the aggregation of data from a variety of equipment and sensors in an environment.

In this paper, we will discuss the rise of intelligent industrial machines enabled by edge computing, and provide use-case examples for applying this latest innovation to more effectively tap and unleash machine data for better industrial business results.

For industrial organizations, this isn't a fuzzy vision of the future — it's a necessary and logical next step in the march towards digital transformation.



Connected things and the data tsunami

The notion of connectivity has evolved greatly over the past 20 years. In the 1990s, the emphasis was on connecting computers. Fast-forward ten years and the rise of cloud computing, smart phones, and social media shifted the focus to connecting people to enterprise resources. Today, it's about connecting everything—a vast distributed computing system comprised of billions of smart sensors, machines, and devices.

The scale of these industrial “things,” the systems connecting them, and the data they produce will be unprecedented. An estimated 44 zettabytes of digital data will be created by 2020¹, with 180 zettabytes generated by 2025. To add some perspective, one zettabyte is one trillion (with a T) gigabytes (GB). How much of the 180 zettabytes of data will come from IIoT is unknown. But industry analysts agree that the bulk of the data generated from all these “things” will come from smart, intelligent machines such as undersea blow-out preventers, water injection pumps, and MR scanners.

Here's the issue, though: sending massive volumes of data to the cloud, even if technically doable, is both cost prohibitive as well as impractical. And with more compute, storage, and analytic power being packed into smaller devices, research firm IDC estimates that “by 2019, 40% of IoT data will be stored, processed, analyzed, and acted upon close to or at the edge of the network².”

While machines are getting smarter (thanks to all those sensors), extrapolating the full value of the data these smart machines create is getting harder. GE believes that roughly 3% of the data generated by machines is actually delivering meaningful insights and effectively being monetized. Put another way, there's a 97% upside of machine data value that edge computing can help unlock.

Operating at industrial scale and speed

The IIoT has put in motion a new paradigm to help industrial organizations become digital industrials in the pursuit of higher growth and optimal performance. The World Economic Forum³ identifies several key business outcomes from digital transformation, including operational efficiency (e.g., improved uptime, asset utilization) and increased visibility into products, processes, customers, and partners. Companies that lead their industry in monetizing machine-generated data have the opportunity to distance themselves from organizations that lag behind.

However, until recently, making sense of all the data generated by intelligent machines has been limited to collecting, aggregating, and forwarding data to the cloud where it gets processed. But now, edge computing—pushing computing apps, data, and services to the logical extremes of the network⁴—is emerging as an indispensable element of the IIoT value proposition.

The rise of edge computing is being driven by four key enablers:

- 01 **Dramatically less expensive and more powerful processors and sensors over time, thanks to Moore's Law**
- 02 **More computing that can be performed in smaller physical spaces and in smaller devices**
- 03 **“Small data” analytics performed at the edge (vs. big data in the cloud) allowing industrials to tap new value directly at the machine level**
- 04 **Machine learning, deep learning, neural networks, and other advanced techniques for analyzing and understanding data continues to improve**

40% of IoT data will be acted upon at the edge by 2019



For IIoT operations, edge computing can mean the difference between growth and stagnation, or worse. The evolutionary transformational steps of edge computing capabilities will open the door to a new universe of opportunities for both contextualizing and analyzing data at the speed and scale required for delivering meaningful and significant business outcomes.

That's where innovative software and computing platforms come into the picture. By themselves, sensors and smart machines have limited value. What good is the data they produce if it can't be put to use quickly and easily by the people who need it?

Take, for example, a windfarm operator who is tasked with ensuring that each wind turbine operates optimally to capture maximum wind currents. In some situations, the remoteness of the windfarm may prevent it from Internet connectivity. As wind directions shift, edge technology can be used to collect, analyze, and take action on turbines to adjust blades accordingly. This allows the operator to reap maximum machine value, productions, and revenue generation—even without connectivity.

Edge computing and cloud computing: A perfect match

Unlike centralized computing paradigms such as cloud computing, which usually takes place at a considerable distance from a user or a device, edge computing is close to the heart of the action, dealing with shifting conditions and changing circumstances as they occur, from moment to moment.

Any connected gadget or piece of equipment can be an edge computing device—wearable tech, driverless cars, smart thermostats, and even smart appliances. But in an industrial setting, such as electric power generation or manufacturing, edge computing devices can include machines such as robots, drones, elevators, traffic signals, street lighting, jet engines, pumps, valves, wind turbines, and more.



Lower cost through automated process changes

A municipal waste water treatment plant cleans water prior to discharge into a local river. It's an energy-intensive process where electricity is the highest cost. The timing of the processes is defined in the control logic with scheduled set-points. These set-points are revised based in part on electricity pricing forecasts. Operating when pricing is lower drives down the cost of the process.

GE's Predix platform was implemented to access external electricity price time-series data, which is fed into a forecasting algorithm coded into a GE application. The app computes the optimal set-point for the process based on pricing forecast and feeds it into the controller. By adjusting the timing of the process through the controller according to changing market conditions, the customer reduces production cost by reducing electricity usage—all without human intervention.

And while edge computing will take on more industrial compute workloads in the future, make no mistake: cloud will continue to play a critical collaborative role with the edge. Remember the 44 zettabytes of data? Some of that data will be actuated at the machine level where it's created. But a lot of that data will still be necessary to IIoT success, and cloud was built for compute and analytic heft.

Think of edge and cloud computing as two hands working together, sharing workloads as needs dictate. Some scenarios will have edge computing handling the bulk of the workload, while cloud plays a minor role. In other scenarios, edge computing will play a limited role, pushing the bulk of the data to the cloud for tasks such as machine learning, predictive

analytics, and so on. The point is, both the 'edge hand' and the 'cloud hand' are needed to effectively manage and hand-off workloads for maximum impact.

Consider a turbine running in a modern power plant. A single turbine can generate 500 gigabytes of data every day. Some data will have brief relevance (the need to take immediate action based on a given condition), while some of it will have longer-term value (e.g. multi-site, multi-machine analysis).

The edge device extracts relevant information from the flood of raw data streaming from a machine and quickly converts it into actionable insight that can be actuated directly on the machine in near real-time, or be used by technicians at the

plant to optimize operations. Other data will be sent to the cloud to track historical and current behavioral patterns that can then be used for asset performance management (APM), digital twin modeling, and related high compute and analytic tasks.

What we will see, then, is the rise of a new generation of distributed computing systems that comprise on-premises, cloud, and edge computing—all playing complementary roles.

Edge computing vs. On-premises technology—Important distinctions

Edge computing refers to computing power nearer to where the data is created—the machines.

While edge computing is by definition on-premises, there are many types of on-premises computing that are not considered edge technologies. For example, a private cloud environment, or a typical application server are not considered edge computing per se.

Use cases for edge computing, include:

- Latency—when extremely low latency is essential for near real-time control of the industrial machines
- Bandwidth—when limited bandwidth prevents data being pushed to the cloud
- Connectivity—when location has limited, intermittent or no connectivity
- Small form factor—when smaller footprint apps/services are required to manage machine assets

Use cases for cloud computing, include:

- Compute-intensive workloads, such as machine learning
- Cross-plant, multiple machine data analysis
- Integration with business systems
- Predictive maintenance and asset performance management



Unlocking new value from machine data: The march toward predictive operations

It's not an exaggeration to say that edge computing will become critical to the practice of predictive operations, and that predictive operations will be crucial to the smooth functioning of a global economy that's increasingly dependent on automated systems of smart machines and connected devices.

A predictive operation is an agile operation designed to meet business demand, align people and systems, and reach actual capacity of an operation while still reducing cost and downtime. And achieving lower downtime requires predictive maintenance—a critical outcome found on the road to digital industrial transformation.

Predictive maintenance provides a heads-up before machines and parts begin to fail. The advance warning enables industrials to repair or replace the failing machine or part before it brings down the larger system. Predictive maintenance allows companies to minimize costs while reducing the risk of production failure and human safety.

For example, a national trucking company operates a fleet of 1,000 semi-trailer trucks. The company uses edge computing devices on the vehicle that pull sensor data from the engine, battery, transmission, wheels, and other parts of the vehicle. Edge computing plays an important role of collecting, storing, and sending data securely to the cloud. The fleet operator gains visibility into pending problems that can be scheduled at appropriate times. The operator can also track costs over time per part type, total cost of truck over time, total cost of fleet over time, and so on. This allows the operator to extend truck lifetime value, reduce maintenance costs, and improve physical safety of the truck driver.

In addition to advanced warning of imminent problems, there's a need to know not just the "what," but also the "why." There can be multiple reasons for devices to malfunction or to perform out of their normal parameters. Is the problem inside the device, or is it caused by other devices around it? Is the signal a false positive, or the sign of impending calamity?



OEMs using edge technology to add new customer value

GE Digital worked with an industrial manufacturer to transform its service model it built to support its assets on customer sites. Before implementing a solution to gain visibility to its assets, the OEM support and services teams operated on a reactive basis—responding to calls once a problem hit. Using Predix, the OEM was able to use the data coming from its assets to avoid outages and downtime, increasing customer satisfaction.

With increased visibility, the OEM was able to trouble-shoot faster, which in turn increases their technician's productivity. Its customers recognize the value-add the OEM brings, renewing contracts. And by using newly built diagnostic procedures tied to additional sensors in their assets, the OEM can better pinpoint where failures occur—needing only to replace the failing parts and thereby removing the cost of shipping and repair of redundant parts.



A broad IIoT ecosystem for interoperability

Connected products and smart devices will require new forms of technology infrastructure and distributed software architectures. The “connected technology stack” is emerging, just in time for a new round of evolving operational realities and shifting customer demand.

In this new, “connected everything” world, technology is also a natural and embedded part of products. This in turn is enabling new business models for ecosystem partners that deliver revenue benefits and added value to end customers.

For example, original equipment manufacturers (OEMs) need real-time monitoring and analysis of front-line machinery and equipment to optimize operations, reduce defects, and maximize the return on their capital investments.

Clearly, for any technology to achieve mass adoption requires interoperability and integration. The same is true of edge systems with other operational technology (OT), traditional database systems, enterprise applications such as ERP or MES, corporate data, and third-party information. Users and consumers will expect and demand seamless blends of real-time and near-time interaction with other technology. Achieving that state of seamless interoperability and integration will require deeper and richer ecosystems of vendors, integrators, technology partners, and OEMs at all levels.

Undoubtedly, the next evolutionary step in edge computing will depend on higher levels of collaboration among larger sets of technology providers and users, and the emergence of globally accepted standards to guarantee seamless and consistent interoperability across the entire value chain.



Edge computing: GE Digital guidance

Most industrial organizations are still in the early stages of their digital industrial transformation. But as companies map out their strategy, we have provided some guidance for edge computing as part of an overarching IIoT approach.

1. Before you start

Define your goal. This is an obvious point, but one worth mentioning given the criticality of this step. Outlining the industrial outcomes you are trying to achieve, and how edge computing enables those goals is paramount. Key business outcomes can include reduced unplanned downtime, lower maintenance costs, improved asset utilization, optimal performance, and even new business model innovations that further monetize assets and the data they create.

Start with industrial-level cyber security. As part of GE's own digital industrial transformation, we have invested to protect what we connect across edge and cloud devices. Secure-by-design isn't a brand tagline, but a core part of our

development DNA. In addition to GE Digital's secure software development lifecycle practices, we also provide Industrial Control System (ICS) cyber security technology designed for the unique needs and criticality of assets in industrial operations where safely meeting production targets at the lowest cost rule the day. Bottom line: this isn't your consumer cloud or device. This is about intelligent industrial machines that produce the products that fuel revenue for your business. The underpinnings of security must meet the outcome you're trying to achieve.

Pick the right software platform. To achieve your goals, pick a robust, distributed Industrial Internet platform that can scale as your transformation initiative scales. It's important to remember that connected industrial systems grow continually in scale and heterogeneity. That continual expansion supports the business case for comprehensive platforms over point solutions. For example, GE's Predix platform is designed for handling the challenges inherent in IIoT scenarios and use

cases. As a distributed application and services platform from edge to cloud, Predix is a key enabler to GE's own digital industrial transformation. Also, make sure there is a robust partner ecosystem (ISV, systems integrator, VARs) to help you navigate the transformation journey.

2. Pitfalls to avoid

As you begin the process of mapping your strategy, there will be definite dangers along the way. For example, agile development and minimal viable products (MVPs) have become key success factors in getting technology created iteratively and quickly. But in industrial operations, getting technology working quickly and getting something working sustainably—in what is often very severe conditions—are extremely different.



Gartner's Ganesh Ramamoorthy says 8 out of 10 IoT projects fail⁵ even before they are launched because most IoT projects that are being deployed are solutions in search of a business problem. And if high IoT project failure rates aren't motivation enough, there's also a tendency to underestimate the high cost associated with stitching together a home-grown industrial software application, or even a mix of home-grown and general-purpose platforms that span from edge devices to cloud systems.

3. Learn from others

At GE, we get a lot of questions about our approach to IIoT, and what we're doing to implement digital transformation strategies. We recently published our own [Digital Industrial Transformation Playbook](#)—a proven strategy and set of practices GE took to improve productivity and drive down costs. Reducing costs frees up cash that can be used to enable internal improvements that self-fund the next step in the transformation journey, such as new product introductions or x-as-a-service models.

Net takeaways

Tens of billions of devices are expected to be connected by 2020, unleashing a torrent of machine data in the decade to come. Achieving growth and productivity gains will require industrial organizations to become digital industrials.

In recent years, cloud computing and big data analytics have helped industrials gain insights into production and performance that have improved operations. But the emergence of edge computing will play a pivotal role in meeting the unique needs of industrials that require faster response times and lower latencies than would be possible with cloud-only systems. As noted, cloud computing isn't going away anytime soon. Cloud combined with edge technology will be essential allies that help industrials monetize machine-generated data more completely.

The emergence of seamless ecosystems of interoperable components and subsystems functioning together smoothly will enable real-time data analytics and actionable insights that drive growth for a new generation of digital industrials. To learn more of GE's approach to edge computing and the Predix platform, visit www.ge.com/digital/predix.

Sources

¹[152,000 Smart Devices Every Minute In 2025: IDC Outlines The Future of Smart Things](#)

²[The IDC FutureScape: Worldwide Internet of Things 2017 Predictions](#)

³[Industrial Internet of Things: Unleashing the Potential of Connected Products and Services](#)

⁴Wikipedia: [Edge Computing](#)

⁵Gartner: *8 out of 10 IoT projects fail even before they are launched*, [ETCIO.com](#)





About GE

GE (NYSE: GE) is the world's Digital Industrial Company, transforming industry with software-defined machines and solutions that are connected, responsive, and predictive. GE is organized around a global exchange of knowledge, the "GE Store," through which each business shares and accesses the same technology, markets, structure, and intellect. Each invention further fuels innovation and application across our industrial sectors. With people, services, technology and scale, GE delivers better outcomes for customers by speaking the language of industry.

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