Working Smarter Starts with AI at the Edge

Learn about the latest advances at the edge and get useful tips for putting smart IoT to work today.

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Introduction

The benefits of Internet of Things (IoT) technology powering edge computing solutions grows daily, fueled by the demand for real-time insights, better connectivity, and more autonomous operations. It is no surprise that the size of the global IoT market is projected to exceed USD 1.5 trillion by 2025. Edge solutions are rapidly increasing, driven by business leaders looking for ways to compete and win in their respective verticals.

Early IoT devices were typically rigid, proprietary systems that had a fixed function and hardwired code. Today, software-defined edge systems that use modern IT management models can be remotely programmed in the field.

Now edge devices are running artificial intelligence (AI) applications in practically every industry.

- **Smart manufacturing devices and robots automate tasks and schedule their own maintenance appointments, yielding savings and less downtime.**
- **In stores, smart shelves automatically reorder hot items to ensure product availability and maximize profitability.**
- **Smart medical devices use AI to assist with both diagnostics and procedures, freeing up physician time to focus more on providing the best possible patient care.**
- **Modern medical imaging equipment can learn to perform new tasks, expanding capabilities from just capturing images to also analyzing them to uncover anomalies.**
- **Robots can rapidly switch between welding trucks and welding motorcycles.**

AI at the edge requires precise planning, iterative implementation, and expert partners from device to data center to the cloud. Once in place, intelligent edge systems offer businesses the ability to rethink and reinvent themselves. Although these changes are not trivial, finding the right partners and technology can help deliver dramatic payoffs in relatively short order.

IoT evolution: From sensors to sentient

1974

Early computer vision enables **barcodes** to automate supermarket checkout and airport luggage processing.

1982

Internet-connected sensors in factory equipment eliminate need to manually **check machine status**—saving travel time and improving efficiency.

1990

First IoT device—an internet-controlled smart toaster—debuts at Interop 1990.

1999

The term **"internet of things"** coined by RFID pioneer Kevin Ashton; legacy devices connect to the internet.

Rise of AI in IoT enables smart analytics at the edge. Machines react, make decisions, and pass insight to other machine and control systems. Automation and autonomy further improve IT efficiency.

2014

Dublin becomes the **first IoT city**, using IoT devices to improve city functions such as flood zone monitoring, smart trash bins, and city sound monitoring.

2015

DHL predicts IoT will save organizations USD **1.2 trillion in productivity costs alone.**[1]

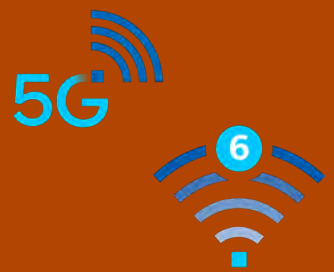
2020

Converging technologies such as **5G and Wi-Fi 6** put wireless edge connectivity almost anywhere, while convergence of IT and operational technology (OT) eases IoT integration across the board.

Open standards, middleware, and software—running on industry-standard PCs and servers—are **growing the number of use cases daily** while lowering total costs.

2025 and beyond

The edge experiences explosive growth. **More than half of all enterprise data will be generated by IoT by 2025.**



Smart IoT is not tomorrow. It is now.

Until recently, organizations undertaking IoT projects often found the reality did not live up to their expectations, as projects ran head-on into compute limitations and prohibitive bandwidth costs, wiping out projected ROI. Designers and developers would struggle to create solutions for many industry segments due to the lack of options available to build more purposeful solutions.

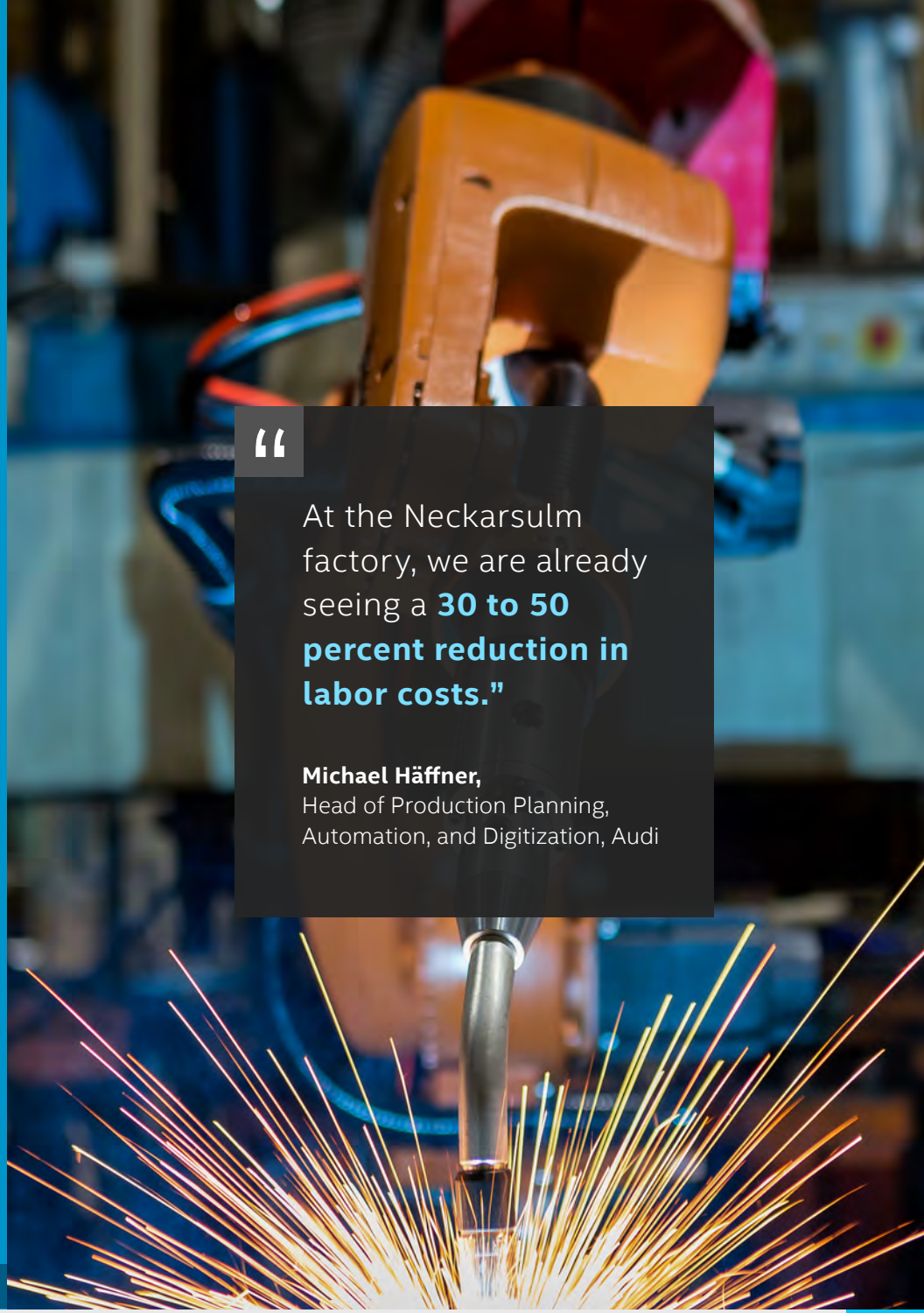
Now technology advances are enabling the vision to be fully realized. AI-enabled IoT has graduated from possible to the plant floor. More-powerful smart IoT solutions are now deployed across a wide swath of industries with new uses being rolled out daily. Here are some innovative IoT deployments that are leading the charge.

Case study

Smart Industrial IoT: Higher quality, lower costs for Audi

Carmaker Audi's secret to success is a commitment to cutting-edge technology to build high-quality vehicles while striving to achieve Industry 4.0 levels of production.

Audi partnered with Intel to improve the quality-control (QC) process for thousands of robotic spot welds that go into each vehicle produced daily at the Audi factory in Neckarsulm, Germany.



> "At the Neckarsulm factory, we are already seeing a **30 to 50 percent reduction in labor costs."**
>
> **Michael Häffner,**
> Head of Production Planning, Automation, and Digitization, Audi

To ensure the quality of its welds, Audi performed manual QC inspections by sampling one car out of the thousand or so manufactured each day. Eighteen engineers with clipboards used ultrasound probes to test and record the quality of each weld. This costly, labor-intensive method also left many unanswered questions about the quality of the other 999 cars produced each day.

To solve this issue, Audi and Intel created algorithms that could spot problem welds as they occurred at each welding gun. By training the algorithm using actual inspection data, they created a visual dashboard that alerts technicians of faulty welds or determines a potential configuration change that could minimize or eliminate faults altogether.

Moving from manual inspections to an automated, data-driven process has enabled Audi to go from **inspecting just one car per day to 100 percent inspection of every weld.** And there are other benefits that result from automation. These precise inspections enable Audi to be proactive and focus on avoiding problems rather than merely reacting to them.

"Let's say we do an overall inspection of 5,000 or more welds on one car a day, and maybe 95 percent of those welds are good and 5 percent are not," says Mathias Mayer, who leads automation technology planning at Audi. "In the future, we can focus on the 5 percent, because we know where they are in the factory and we can take action much sooner."

Read more about Audi's automated inspection system ›

Case study

Smarter oil wells: ExxonMobil powers innovation in oil and gas production

There are big changes underway in the world of oil and gas exploration and production.

Many gas and oil field locations have dozens of individual wells, which typically require their own monolithic devices to control pumping, measurement, equipment control, and more. These devices each have their own proprietary interfaces, creating a communications backlog and management nightmare, forcing producers to purchase additional units that are spread out across the site.

ExxonMobil

The Universal Wellpad Controller (UWC), developed by ExxonMobil and Intel, eliminates these monolithic, single-function devices and replaces them with industry-standard hardware and open source, software-based systems that eliminate the vendor lock-in that plagued older systems.

The UWC is an extremely high-performance control system built on an industrial PC. Multiple control functions run side by side as containerized software, which allows the UWC to adapt and evolve. When operators need to add new equipment or change sensors on a well, they simply plug them in and upload new control software.

The UWC reference design also puts AI at the center of well operation, production, and maintenance. The UWC analyzes and optimizes production in near-real time on the controller, without the need to send collected data to a central location for processing and analysis.

The system includes asset management software that can actively track wellpad equipment, analyze performance, and notify technicians when a component needs to be repaired or replaced.

A single UWC can serve every phase of a well's life cycle, from free-flowing high production to secondary recovery and low production.

The net results are increased performance and reduced expenses throughout the well's production life cycle. Field technicians and IT work with one system, which lowers training and administration costs. Monitoring, updates, and upgrades can happen remotely, and there is less equipment to house and secure in the field.

Read the white paper ›

Case study

Medical magic: Samsung IoT improves maternal, fetal safety

The World Health Organization estimates that nearly 300,000 women died during and after pregnancy and childbirth in 2017. Although most maternal deaths are preventable, women receiving no prenatal care are five times more likely to have a pregnancy-related death than women who do receive prenatal care. In particular, the lack of information on fetal growth can hinder the delivery of essential prenatal care.

SAMSUNG MEDISON

To help physicians detect potential issues earlier, Samsung Medison and Intel have collaborated to bring AI into ultrasound clinical workflows. Samsung Medison's BiometryAssist automates and simplifies fetal measurements, while LaborAssist uses ultrasound images to automatically estimate the fetal position during the birthing process, reducing the need for invasive internal exams.

Combined, these tools enable teams to recognize fetal growth restrictions during pregnancy and determine the best mode of delivery, improving fetal health and potentially reducing the number of unnecessary cesarean sections.

Automating and standardizing fetal measurements with a single click at over 97 percent accuracy[1] allows doctors to spend more time talking with their patients instead of manually interpreting readings.

"Samsung is working to improve the efficiency of new diagnostic features, as well as healthcare services, and the Intel® Distribution of OpenVINO™ [toolkit] library and OpenCV library have been great allies in reaching these goals," said Won-Chul Bang, corporate vice president and head of Product Strategy, Samsung Medison.

Read the white paper to learn more ›

> "LaborAssist provides automatic measurement of the angle of progression as well as information pertaining to fetal head direction and estimated head station. So it is useful for explaining to the patient and her family how the labor is progressing, using ultrasound images, which show the change of head station during labor. It is expected to be of great assistance in the assessment of labor progression and decision-making for delivery."
>
> **Professor Min Jeong Oh,**
> MD, PhD, Department of Obstetrics and Gynecology, Korea University Guro Hospital in Seoul, Korea

Case study

Context-aware recommendations improve Burger King customer experience

Few industries have as much competition as fast food and quick-service restaurants. Although some chains have adopted edge devices such as kiosks and digital signs indicating an order is ready, Burger King, a global fast food leader, has taken intelligence at the edge up a notch. Their adoption of AI at the edge demonstrates how restaurants are transforming themselves with new business models that provide a richer, more rewarding customer experience.

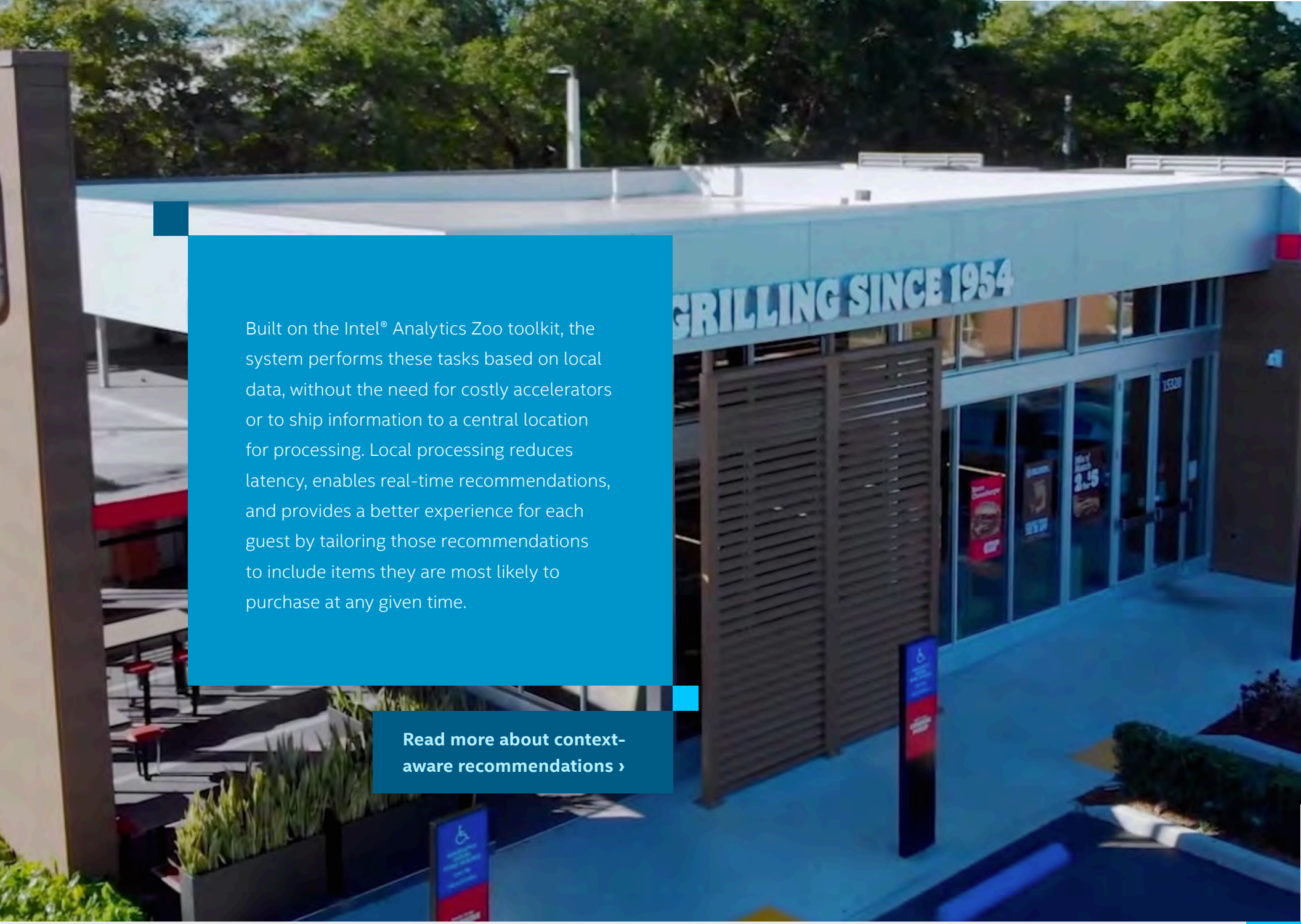
Burger King has developed a fast food recommender system that offers customized suggestions, considering factors including the guest's ordering behavior as well as contextual information such as weather, time, and location.

> What we're doing is using data to personalize based on weather or time of day or other data we've collected to make sure that each individual is experiencing a truly personal experience while they're interacting with our brand and in our drive-throughs."
>
> **Whitney Gretz,**
> Vice President of Digital and Loyalty,
> Burger King

The system learns order sequence data and combines it with information such as the local weather and typical order behavior. The system will suggest items based on:

- **What is already in the basket**
- **What has been sold in the past**
- **What is selling today**
- **What is offered at that location**

The results can be surprising. For instance, Luyang Wang, director of Advanced Analytics and Machine Learning at Burger King, said the software found that guests will order milkshakes in any weather—even when it's cold outside. Wang also noted the software found that people are much more willing to add a dessert when they have a high-calorie basket vs. a low-calorie basket.[2]



Built on the Intel® Analytics Zoo toolkit, the system performs these tasks based on local data, without the need for costly accelerators or to ship information to a central location for processing. Local processing reduces latency, enables real-time recommendations, and provides a better experience for each guest by tailoring those recommendations to include items they are most likely to purchase at any given time.

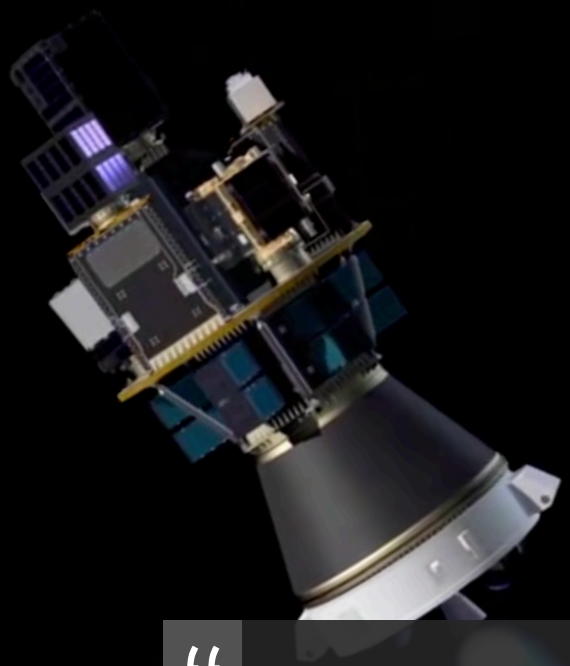
Read more about context-aware recommendations ›

Case study

European Space Agency satellites use AI to send more actionable data, improve bandwidth efficiency

When thinking about AI and edge computing, most IT pros consider factory sensors and industrial robots. However, there is no AI platform more "on the edge" than the PhiSat-1 satellite, now zooming around the Earth at 17,000 miles per hour at an altitude of 329 miles in a sun-synchronous orbit.

Since about two-thirds of Earth's surface is covered by clouds at any given time, Earth-imaging satellites typically capture—and transmit—many useless images of clouds, wasting both valuable bandwidth and storage capacity. Worse, scientists (or algorithms) then must sort the usable images from the cloud-shrouded ones, wasting even more resources.



> "Space is the ultimate edge."
>
> **Aubrey Dunne,**
> Chief technology officer, Ubotica, designer of PhiSat-1's technology

Enter PhiSat-1, one of a pair of satellites powered by a new hyperspectral-thermal camera and onboard AI. PhiSat-1's primary mission is to monitor polar ice and soil moisture while also testing intersatellite communication systems to create a future network of federated satellites.

Another major goal for PhiSat-1 is to solve an emerging problem: how to deal with the exponentially growing amount of data captured—much of it cloud cover—by increasingly powerful sensors on the edge when bandwidth is limited.

"The capability that sensors have to produce data increases by a factor of a hundred every generation, while our capabilities to download data are increasing, but only by a factor of three, four, five per generation," says Gianluca Furano, data systems and onboard computing lead at the European Space Agency (ESA), which led the collaborative effort behind PhiSat-1.

PhiSat-1 uses onboard AI to identify and delete cloud-covered images before transmitting data back to Earth. After a three-week test, ESA announced the AI system a success. “We were happy to reveal the first-ever hardware-accelerated AI inference of Earth observation images on an in-orbit satellite,” says Furano.

By only sending useful pixels, Furano says PhiSat-1 will “improve bandwidth utilization and significantly reduce aggregated downlink costs”—not to mention saving scientists time on the ground.

Future applications may include spotting wildfires and notifying local responders in minutes rather than hours, spotting rogue ships on the high seas, and helping to prevent environmental accidents.

Read more about the first satellite with AI on board ›

Tips you can use: How to put smart IoT to work

How can organizations accelerate moving intelligence to the edge? In this chapter, we have compiled some best practices from the most-successful IoT implementations that every professional should consider.

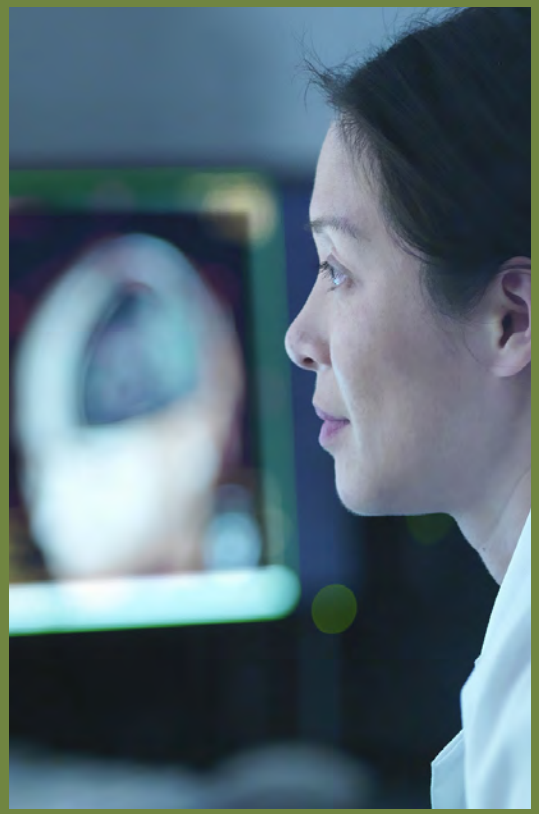
01 Prioritize impact

Identify high-potential applications that can offer solid, measurable returns on capital investment. IoT leaders are challenged by balancing shrinking budgets while trying to move their organization toward the edge and emerging technologies. Leaders tend to implement more high-potential IoT applications including those applications focused on:

- **Employee health and safety**
- **Improvements to the customer experience (CX)**
- **Efficiency through automation and instrumentation**
- **Product or service quality to produce better outcomes**

02 Own it

Drive action from the top down through the organization. Executive-level participation can be a determinant of IoT success, but it is also critical to identify every stakeholder in the organization—including customers. Use their feedback to tailor IoT practices to maximize existing skills while identifying new hardware, software, and integration skills required to achieve the desired goals.



Tips you can use: How to put smart IoT to work

03 Unify IT and OT

Partner with operations early on. Although IT may be driving AI projects, operations teams have experience interacting with the physical world where edge and IoT devices are deployed. Similarly, although many IoT and edge projects are born outside of IT, IT advances can accelerate AI and deep learning at the edge. IT and OT should collaborate toward a common set of goals to maximize bottom-line benefits of current and emerging technologies.

04 Start where you are

Create a practical plan for adoption. IoT projects that start by augmenting existing processes through workload convergence in partnership with OT teams show more early success than those projects that reach for the stars and beyond the core business. For example, adding connectivity and IoT to existing products and optimizing field service or maintenance products often produces the early wins that fuel further acceptance for more-aggressive projects down the road.

Tips you can use: How to put smart IoT to work

05 Build your team

Don't reinvent the wheel when a **global partner ecosystem** can deliver components, software, IoT management, business processes, or security solutions that are tailored for IoT and edge deployments. By building a team with development, deployment, and management partners, the organization can get to market faster, use proven methods, and acquire necessary skills to perform post-deployment optimizations without impacting the deployment of early IoT wins.

06 Avoid lock-in

Use open, standards-based platforms and open software solutions. Not only does this enable portability, but it also simplifies maintenance and upgrades. Furthermore, open infrastructure typically has a longer total lifespan than point products, and the universe of tech talent for standards-based products is far broader, enabling easier hires.

07 Prepare for change

Moving AI to the edge often requires changes in business processes that follow from IoT adoption. For example, if support teams are used to preventative maintenance, machine sensors that can enable a change to preventive maintenance can confuse management and technicians alike. Consider what else technicians can be doing to add value when their time is freed up by AI at the edge.

Tips you can use: How to put smart IoT to work

08 Defend your data

Prepare for cyberattacks to ensure they do not compromise projects or data. Since the edge can present a new attack surface, ensure that IoT devices and systems take appropriate measures, such as a zero-trust edge (ZTE) approach that helps eliminate most threats before they can do any damage.

09 Crawl, walk, run

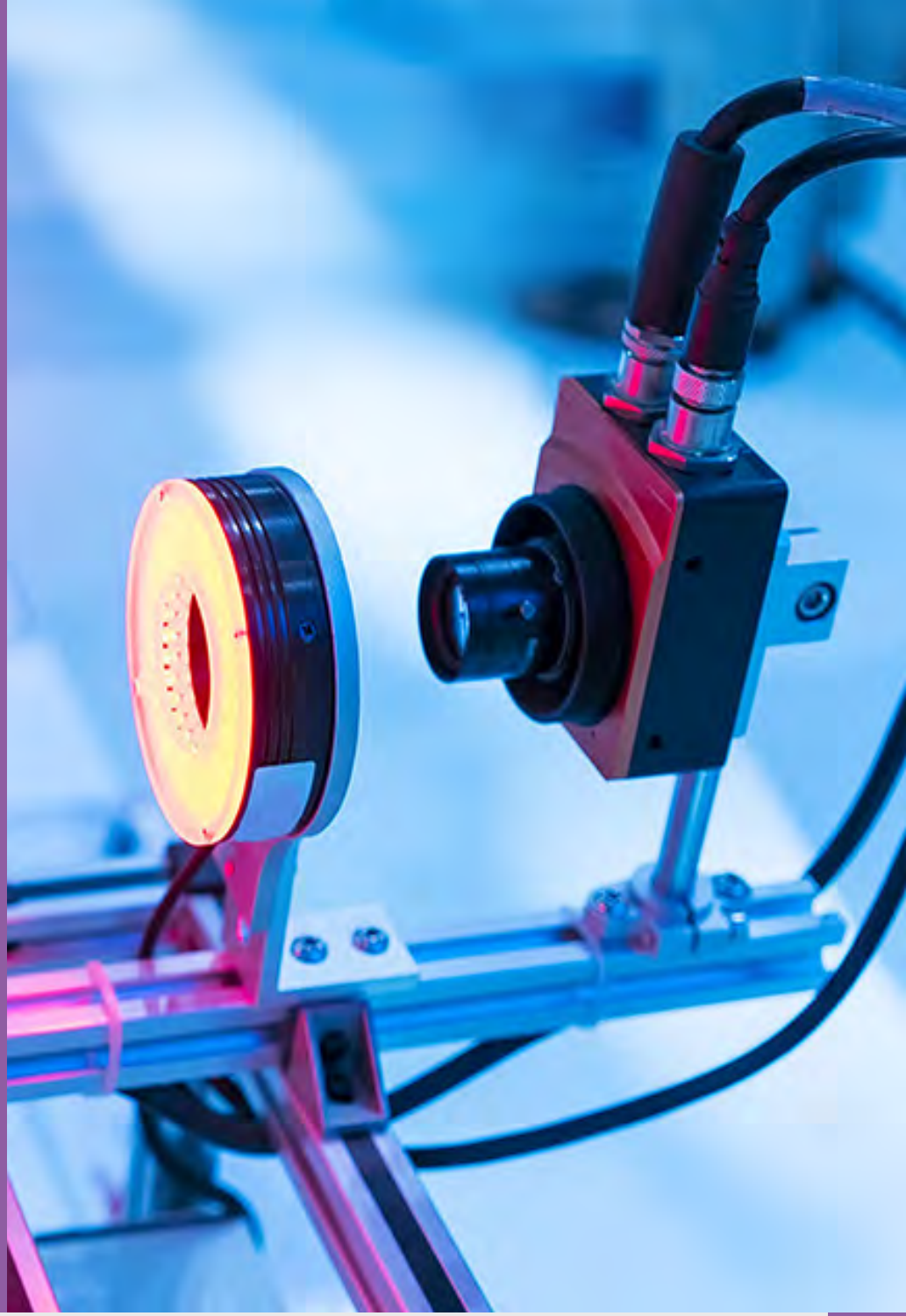
Do not race through each project. Every IoT deployment should have a test phase and a pilot that determines real-world value, and then the project should be refined and expanded based on learnings. Prove value, build success, repeat.

Pushing boundaries to the edge of possibility

Intelligent edge computing is not a pipe dream; it is happening now.

Edge computing solutions from Intel have already powered tens of thousands of deployments that generate real bottom-line value. Edge intelligence is driving IT, and AI is a driver of both edge and IoT solutions.

Innovative solutions from Intel help shift IoT from locked-down, proprietary point products running on dedicated platforms to scalable, off-the-shelf hardware running open source software that offers new solutions and use cases every day.



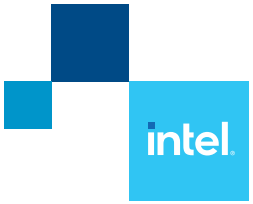
When it comes to IoT hardware, Intel offers a broad range of **processors enhanced for IoT** that are low power, edge optimized, and deliver fast, powerful graphics. But hardware alone does not create value at the edge. Complete IoT solutions from Intel include software tools such as inferencing with the **Intel® Distribution of OpenVINO™ Toolkit**, and testing and prototyping with **Intel® DevCloud for the Edge**. Together, these software and hardware tools lower the barriers to create IoT applications by making things easy with the **Intel® Edge Software Hub**.

And Intel® hardware and software are just the beginning. Intel makes IoT real, reducing complexity and speeding deployment by offering thousands of market-ready solutions for virtually every industry, with new solutions expanding the uses for AI at the edge.

These prebuilt solutions offer speed to market for innovative edge and IoT projects, speeding time to value for a broad range of uses. **Explore the solutions** available to learn what is possible today.

At Intel, we believe IoT and edge solutions are critical components of IT and OT across all industries and for organizations of all sizes. And since data does not stop at the edge, Intel® solutions encompass edge-to-cloud capabilities for communications, data integration, and analysis that meet a broad range of edge and IoT demands.

Smart IoT from Intel pushes AI boundaries to the edge–and beyond.



When it comes to the edge, Intel, together with our partners, is making it real.

Learn more about how Intel can make your edge and IoT vision into reality today.

Get started at **intel.com/edge**.

1. DHL/Cisco IoT Trends Report.
2."How Intel and Burger King built an order recommendation system that preserves customer privacy." VentureBeat, April 6, 2021.

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