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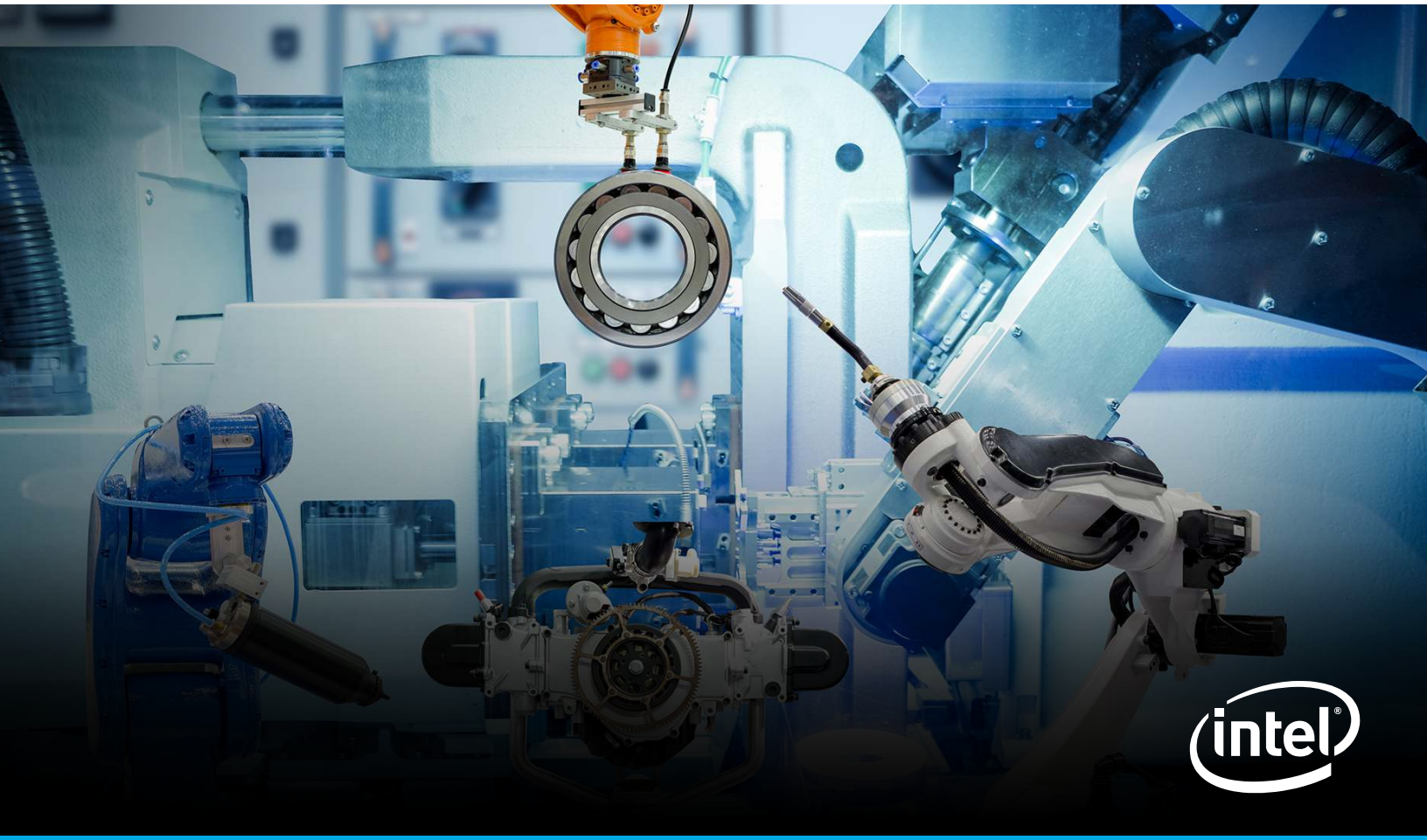
# INCREASING MANUFACTURING FLEXIBILITY, AGILITY, AND COST EFFECTIVENESS WITH EDGE COMPUTING

## HIGHER LEVELS OF AUTOMATION, PRODUCTIVITY, AND EFFICIENCY IN THE AGE OF INDUSTRY 4.0



# IN THIS ISSUE





# REDUCE INDUSTRY 4.0 DATA COSTS WITH EDGE COMPUTING

Industry 4.0 is taking shape, driving manufacturing operations to be more intelligent, networked, digitized, and autonomous. This is happening through the integration of advanced technologies like data analytics, artificial intelligence (AI), the Industrial Internet of Things (IIoT), and edge computing, that are contributing to improved decision-making, and increased productivity and efficiency.

**COVID-19:** As we work through the repercussions of COVID-19, Industry 4.0 solutions are helping manufacturers maintain the operations of their factories.

**Jonathan Luse,**
*General Manager, Industrial Solutions Management at Intel*

**INDUSTRY 4.0** is driving higher levels of computerization of industrial environments, enabling greater efficiency, agility, and productivity through real-time, data-driven control of industrial processes.

**THE INDUSTRIAL INTERNET OF THINGS** (IIoT) connects devices, equipment, and data centers in industrial environments, allowing valuable information to be extracted from

**Edge Computing:** Edge computing is the foundation to enable Industry 4.0. It is a powerful compute base at the edge of an industrial network, enabling the consolidation of applications and services critical to factory operations onto one device, which can save equipment and support costs. Also, analyzing operational data close to where it is generated can improve security and response time, and greatly reduce the amount of data sent to the data center.

**EDGE COMPUTING SYSTEMS** process and analyze data near its source (e.g., factory floor) instead in faraway data centers. This approach improves response time and uses less network bandwidth.

The ability to process and analyze this data in near-real-time also reduces the cost and complexity associated with sending the data to cloud. Managing the data and applications at the edge improves security, and in many areas allows compliance to local data regulations.

**Benefits:** In many cases, edge computing will achieve Industry 4.0 objectives at a lower total cost of ownership (TCO) than cloud computing. This is because the data generated by smart factories and power plants can be enormous, measured in petabytes, making it uneconomical and delay-prone to send, store, and process it all in the cloud. In addition, edge computing solutions may provide other cost savings related to security, regulatory compliance, time-critical application development, etc.



**Development Support:** For developers of edge computing solutions, like OEMs, ODMs, and systems integrators, Intel offers a large family of high-performance, scalable computing platforms, as well as technical and business support through the Intel® Internet of Things Solutions Alliance. Edge computing, based on powerful Intel® processor-based platforms, makes it possible to lower solution cost by enabling the consolidation of multiple industrial applications and systems onto one system.

This publication is part of a series related to advanced computing and networking technologies that will drive tremendous innovation in industrial and energy market segments. Future publications will discuss how to architect 5G, AI, and IIoT into industrial environments.

*We're excited by the potential of unleashing data and transforming it into real-time insights to reduce downtime, increase output, invigorate revenue streams, and much more.*

*Around* **10%** *of enterprise-generated data is created and processed outside a traditional centralized data center or cloud. By 2025, Gartner predicts this figure will reach* **75%**.[1]

1. Rob van der Meulen, Gartner, Edge computing promises near real-time insights and facilitates localized actions," October 3, 2018, https://www.gartner.com/smarterwithgartner/what-edge-computing-means-for-infrastructure-and-operations-leaders.

# WHY EDGE COMPUTING IN INDUSTRIAL APPLICATIONS

In industrial and energy production environments, edge computing devices process and store data near the sensors and actuators that generate and consume the data instead of in faraway data centers, providing benefits such as:

- **Faster response:** Eliminate data transmission delay to/from the cloud
- **Lower network usage:** Transmit less data over the network
- **Better data security:** Enable local storage and encryption at the edge to avoid tampering
- **Higher reliability:** Avoid impacts from external network connectivity or other potential service interruptions caused by hosting offsite in a cloud compute environment

Edge computing devices are also gateways for the growing number of IoT devices, helping the integration of operational technology (OT) systems with informational technology (IT) systems, as shown in the figure below.

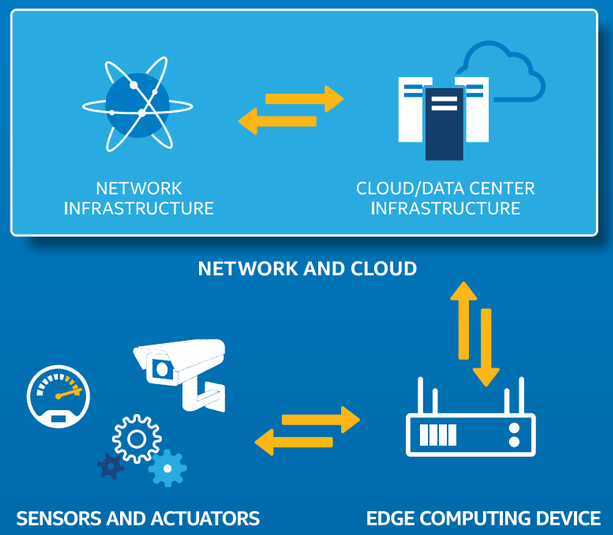



Figure 1. Edge computing devices provide an IT/OT integration layer.



# 7 WAYS EDGE COMPUTING REDUCES MANUFACTURING COSTS

1 **Lower data center/network costs**
Use less network bandwidth and data storage

2 **Higher quality**
Improve processes with high performance processors

3 **Improved reliability**
Reduce reliance on inconsistent networks

4 **Enhanced security**
Minimize the risk of data being intercepted

5 **Simpler IT/OT convergence**
Gain a cost-effective IT/OT integration layer

6 **Fewer manufacturing systems**
Consolidate systems on edge computing device

7 **Easier regulatory compliance**
Encrypt data from the edge to the data center

# MICROSERVICES INCREASE FLEXIBILITY AND AGILITY

Industry 4.0 is facilitating a move to software-defined manufacturing (SDM), which gives manufacturers more flexibility and agility than the fixed-function, monolithic systems used today. At a basic level, SDM decouples manufacturing software and hardware, so software performing a specific task, like "compare two images," can be run on various general-purpose hardware platforms, like edge computing devices.

The figure below compares monolithic and microservices architecture, depicting how microservices, because of their small size, can be relatively easy to build, deploy, scale, and maintain.[2] As manufacturers require more agility to handle greater product and batch variance, the flexibility to quickly modify or create microservices (potentially running on an edge computing device) helps deliver the efficiency and innovation potential of Industry 4.0.

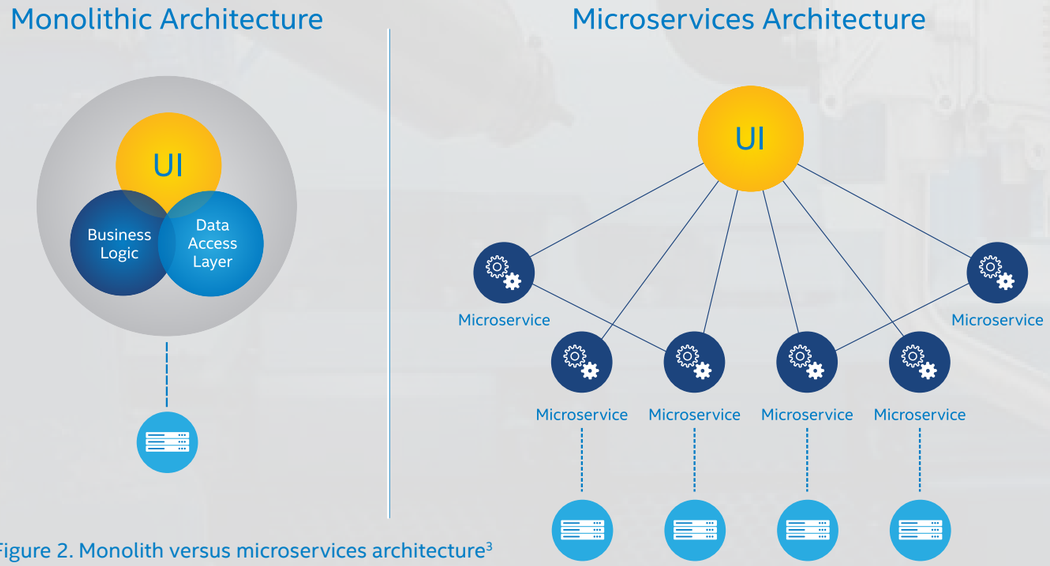



Figure 2. Monolith versus microservices architecture[3]

2. Hazelcast, "Microservices Architecture Explained," https://hazelcast.com/glossary/microservices-architecture.
3. Alex Barashkov, "Microservices vs. Monolith Architecture," December 4,2018, https://dev.to/alex_barashkov/microservices-vs-monolith-architecture-4l1m.



# EDGE COMPUTING AND MANUFACTURERS

It's not unusual to find manufacturing systems still in use after many decades or more, so when some manufacturers are apprehensive about edge computing, it shouldn't be a big surprise. Like the saying goes, "*if it ain't broke don't fix it.*"

With that in mind, edge computing solution providers need to be aware of some of the concerns their customers may have about deploying edge computing.

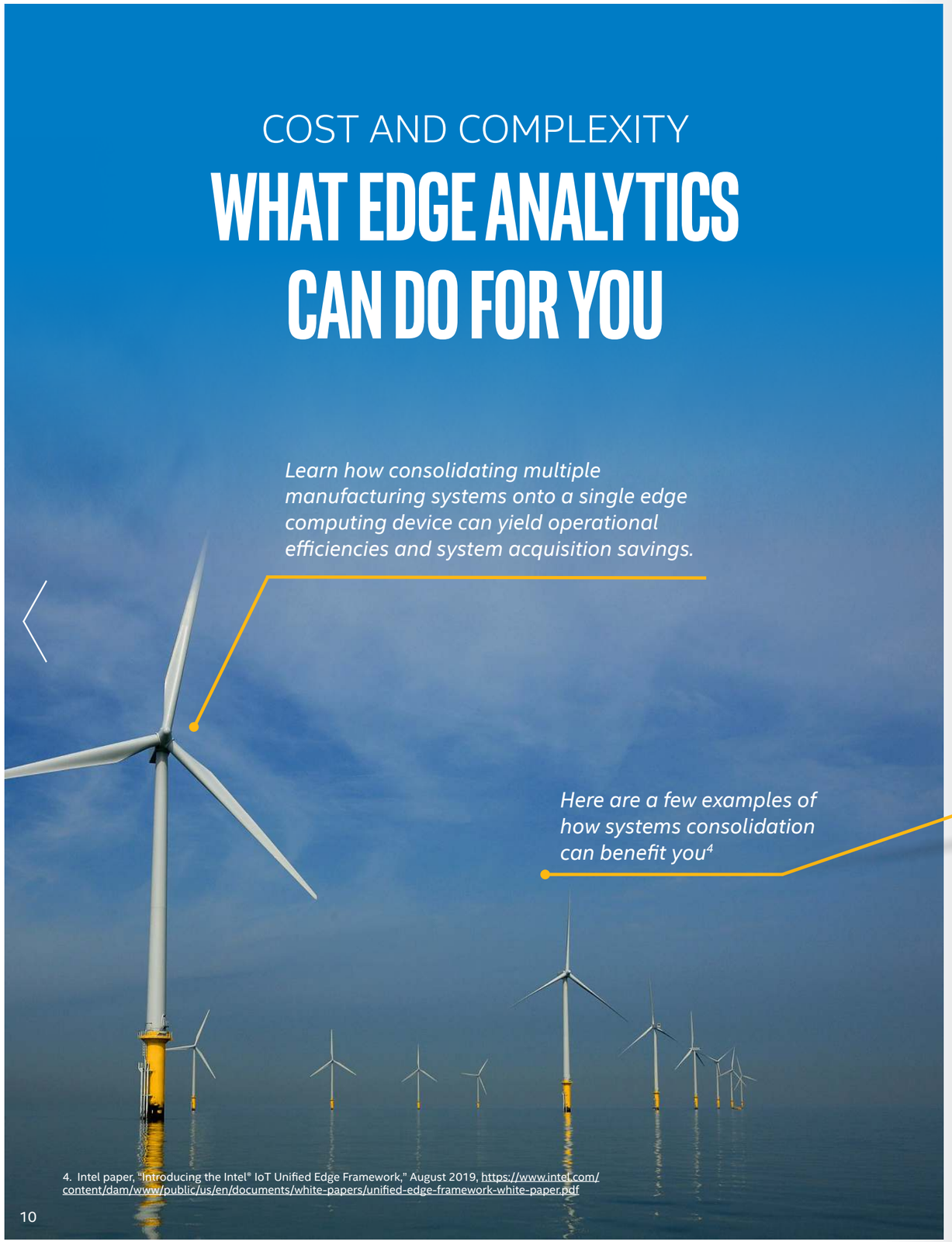
## MANUFACTURERS' PAIN POINTS

COST AND COMPLEXITY

# WHAT EDGE ANALYTICS CAN DO FOR YOU

*Learn how consolidating multiple manufacturing systems onto a single edge computing device can yield operational efficiencies and system acquisition savings.*

*Here are a few examples of how systems consolidation can benefit you*[4]



4. Intel paper, "Introducing the Intel® IoT Unified Edge Framework," August 2019, https://www.intel.com/content/dam/www/public/us/en/documents/white-papers/unified-edge-framework-white-paper.pdf



**Georgia Pacific (GP)** one of the world's leading makers of tissue, pulp, packaging, building products, and related chemicals – deployed IoT solutions at scale in order to improve production efficiency and quality at its 150 manufacturing locations in North America. It later became clear the maintenance and support for all these solutions was an enormous task.

To lower support costs, local teams consolidated three systems from different vendors into one standardized compute stack running on an edge device designed with an Intel® Core™ processor.

Based on the initial deployment, GP estimated the following savings from continuing to consolidate manufacturing systems.

**Maintenance and Support**
Manufacturing systems consolidation could reduce training and troubleshooting, and simplify integration, patching, and upgrades.

Cost Reduction: **+30%**

**Hardware**
Assuming a five to seven year replacement, initial hardware costs are less.

Cost Reduction: **+30%**

**Performance and Uptime**
Reducing the number of systems lowers MTBF and MTTR (labor only).

Cost Reduction: **+10%**

**Initial Deployment** (One time)
The time and effort for image and workload deployment, networking, mounting, and activation is reduced by having fewer systems.

Cost Reduction: **+40%**

LACK OF DATA ANALYTICS EXPERTISE

# COMMERCIALLY-AVAILABLE DATA ANALYTICS

Industry 4.0 promotes the use of data analytics to increase productivity and efficiency in ways that help manufacturers make the best business decisions about running their plants. However, incorporating AI and machine learning presents some infrastructure challenges, such as deploying solutions to capture, store, and process a large amount of data and do it in real time, or near-real time.

But not every OEM, systems integrator, or manufacturer has the resources to create an edge analytics solution. Fortunately, there are many commercially-available data analytics software packages that can dramatically reduce development and deployment times.

### Off-the-Shelf Solutions Available

For example, Intel's Edge Insights for Industrial software works out-of-the-box to extract data from machines, gateways, and devices, such as cameras, at the edge. It can also communicate information interchangeably and securely, provide cohesive management, and analyze data quickly in an industrial environment. As a result, this open, modular, and validated software product enables fast productization, quick deployment, and shorter time-to-market for industrial use cases.

## DIGITAL TRANSFORMATION BY 2020[5]

| | | |
|---|---|---|
| AVERAGE INTERNET USER | 1.5GB | Data/day |
| SMART HOSPITAL | 3TB | Data/day |
| AUTONOMOUS AUTOMOBILE | 4TB | Data/day |
| CONNECTED AIRPLANE | 40TB | Data/day |
| SMART FACTORY | 1PB | Data/day |

## INTELLIGENCE AT THE EDGE

Bandwidth, Storage, Latency, Security

**45%** of data will be stored, analyzed, and acted on at the edge by 2019[6]

**43%** share of AI tasks taking place on edge devices (vs. cloud) in 2023[7]

5. Amalgamation of analyst data and Intel analysis.
6. IDC FutureScape Worldwide Internet of Things 2017 Projects.
7. ABI Research



SLA REQUIREMENTS

# ACHIEVING REAL-TIME PERFORMANCE

Many manufacturing processes require a constant stream of accurate, well-synchronized data to coordinate various machines on the production line. Likewise, control systems must satisfy stringent precision and accuracy metrics, which play a key role in determining a machine's service level agreement (SLA) guarantees.

When real-time performance is a necessity, time-sensitive networking (TSN) can be used to precisely synchronize manufacturing devices over the network, eliminating the need for the signal-based synchronization methods that are common today. TSN is an update to standard Ethernet IEEE 802.1 that adds network-based time synchronization and deterministic communication.

TSN also enables traffic scheduling and the deterministic transfer of time-sensitive data, which is key machine for control applications requiring low latency and minimal jitter to meet closed-loop control requirements.

Edge computing devices supporting real-time applications can implement TSN by integrating the Intel® Ethernet Controller I210.

### Improving Performance Determinism

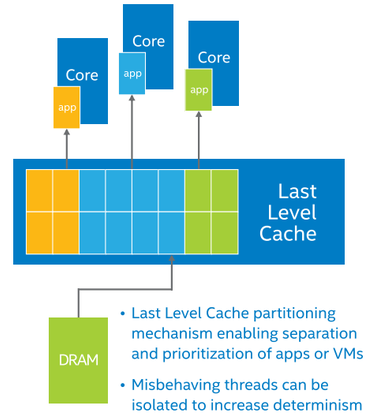
Edge computing devices will typically run a wide variety of applications, but the deterministic performance of time-critical applications must be the top priority. Therefore, it is prudent to prevent non-critical applications from overconsuming platform resources, like cache and memory bandwidth, to the performance detriment of other applications.

### Shared Resource Monitoring and Allocation

Intel® Resource Director Technology (Intel® RDT) brings new levels of visibility and control over how shared resources cache and memory bandwidth are used by applications, virtual machines (VMs), and containers.

The insights gained by cache monitoring can be used to dedicate regions of cache to critical threads, applications, containers, or virtual machines, thereby enabling isolation and prioritization of select workloads. In addition, Intel RDT provides separate control over code and data placement in cache.

Cache Allocation Technology (CAT)




Intel® Resource Director Technology allocates dedicated areas of cache to specific applications.[9]

8. Intel Solution Brief, "National Instruments and Intel deliver accurate, holistic insight for optimized IIoT," August 2018, https://www.intel.com/content/www/us/en/manufacturing/solutions/time-sensitive-networking-brief.html
9. Priya Autee, Harpreet Sindhu, "Intel® RDT Hands-on Lab," June 2017, https://www.slideshare.net/MichelleHolley1/intel-rdt-handson-lab

*"National Instruments chose Intel® architecture as the foundation for the next generation of CompactRIO* because it provides remarkable system performance with low power consumption in a compact board design. This choice resulted in small and rugged controllers that support the synchronization requirements of time-sensitive networking (TSN),"* said Graham Green, principal product marketing manager, National Instruments.[8]

RISK OF CYBER THREATS

# MULTILAYER DEFENSE

As cyberthreats escalate, it is critical to adopt advanced security technologies to better defend manufacturing systems. Although no computer system can be absolutely secure, Intel security technologies provide a comprehensive suite of capabilities that can dramatically reduce a computer's attack surface area. To cover all the bases, it's essential to implement a multilayer approach.

## HERE ARE SOME OF THE WAYS YOU CAN PROTECT MANUFACTURING SYSTEMS


**Secure Boot:** Prevent attackers from injecting malware into the firmware, which loads before the computer's security defenses are activated.

- Determine whether the firmware booting the platform can be trusted or was inappropriately modified.
- Establish a measured launch environment (MLE) that compares all critical launch software (e.g., drivers, operating system) against a known good source.

» Supported by Intel® Boot Guard and Intel® Trusted Execution Technology (Intel® TXT).[10]


**Secure Memory:** Prevent attackers from snooping or hijacking the computer's external memory bus in order to steal or overwrite data stored in external memory.

- Encrypts the computing platform's entire physical memory
- Encrypt/decrypt data on-the-fly when entering and leaving memory

» Supported by Intel® Total Memory Encryption (Intel® TME)


**Secure Data and Applications:** Prevent attackers or malware from gaining access and control of the computing platform, applications, and data.

- Ensure malware cannot read or write the system memory used by mission-critical applications.
- Protect critical applications, even when an attacker has physical control of the platform.

» Supported by Intel® Software Guard Extensions (Intel® SGX)

10. No computer system can provide absolute security under all conditions. Intel® TXT requires a computer with Intel® Virtualization Technology, an Intel TXT-enabled processor, chipset, BIOS, Authenticated Code Modules and an Intel TXT-compatible measured launched environment (MLE). Intel TXT also requires the system to contain a TPM v1.s. For more information, visit http://www.intel.com/technology/security.



## INSIGHTS FROM A TECHNOLOGY JOURNALIST[11]

Linda Tucci is Editor at Large for TechTarget, overseeing coverage for the award-winning SearchCIO news site.

# THE SHIFT TO EDGE COMPUTING IS HAPPENING FAST -- HERE'S WHY

**Why is there a shift to edge computing?**
Something is happening right now that could irreversibly change the dynamic between centralized and edge computing. The periphery is being empowered by smart sensors and actuators at an unprecedented pace.

**How big is the opportunity?**
The shift to edge computing, pegged to be a $7 billion market by 2022,[12] will be a hardware and software bonanza for the IT industry, due in no small part to the plethora of technology in play between the edge and the central processing source.

**On edge computing economics**
For all the economies of scale offered by the cloud, the cost of storing and processing large sets of data is not negligible. As the data produced at the edge explodes, enterprises are finding it's not economical to move all the data back to a central processing facility, even if bandwidth and latency are not issues.

**Latency: cloud versus edge**
Stephan Biller, vice president for offering management at IBM Watson IoT, provided a great example. He said, "If on a plant floor you need a reaction time of 25 milliseconds so somebody doesn't get hit by a robot, the cloud is simply not fast enough or even reliable enough to navigate those safety issues."

**Optimizing the factory floor**
Product quality inspection is crucial to many manufacturing processes. Failing to spot defects before products are sent to customers could easily lead to costly product returns, rework, and reputation damage. Automated optical inspection at the edge avoids the delay and network bandwidth consumption from sending enormous amounts of data to the cloud.

**Algorithms and decision making**
A CIO with 15 manufacturing plants globally, for example, should be thinking about what types of algorithms are easier to implement and cheaper to operate on an edge device than trying to bring all that data back centrally.

11. Linda Tucci at TechTarget, "The shift to edge computing is happening fast -- here's why," April 2019, https://searchcio.techtarget.com/feature/The-shift-to-edge-computing-is-happening-fast-heres-why.

12. MarketsandMarkets, "Edge Computing Market worth $9.0 billion by 2024," October 2019, https://www.marketsandmarkets.com/PressReleases/edge-computing.asp.

# INDUSTRIAL SOLUTIONS EXAMPLES

## IN BRIEF

Many companies are already using edge computing solutions to advance their Industry 4.0 initiatives to increase operational efficiency. Here is a brief sampling of what's being done.

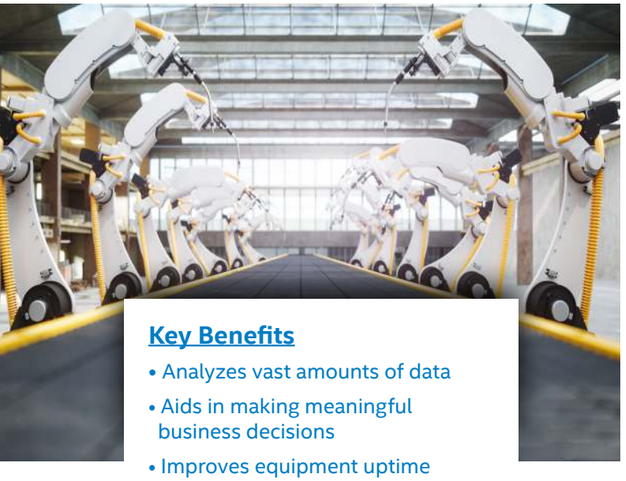
### Audi[13] A leading German automaker

**Challenge:** Implement cutting-edge technology to maintain a competitive advantage.

**Solution:** Audi worked with Intel to create algorithms using Intel's Edge Insights for Industrial that resulted in predictive analytics and modeling to transform factory data into valuable insights. The edge solution collects data from the welding-gun controllers and analyzes it at the edge. Intel's data scientists created a machine-learning algorithm and trained it for accuracy by comparing the predictions it generated to actual inspection data provided by Audi.

**Key Benefits**

- Enables all welds to be inspected
- Increases weld inspection accuracy
- Allows transition from manual to automated weld inspections
- Reduces labor costs by 30%-50%



**Key Benefits**

- Analyzes vast amounts of data
- Aids in making meaningful business decisions
- Improves equipment uptime
- Takes action in real time using TSN

### National Instruments[14] A global leader in test, measurement, and control solutions.

**Challenge:** Boost throughput, improve efficiency, and reduce downtime.

**Solution:** NI's CompactRIO* IoT/edge solution analyzes large volumes of data to help improve decision making and operations in industrial settings. It supports all the necessary connectivity and data analytics while meeting requirements of latency, synchronization, and reliability. With the NI platform, engineers perform data analysis and execute control commands anywhere analog data is converted to a digital signal—otherwise known as "the edge". CompactRIO controllers use a 64-bit Intel Atom® processor that delivers high levels of performance and functionality, including an integrated GPU and a multicore processor.

13. Intel Case Study, "Audi's Automated Factory Moves Closer to Industry 4.0," Dec 2019, https://www.intel.com/content/www/us/en/customer-spotlight/stories/audi-automated-factory.html.

14. Intel Solution Brief, "National Instruments and Intel deliver accurate, holistic insight for optimized IIoT," August 2018, https://www.intel.com/content/www/us/en/manufacturing/solutions/time-sensitive-networking-brief.html.



# CONCLUSION

We are well along the journey to Industry 4.0 – where analytics, AI, IoT, and edge computing are helping to improve decision-making, efficiency, and productivity.


*It is not just a "smart factory," marked by greater machine automation. It is an "intelligent factory," defined by hyper-agility and autonomous production, where data is transforming business.*

Intel's flexible solutions, extensive ecosystem, and focus on convergence makes it possible for manufacturers to consolidate data and applications at the edge at a lower total cost of ownership (TCO), driving the deployment of intelligence from edge to cloud and helping realize the power and increased efficiency of Industry 4.0.

Companies choose Intel to help them accelerate the development of data-centric, interoperable Industrial IoT solutions so they can seize the massive innovation potential of Industry 4.0 and gain a competitive technological and competition advantage.

# RESOURCES

Big data and IoT are enabling industrial process transformation. Intel and its ecosystem partners deliver industrial solutions optimized for scalable Intel® architecture, designed to reliably interoperate with the entire industrial environment.

**Intel® Internet of Things Solutions Alliance**
Members of the Intel® Internet of Things Solutions Alliance provide the hardware, software, firmware, tools, and systems integration that developers need to take a leading role in IoT.

**Intel's Edge Insights for Industrial**
Taking advantage of modern microservices architecture, this solution integrates data from sensor networks, operational sources, external providers, and industrial systems, and allows machines to communicate interchangeably across different protocols.

**Intel® Smart Edge**
This multi-access edge (MEC) platform for industrial use cases for on-premise enterprise deployments that require low latency, private mobility, simplicity, and open architecture.

**Light-Guidance and the Intel® Connected Logistics Platform (Intel® CLP)**
This pre-certified track-and-trace solution is designed to help companies of all sizes ease warehouse management in the supply chain, combining elements smart tags, a proprietary Wireless Sensor Network, Intel® technology-based smart gateways, and an optional smartphone application.

**Intel® IoT Gateway Development Kits**
Intel IoT Gateway development kits enable solution providers to quickly develop, prototype, and deploy intelligent gateways. Available for purchase from several vendors, the kits also maintain interoperability between new intelligent infrastructure and legacy systems, including sensors and data center servers.

**For more information** about Intel® solutions for industrial automation, visit **intel.com/industrial**.

## Notices & Disclaimers

Intel technologies may require enabled hardware, software or service activation.

No product or component can be absolutely secure.

Your costs and results may vary.



*Other names and brands may be claimed as the property of others

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