451 Research® | PATHFINDER REPORT

Industrial IoT and the IT/OT Operational Edge

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About this paper

A Pathfinder paper navigates decision-makers through the issues surrounding a specific technology or business case, explores the business value of adoption, and recommends the range of considerations and concrete next steps in the decision-making process.

ABOUT THE AUTHOR

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Rich Karpinski is Research Director for 451 Research's Voice of the Enterprise: Internet of Things survey and advisory offering. In that capacity, Rich tracks, analyzes and anticipates the pace and direction of IoT adoption, overseeing 451's quarterly survey of IoT adopters and twice-annual survey of operations technology (OT) professionals. As a member of 451's IoT team, Rich also is responsible for smart city and smart spaces coverage. In addition to that role, Rich closely tracks the evolution of mobile operator business models – including IoT and other digital service strategies – and works with 451's mobile operator customers to help them understand market trends and plot strategies.

Executive Summary

The Industrial Internet of Things (IIoT) represents the convergence of manufacturing and industrial processes, often called operational technology (OT), with the highly interconnected digitally transformed enterprise, powered by information technology (IT). It offers opportunities for long-established industrial enterprises to optimize for greater efficiency, find new revenue streams and gain competitive advantage over rivals. In this 451 Research Pathfinder, we detail the evolution and current deployment of IoT within the industrial sector and explore the corporate cultural and technology challenges that must be overcome to achieve full industrial IoT success.

Key Findings

- Industrial firms today are aggressively deploying IoT to provide new actionable insights to optimize key business processes and enable altogether new ways of working. The manufacturing, transportation, oil/gas and utility sectors are among those aggressively implementing IoT use cases.
- That said, too few IIoT projects – only about 40% – move from proof of concept (PoC) into full production, and those that do often struggle to achieve a positive ROI or business outcome while running into significant technology scaling and data integration challenges.
- The emergence of a more capable industrial IoT edge has emerged, with significant compute, storage, analytics and connectivity advantages over cloud-only IIoT approaches.
- This OT/IT industrial edge – deployed closer to where industrial machines and systems operate – is quicker to insight and action while reducing costs and improving performance. It has the potential to solve many of the challenges and headaches associated with early industrial IoT implementations.
- But it also requires closer OT/IT collaboration and a more holistic way of thinking about the type of IIoT architecture and systems necessary to realize the full potential of IIoT.

The Advent of Industrial IoT

If the industrial revolution of the 18th and 19th centuries brought new levels of mechanical automation to industry, the digital revolution of the 20th and the early years of the 21st centuries can be characterized by the introduction and evolution of computing power and digital automation to industrial processes. Industrial sectors such as manufacturing, transportation and energy are today deep in the Industry 4.0 era where computers, robots and networks of the initial digital wave work even smarter and more autonomously. With the mountains of industrial machine and sensor data that is being created, there is an opportunity to use information technology to deliver ever faster and more actionable insights.

The processing and application of that data to drive new business value within those sectors, often dubbed the Industrial Internet of Things (IIoT), has much in common with enterprise IoT implementations in other areas – such as retail and healthcare services. Commonalities include increased use of sensors and data collection and the application of new IT technologies – cloud computing, software as a service (SaaS) and increasingly flexible wireless networking – to transport, process and analyze all that data.

But industrial firms face unique IoT challenges as well. Today's industrial environments include vertical-specific – and often decades-old – programmable logic controller (PLCs), supervisory control and data acquisition (SCADA) systems and other computerized platforms that sit outside the realm of enterprise IT. Those OT systems, which enable demanding command and control processes – often in remote or harsh operating environments – are deeply embedded and characterized by long depreciation cycles and thus unlikely to be ripped out and replaced anytime soon. They're often completely air-gapped (i.e., disconnected) or otherwise shielded from the internet or other enterprise networks. The fear has been that exposing them to the outside world – and thus attacks or performance disruptions – could affect vital business operations. And finally, such systems are typically implemented by and the responsibility of a set of technologists with distinctly different and necessary mechanical and engineering mindsets than typical IT professionals.

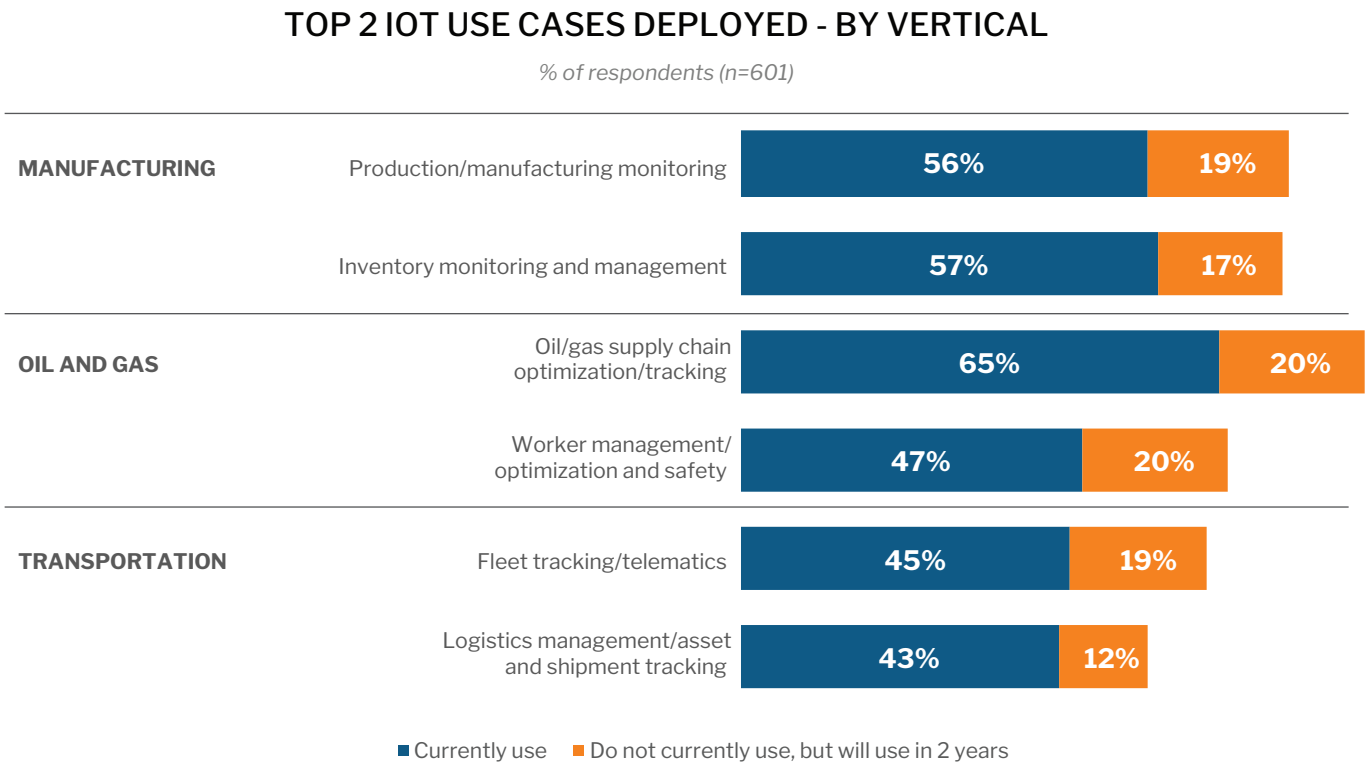
IIoT brings these two worlds together – IT and OT – linking high-speed IT disruption and deployment principles with more conservative, and rightfully rigorous, manufacturing processes. It's an intersection that heralds tremendous new business value and competitive advantage for those who can master it. But it also presents – to both sides – significant challenges on many fronts, including technology, culture and management approach.

IIoT in Action

Enterprises across industrial-focused sectors – from manufacturing and transportation to oil/gas and mining – have set off on the path to digital transformation enabled by new IIoT capabilities. Various industries are leveraging digital IT and communications technologies to transform how they do business – AI-powered, robotically enabled assembly lines in manufacturing, autonomous vehicles and intelligent logistics in transportation, and automated metering and smart grids in energy to name a few. Responses to 451 Research's Voice of the Enterprise: IoT, the OT Perspective survey show the already strong adoption of IIoT use cases in those industries (see Figure 1).

Figure 1: IoT use cases in key operationally driven industries

Source: 451 Research's Voice of the Enterprise: IoT, the OT Perspective 2018



Manufacturing

In manufacturing, industrial IoT use cases are led by a pair of applications that have been evolving: one, the monitoring and optimization of production and manufacturing processes, and two, the management of inputs and inventory across the value chain. Neither of these industrial processes is new – whether they were done with pen and paper and a keen eye or have evolved to encompass computerized systems of record and data-driven predictive forecasts, they are central to optimized manufacturing environments. IIoT leverages the power of the data generated from industrial processes and analyzes it in both real time and historian modes

to bring greater levels of control and anticipation to these key processes. Within two years, according to our survey of OT professionals in the midst of industrial IoT deployments, 75% of manufacturers expect to apply IIoT to optimizing their production processes, while 74% will leverage it to enhance inventory management.

Oil and Gas

The oil and gas industry is both operationally intensive and geographically remote, with highly intelligent, automated and sensored systems to help manage the supply chain and improve exploration and worker safety. The environment OT systems operate in is often both extremely remote and rugged – for instance, an oil rig at sea. Within two years, according to our survey respondents, 85% of oil and gas companies expect to be collecting and analyzing machine and sensor data across their supply chain – from discovery to distribution and delivery – to optimize operations. Another 67% plan to leverage IIoT to improve worker safety and to reduce risk in dangerous industrial operational environments.

Transportation

The transportation industry is both a broad horizontal category – most companies move product from place to place at some point – as well as home to an array of vertical subcategories such as consumer automotive and business fleet operations. Our survey shows IIoT data being used by enterprises to optimize transportation, led by fleet tracking and telematics – in use by 64% of respondents within two years – followed by asset and shipment tracking – deployed by 55% in the same time frame. Transportation use cases demonstrate the power of IoT sensors, applications and insights to more intelligently track and manage both vehicles (trucks, ships, rail) and things (operational assets and products in the supply chain) in motion.

Industrial IoT Pain Points

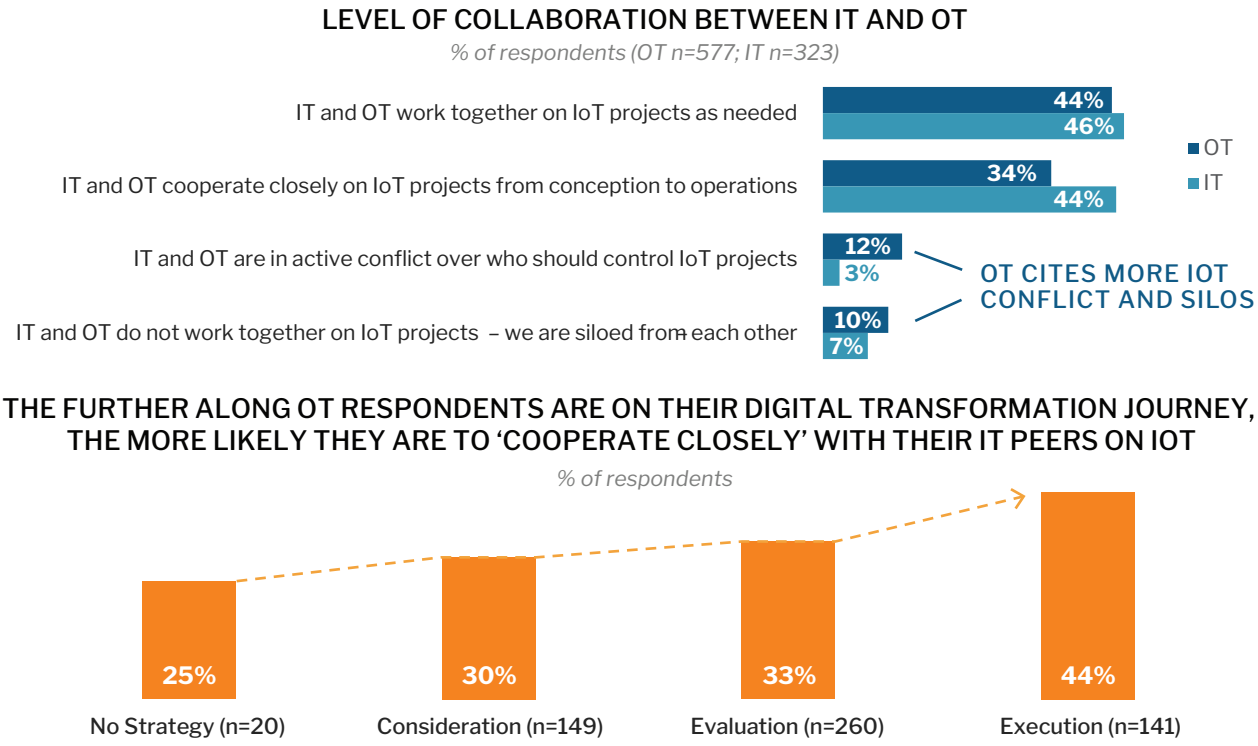
While IIoT applications and use cases can dramatically improve and deliver entirely new business value, they also present keen challenges to both the OT and IT professionals supporting their deployment.

Lack of IT/OT Collaboration

As historically distinct technology organizations, IT and OT personnel are not accustomed to working together, and unfortunately, they often do not work together well, if at all (see Figure 2).

Figure 2: IT/OT collaboration in IIoT projects is often lacking

Source: 451 Research's Voice of the Enterprise: IoT, the OT Perspective 2018 and Voice of the Enterprise: IoT, Workloads and Key Projects 2018



According to our surveys, just 34% of IT respondents and a slightly higher number (44%) of OT respondents said the two groups work 'closely on IoT projects from conception to operations.' That's unfortunate, because close collaboration is clearly a digital best practice, with OT responsible for defining and meeting business metrics but relying heavily on IT to scale and, in many cases, fund production IIoT deployments. To that end, enterprises that are in the 'execution' stage of their digital transformation journey, according to the same surveys, are much more likely to have IT and OT working closely together. And while a relatively small

percentage of respondents said IT and OT were in 'active conflict' in the organization, OT respondents were four times more likely to characterize the relationship in this way. Again, that's a bad sign because OT is the group most responsible for IIoT business outcomes and thus the ultimate success or failure of such projects.

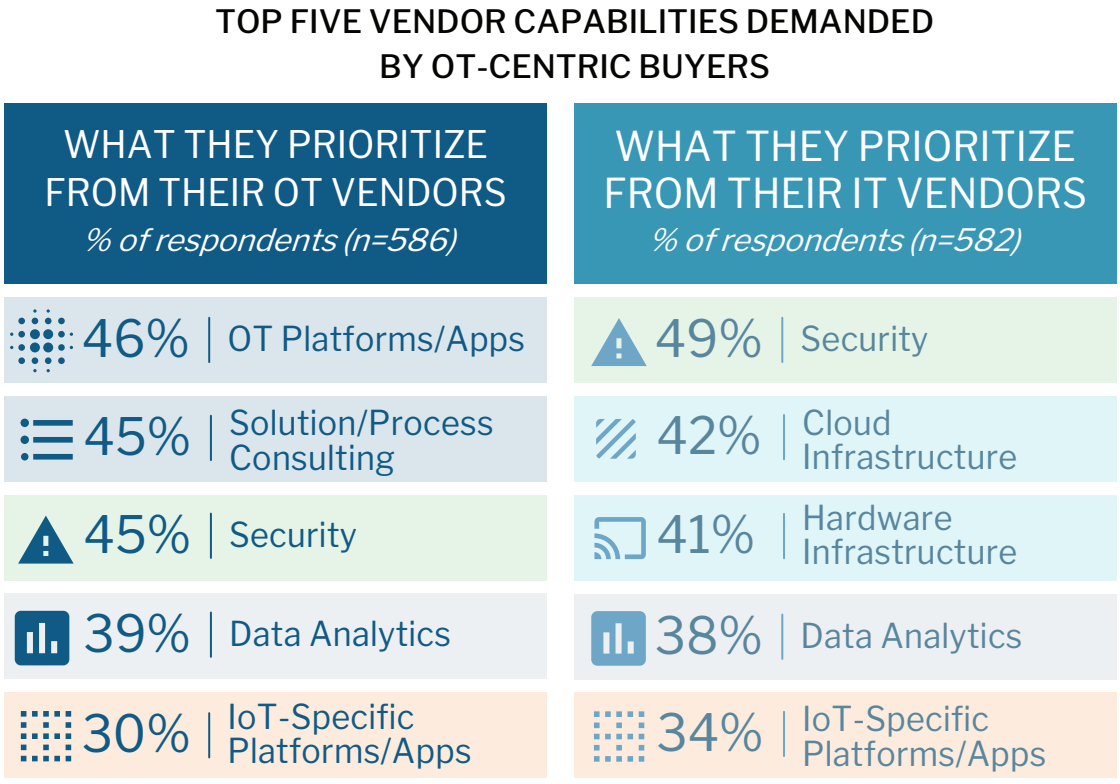
For industrial enterprises, getting the right stakeholders at the table early in the development of IIoT applications is critical. The concept of embedded IT also comes into play here, with growing numbers of organizations integrating IT capabilities into business units, including OT groups. Regardless of the tactical approach, both IT and OT must understand what the other brings to the table, as well as the most effective role each can play. Experience says that applies to IIoT-enabling vendors as well.

The Right Vendor for the Right IIoT Job

The ecosystem of vendors and other partners required to deliver an end-to-end industrial IoT deployment can be vast. IIoT encompasses so many types of systems and technologies: legacy/brownfield OT manufacturing systems; IoT-specific sensors, connectivity modules and gateways; compute and storage infrastructure; data analytics and process applications; security capabilities, etc. In the early days of IIoT, many vendors tried to provide end-to-end solutions, an approach that largely proved a failure. Legacy industrial OT vendors knew their systems and their customers' business processes very well but lacked expertise in cloud infrastructure or enterprise-scale security. IT vendors similarly overreached, aiming to swallow not only IoT infrastructure opportunities but also to lead the way in IoT applications and analytics. Truth be told, IIoT – encompassing both OT and IT – is too big of a gulp for any one vendor to swallow. The good news is that industrial customers looking to deploy IIoT have come to understand this reality. The OT respondents we've surveyed look to OT vendors primarily for their knowledge of OT systems, business processes and insights while capabilities in security, cloud infrastructure and hardware infrastructure ranked as the highest priorities expected from their IT vendors (see Figure 3).

Figure 3: IIoT must rely on the right vendors for the right job

Source: 451 Research's Voice of the Enterprise, OT Stakeholder Perspective 2018



DIFFERING IIOT TECHNOLOGY PRIORITIES AND REQUIREMENTS

Vendor decisions aside, OT and IT often have a very different view of how technology can best and most affordably support enterprise IoT deployments. IT is in the midst of a significant evolution, with many organizations moving away from on-premises technologies in favor of private- or public-cloud-style infrastructure and applications. The cloud drives enterprise agility, elasticity and asset efficiency, and was broadly embraced as the deployment style of choice for many first-generation industrial IoT projects. Traditional OT vendors tapped cloud and SaaS delivery as the easiest path to market for their initial IIoT offerings. The strong push by public cloud hyperscalers to support IoT in their platforms also positioned cloud as a strong option for early enterprise and industrial IoT deployments.

That said, industry has quickly come to understand that IIoT applications are best suited to run where performance best meets business objectives, edge to cloud. A number of considerations come into play when making those decisions – and according to 451's Voice of the Enterprise surveys, IT and OT professionals are largely of a common mind about what criteria are most important in choosing an IoT execution venue (see Figure 4).

Figure 4: Factors impacting IIoT execution venue

Source: 451 Research's Voice of the Enterprise: IoT, the OT Perspective 2018

Q: Which factors are most influential when determining the best execution location or venue (i.e., edge vs. near-edge vs. core/cloud) for an IoT workload?

	OT *(n=588)*	**IT** *(n=557)*
SECURITY	57%	57%
COST	50%	54%
NETWORKING CONNECTIONS	43%	45%
AVAILABILITY OF STAFF/EXPERTISE	41%	40%
INFRASTRUCTURE RESILIENCY	34%	38%
LATENCY CONSIDERATIONS	27%	28%

Such considerations are particularly keen for industrial IoT projects. For instance, many IIoT use cases require ultra-low latency for real-time application response. Legacy OT systems may lack the IP/Ethernet interfaces to easily transfer machine data. Bandwidth to transport data from the endpoint is often unavailable, unreliable or expensive, and security and data-sovereignty concerns often limit the opportunity to leverage public cloud services.

The IT/OT Operational Edge

To help alleviate such concerns and deliver the performance and reliability industrial firms require, more enterprises are turning to edge computing and intelligent edge devices for their IoT workloads. Such devices perform much more than simple gateway functions, bringing powerful compute, analytics and application execution capabilities closer to where OT systems operate – delivering the security and performance industrial firms require and get in IT environments today. Such converged IT/OT systems help address the key IIoT pain points we discussed in the previous section:

The Need for IT/OT Convergence

The first step to finding a solution is to admit there's a problem. As we described earlier, in IIoT the problem often boils down to the fact that IT and OT live in very different worlds. What's needed is an IIoT edge that supports the unique needs of both camps while delivering the outcomes the business requires. When considering a truly converged IT/OT edge, look for a solution that can meet the needs of all the key stakeholders:

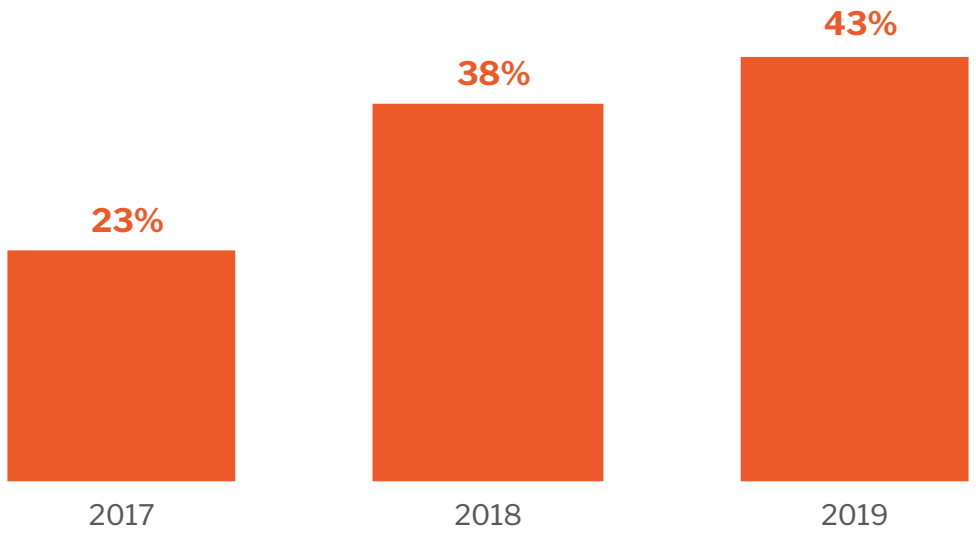
- What IT needs: Systems sized appropriately for today's growing edge requirements – more than a mere gateway, less than a full-blown datacenter. They need to be scalable to support growing requirements for compute and storage, and they need to be ruggedized to fit into harsh environments with the interfaces to connect to both legacy industrial machines, protocols and networks on one end and enterprise IT networks (Ethernet, Wi-Fi) and infrastructure on the other – edge to cloud. They also need the ability to be managed and secure with the flexibility and assurance of any other IT device.
- What OT needs: Systems with the OT know-how to connect to and interact with industrial networks, controls and applications, enabling both physical (at the chassis level) and digital (at the data, process and application level) convergence between previously siloed OT and IT data. They need security capabilities to ensure that previously protected systems are not suddenly exposed to attack or disruption, and the ability to execute truly distributed (again, edge to cloud) IIoT applications and processes with the right workloads being handled at the right location.
- What the business needs: A converged IT/OT operational edge that brings these formerly disparate worlds together via a robust, scalable and secure cloud-to-edge infrastructure capable of gathering industrial data from across the enterprise, creating actionable insights, and ultimately process improvement and business results.

Execution at the IIoT Edge

With an IT/OT operational edge in place, industrial firms can take full advantage of executing more of their industrial IoT use cases closer to where their mission-critical data and systems already reside. As the adoption of IIoT has grown, industry's interest in deploying more functionality at the edge has grown. For example, the amount of IoT processing that manufacturers are doing at the edge has almost doubled in the past two years: in 2017, 23% of respondents said they process data at the edge, which is up to 43% today (see Figure 5).

Figure 5: Industrial use of IoT edge processing is on the rise

Source: 451 Research's Voice of the Enterprise: Internet of Things, Workloads and Key Projects 2018



What types of processing happens at the IoT Edge? According to 451 surveys, 60% of enterprises that process data at the edge today do it in support of data analytics, followed by data aggregation (51%), data synchronization with other data stores (41%) and data modeling (38%). That edge processing is important for a variety of reasons. It helps to speed data analysis, improving business outcomes. It reduces the size and amount of IoT data, cutting storage, compute and connectivity costs. And it helps to improve IIoT security on an end-to-end basis.

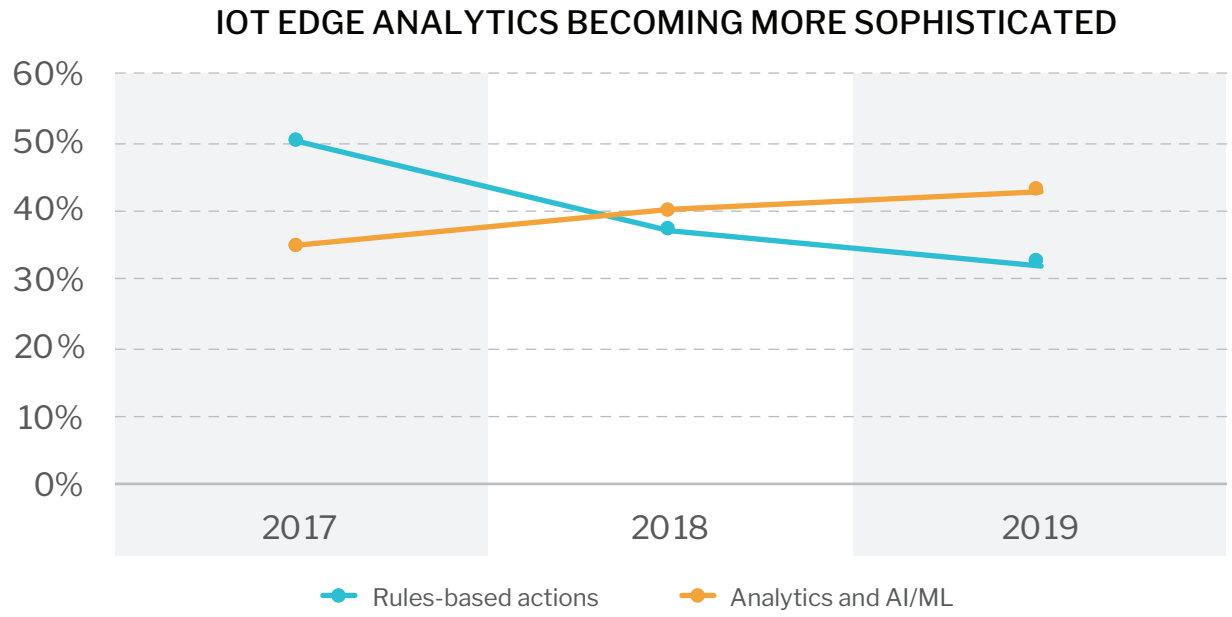
EVER MORE POWERFUL (EDGE) ANALYTICS

As we saw, analytics is the top process enabled by a more capable IT/OT operational edge. IIoT analytics can take many forms. Production-driven control-loop applications deliver rapid, time-sensitive analysis and resulting action. The same data can be aggregated from multiple machines and processes and sent to a historian to help tease out longer-term trends. Video analytics has emerged as another important industrial edge application. Video surveillance or security feeds can be analyzed to provide site-contextual insights and geo-fencing capabilities. Cameras pointed at the manufacturing line can deliver computer vision insights – such as object recognition or anomaly detection – more powerful and fine-grained than other types of sensors. Raw video feeds can generate massive amounts of data; edge analytics can draw out and capture only the metadata necessary to make decisions, greatly reducing storage and bandwidth requirements and costs. And increasingly, industrial data at the edge can be used – often in conjunction with public cloud APIs and capabilities – to train and deploy artificial intelligence (AI) and machine learning (ML) models. AI and ML can help organizations more thoroughly understand what is happening within an operational environment and proactively anticipate both performance degradation and outages, as well as opportunities to optimize further. This sort of application of AI/ML is particularly notable in that it requires powerful capabilities both in the cloud, for model training, and at the edge, for delivering inference capabilities.

The use of AI/ML at the edge is increasing; for many IoT use cases, it is replacing the simple rules-based triggers of yesterday with deeper insights and more intelligent execution (see Figure 6). Across all enterprises, the use of AI/ML at the edge has increased from 35% in 2017 to 43% in 2019.

Figure 6: AI/ML is becoming more critical at the IoT edge

Source: 451 Research's Voice of the Enterprise: Internet of Things, Workloads and Key Projects 2018



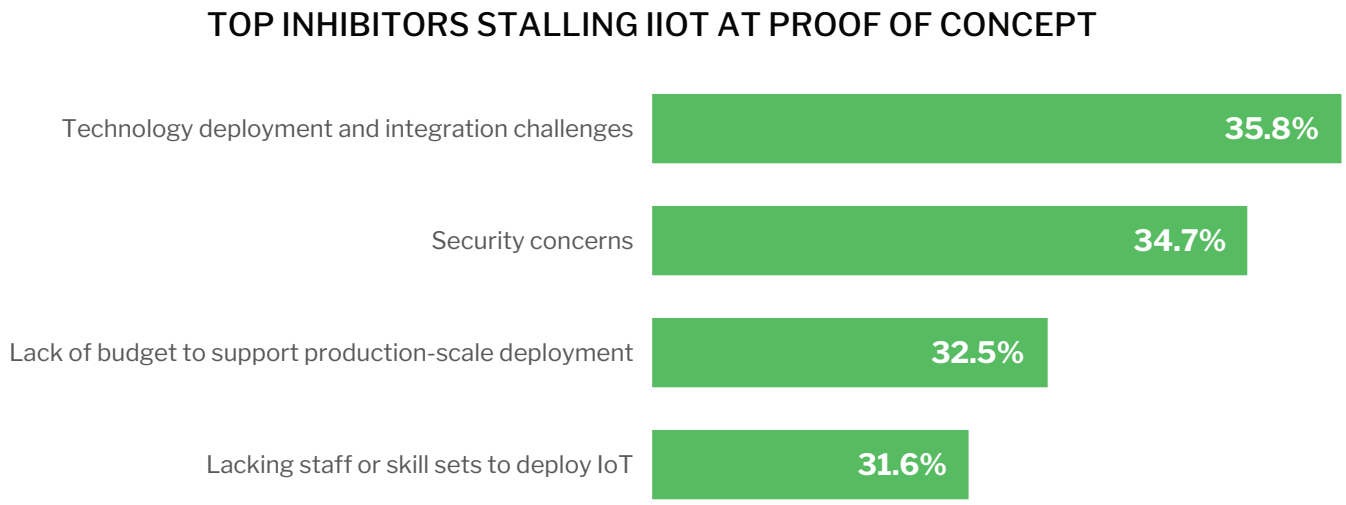
The use of AI/ML at the edge is even higher in manufacturing, with 49% of respondents in that sector saying they are doing some level of AI-based analytics at the IIoT edge. Such heavy use of AI in industrial requires a more capable IT/OT operational edge that can filter out data noise to send just the right data to the cloud for model training and with enough compute power to run AI inference engines at the edge.

Conclusions

The power of the Internet of Things to transform industrial enterprises is clear. Just as clear are the challenges such companies face to launch and scale IIoT deployments. According to 451 Research's survey of OT professionals, less than half – just 42% – of industrial IoT deployments successfully move from proof of concept into production. The potential IIoT inhibitors are a mix of technology and budget/staffing challenges (see Figure 7).

Figure 7: Technology and security challenges stall IIoT at the PoC stage

Source: 451 Research's Voice of the Enterprise, Operational Technologies Perspective 2018
Q: For IoT projects that have not/will not move to production deployment, which of the following were the largest impediments or inhibitors?



Cookbook for Industrial Edge Success

Given the demonstrated value industrial IoT projects can deliver, it is critical for IoT stakeholders to embrace industry best practices to overcome those IIoT potential deployment challenges and successfully drive their initiatives into production. As this paper lays out, two critical best practices stand out:

- **Full IT and OT executive and team alignment, from whiteboard to implementation.** IT and OT (and other key stakeholders, especially the C-suite) must be aligned from IIoT project whiteboarding all the way through production launch. It is not enough for IT to act as a 'service provider' answering to OT needs, nor is it sufficient for OT to think that IT's only role is as another source of IIoT budget. The two sides must collaborate to build a holistic, future-proofed IIoT architecture capable of delivering the performance, actions and insights the business requires. Such coordination is even more important as enterprises move beyond small PoCs into production projects.

- **Similar IT/OT 'alignment' on the technology front via an integrated IT/OT operational edge.** As critical as the cloud will be for many aspects of IIoT, a purely sensor-to-cloud approach ignores the operational edge at its own peril. By comparison, IIoT best practices leverage large doses of edge analytics capable of delivering the faster insights needed in critical operational environments while also teasing out only the necessary metadata necessary to make those decisions, significantly cutting storage and bandwidth costs. Meanwhile, advanced AI and ML analytics that today often require the cloud for model training can deploy inference insights at the edge, again bringing the intelligence closer to where it is needed to build a truly intelligent industrial enterprise.

  In the end, close IT/OT collaboration and an informed understanding of the operational edge is the 'secret sauce' to help industrial firms successfully move IIoT projects from PoC to production. A well-thought-out edge-to-cloud IIoT infrastructure can ease technology deployment and data integration challenges. Security concerns are mitigated by not relying solely on the cloud via the application of IT standard security technologies and systems. Budget concerns become less pressing as successful PoCs prove the value of IIoT from the business side, and the improved economics of edge-to-cloud (vs. cloud-only) helps on the total-cost-of-ownership (TCO) front. Finally, IIoT staffing and skills acquisition become less of a concern as combined IT and OT teams (with the help of vendors tuned to the needs of industrial IoT) work together with each group doing what it does best to deliver successful IIoT deployments and significant business value.

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