MARKET PERSPECTIVE

Analytics by Design: Demonstrating the Value of IoT

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EXECUTIVE SNAPSHOT

FIGURE 1

Executive Snapshot: Analytics by Design — Demonstrating the Value of IoT

IoT use cases have skyrocketed, exponentially increasing into the tens of billions of connected devices. At the same time, the availability of advanced analytics and artificial intelligence enables organizations to automate part of their internal processes to achieve productivity gains and improve their competitive advantage. This greater supply, combined with an increased maturity in the IoT market, are helping set the necessary foundations to enable more sophisticated AIoT use cases and greater deployments.

Key Takeaways

- European organizations are primarily seeking business agility, automation, and improvements in customer satisfaction as key drivers for their AI initiatives. Unsurprisingly, this set of drivers is similar to the ones behind Internet-of-Things (IoT) investments.
- The lack of understanding of what the entire data life cycle means and the different stages it involves is proving a key challenge to maximize the impact of IoT data throughout organizations.
- When selecting technology partners, the ability to prove data management and analytics capabilities scores high across decision makers and budget holders in all industries across Europe.

Recommended Actions

- End users must recognize the need to deploy both technologies in combination to maximize the value of their investments. Greater intelligence and the ability to deliver insights at scale will define the value of the technology and will determine competitiveness.
- Senior management support is key for success. With AIoT projects being able to show faster time-to-value, the ability to demonstrate ROI and prove the value of the technology to the board improves. This should enable parts of the business to secure funds and support from senior management.
- Assess and build internal skills and digital capabilities to maximize the benefits of the technology beyond data scientists. Ensure investments in staff, processes, and technology for governance, compliance, security, and risk management practices.

Source: IDC, 2020

April 2020, IDC #EUR146187419

NEW MARKET DEVELOPMENTS AND DYNAMICS

Combining IoT and AI Opens up a New Market

In recent years, the number of IoT use cases has skyrocketed, exponentially increasing the number of connected devices into the tens of billions. This vast network of sensors and smart connected devices generates hundreds of gigabytes of data. The benefits of having access to vast amounts of information are immense, particularly for enterprises capable of leveraging the new data for creating new revenue streams, reducing inefficiencies, or optimizing processes. But it also creates challenges, as large data volumes require a greater understanding of more complex data life cycles, including management and analysis processes.

At the same time, the availability of advanced analytics and artificial intelligence enables organizations to automate part of their internal processes to achieve productivity gains and improve their competitive advantage. With the number of players providing advanced analytics and the quantity of use cases rapidly growing, European organizations are increasingly testing or deploying AI techniques in recent years.

Artificial Intelligence and Advanced Analytics

According to *IDC's Worldwide Artificial intelligence Taxonomy, 2019* (IDC #US45013419, April 2019), AI software technologies is defined as a set of technologies that use natural language processing (NLP), image/video analytics, machine learning (ML), knowledge graphs, and other technologies to answer questions, discover insights, and provide recommendations. These systems hypothesize and formulate possible answers based on available evidence, can be trained through the ingestion of vast amounts of content, and adapt and learn from their mistakes and failures through retraining or human supervision.

Advanced and predictive analytics software is part of the overall AI set of development tools that includes data mining and statistical software. It uses a range of techniques to create, test, and execute statistical models. Some of the techniques used include machine learning, regression, neural networks, rule induction, and clustering. Advanced and predictive analytics are used to discover relationships in data and make predictions that are hidden, not apparent, or too complex to be extracted using query, reporting, and multidimensional analysis software.

According to IDC's *Global IoT Decision Maker Survey, 2019* and *AI Global Survey, 2019*, European organizations' main reasons for deploying both IoT and AI are strongly related – improvements on operational efficiencies, customer experience, and competitive gains are the three key drivers behind IoT and AI investments.

In addition, AI deployments benefit from accessing large volumes of data to train and ensure the accuracy of their models, and vast amounts of data is precisely what IoT can offer – according to IDC's *Worldwide Global DataSphere IoT Device and Data Forecast, 2019-2023* (IDC #US45066919, May 2019), almost 17.2ZB of IoT data will be created worldwide in 2019 through sensor-enabled devices such as surveillance cameras and drones, industrial devices, household devices and wearables, and medical devices. This is expected to reach 79ZB in 2025, primarily driven by data generated through surveillance cameras and drones.

On the other hand, the true value of IoT can only be fully achieved when organizations become capable of actionizing and driving decisions based on insights gained from IoT data collected and analyzed from multiple sources in an automated way. With IoT devices capable of producing and sharing data several times per day (or even per minute), acting on such volumes can become a paralyzing challenge for most organizations. AI development tools such as advanced analytics can possibly automate part of the data management and life-cycle process by embedding analytical capabilities throughout the data journey, even facilitating (in some instances) alerts and recommendations that prompt the user to act.

In simple words, the combined use of AI and IoT (i.e., Artificial Intelligence of Things or AIoT) can help maximize the value and unfold the real potential of these two technologies, generating greater results than the simple sum of the two.

Why Now?

The landscape of IT vendors incorporating IoT solutions into their offerings has had incredible growth in recent years, with players such as systems integrators, hardware and infrastructure providers, software analytics organizations, and industry-specific players offering capabilities around various aspects of the overall IoT end-to-end proposition. At the same time, the number of vendors approaching and developing the different aspects and tools around AI have also expanded massively in recent years.

Additionally, ease of use has become a factor behind the rapid expansion of AI technologies, with organizations such as SAS adding continuous extra functionalities focused around specific personas within the organization to facilitate the adoption and usability of its solutions. Visualization techniques and dashboards are an increasing standard component of AIoT propositions to facilitate ease of use among employees besides data scientists and engineering teams.

Greater supply, combined with an increased maturity in the IoT market, are helping set the necessary foundations to enable more sophisticated AIoT use cases and greater deployments. Especially when we consider how the IoT market is now entering a second stage of maturity beyond initial pilots and proofs of concept (POCs), as stated in IDC's *European Internet of Things Best Practices: Becoming an IoT Hero in 2019* (IDC #EMEA44856719, February 2019). In addition, many IoT vendors have also launched their own AI offerings. Often, these vendors have developed use cases that embed both technologies as a way to deliver faster time to value and demonstrate quicker ROI to technology users. In addition to technology becoming more democratized in terms of ease of use and cost of tools/platforms, AI-driven features are being added to increasingly more off-the-shelf applications, both horizontal (e.g., ERP suites and CRM) and vertical/use case specific.

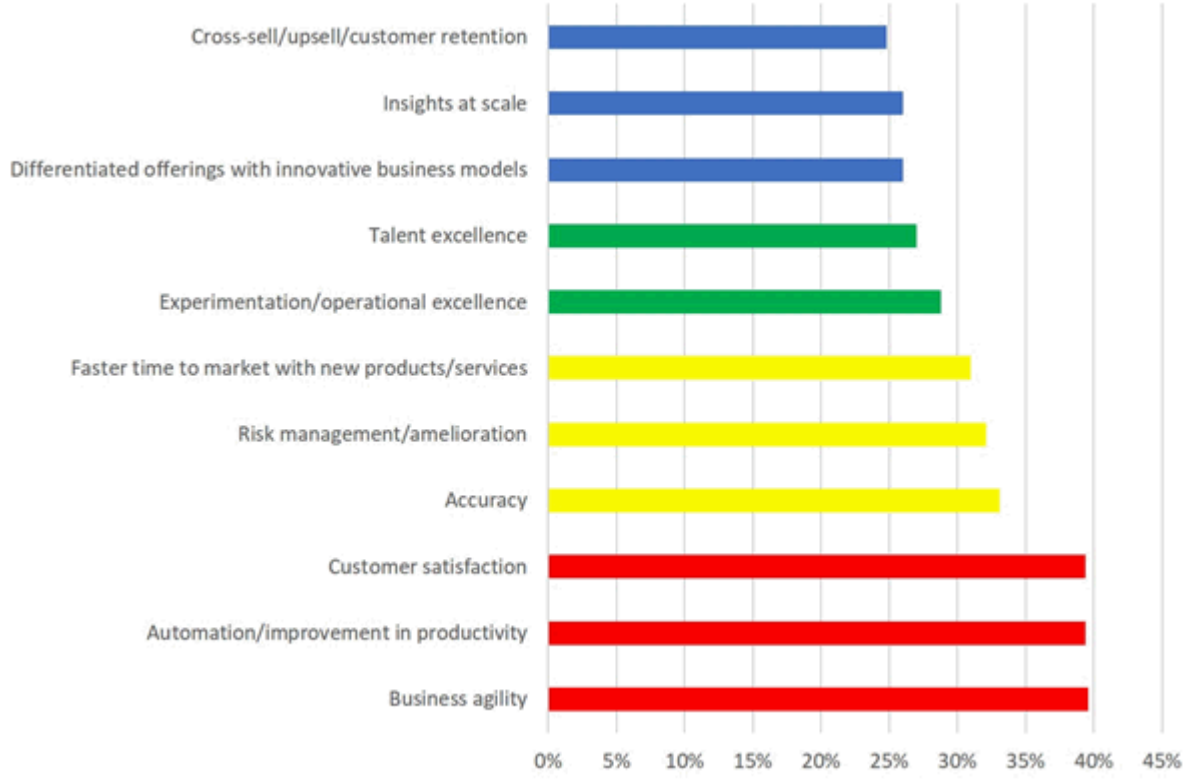
Increasingly, cloud-based models and the ability to incorporate analytics capabilities at the edge are also facilitating use and driving total cost of ownership down, especially for AI technologies in which running full analytics capabilities can become quite costly. This is especially relevant when considering the nascent move toward innovative *as-a-service* business models, based on pay-per-use/pay-per-outcome mechanisms (such as value-based healthcare, with payments tied to actual outcomes) or where customer experience is a key differentiator.

What Business Problems do AIoT Address?

According to IDC's *AI Global Survey, 2019,* European organizations are primarily seeking business **agility, automation, and improvements in customer satisfaction** as key drivers for their AI initiatives, as shown in Figure 1. In addition, other factors such as the need for further productivity improvements, reductions in time to market, and improved accuracy are other reasons driving European organizations to deploy AI.

FIGURE 2

Heat Map: Primary Drivers for AI Across European Countries



n = 604 (Europe)

Source: IDC's *AI Global Survey*, 2019

Unsurprisingly, this set of drivers looks extremely similar to the ones behind IoT investments.

Interestingly, the need to identify innovative business models to provide differentiated offerings is less of a priority across European organizations at the moment. This is also aligned with the level of maturity enterprises demonstrate regarding to both AI and IoT, with only a small percentage of organizations currently deriving value from the IoT data they collect, as seen in IDC's *European Internet of Things Use Cases: A New Business Outcomes "Obsession" Era* (IDC #EUR145638819, November 2019).

Challenges to AIoT

A number of challenges are common to organizations already deploying or wishing to deploy AIoT:

- **A severe lack of data scientists/analytics skills in the organization who are capable of working alongside line-of-business managers to derive valuable, actionable insights**. In many cases, organizations with data scientists are unable to see recurring patterns due to poor understanding of the business, hence facing the challenge of *translating* the business language and needs to those managing the data, and vice versa.
- **Lack of understanding of what the entire data life cycle means and the different stages it involves: from collecting, managing, discovering, and deploying the necessary models**. These stages require thorough understanding and governance to maximize the impact of the data throughout the organization. Often, organizations do not fully understand how to make the IoT data reportable and present it in a manner that can be utilized within existing models.
- **Limited imagination in terms of understanding and creating potential use cases that can help resolve specific business challenges**. Often, decision makers in the organization cannot understand what particular data sets might be valuable to different parts of the organization.
- **Customers' lack of awareness regarding the need to take stepped approaches in their data strategies, since AIoT solutions cannot solve complex problems without going through previous stages**. Organizations need to understand what parts of the business, processes, workloads etc. can be automated and which ones cannot.
- **Data security and privacy as key challenges for both AI and IoT deployments**. Organizations still need to adopt a security-by-design approach.
- **Ensuring all relevant personas within the user organization can define KPIs and obtain value directly from the applications and models, without the need to rely on data scientists and coders**. Implementing low-code solutions, for example, that help minimize coding skills can help speed up uptake within the organization. Organizations such as Oracle, Siemens, and SAS are pursuing this with some of their recent announcements and new capabilities.
- **Not having the right technology architecture and tools that limit the ability to maximize the benefits of AIoT solutions or overcome the above challenges**.

How are European Companies Using IoT and AI/Advanced Analytics?

User Preferences

When choosing IoT providers, European organizations' selection process is, understandably, mainly affected by aspects related to cost, security, and vendors' maintenance and support capabilities. Furthermore, according to IDC's *Global IoT Decision Maker Survey, 2019*, the ability to prove data management and analytics capabilities scores high across decision makers and budget holders in all industries across Europe. This is consistent with companies gaining a greater understanding of the IoT business model, whose success is intrinsically linked to the ability to draw insights from data collected via AI.

In addition, customers deploying IoT that prefer to deal with a single vendor as an intermediary across all parts of an IoT end-to-end solution have a clear preference for analytics vendors, with nearly a quarter of European respondents saying analytics vendors are the best positioned to become that "single provider." While this indicates a clear business opportunity for analytics providers, it also demonstrates a greater degree of maturity from customers seeking to gain real value from their IoT deployments.

According to the same survey, the majority (51%) of European organizations using analytics capabilities do so for diagnostic purposes. This is to provide data about why something happens. On the other hand, predictive purposes (providing data that something is about to happen) are only applied across 40% of organizations, and more advanced uses such as prescriptive analytics (providing recommendations to help improve the outcome) still remain relatively low, with only 34% of European organizations using analytics with this objective.

While the proportion of organizations using truly advanced analytics remains low, it is encouraging to see that IoT user organizations are keen to use analytics for very specific use cases, such as enabling faster response times, disaster mitigation, improving customer service, and generating new revenue streams. These can easily develop into more complex use cases over time, where the use of artificial intelligence and advanced analytics would offer a key differentiator.

Nearly two-thirds of European organizations are already working with software analytics vendors to derive value from their IoT data. This falls short of regions such as America and Asia/Pacific, where 70%-75% of organizations claim to be working with analytics providers. Within Europe, organizations in the Nordic region and the U.K. seek advice from analytics vendors more often.

Use Cases

The vast majority of AI and IoT use cases pivot around similar objectives, as mentioned earlier: lowering labor costs, automating back-office operations, efficiency and performance gains, innovative customer experiences, and virtual assistance. The following are examples of organizations successfully using AI and IoT for specific use cases.

European Water Utility Uses AIoT to Integrate and Monitor Water Systems

A water management agency in Europe was operating its national water measurement system (WMS) to measure and monitor water quantity, quality, weather conditions, and status throughout the network. The system has approximately 450 measurement locations and over 2,000 sensors across its network. Some of the metrics it monitors relate to water levels (low and high water levels), chemical composition of the water, temperature, etc. It currently provides some of this information free of charge to other government agencies and citizens.

While the existing system was a useful, reliable tool for a number of years, the solution lacked uniformity, having been built over a 15-year period by aggregating several regional networks. Its architecture was dated and could not be expanded further to incorporate new networks. Incorporating innovative solutions and technologies was often a complex and unreliable process in such an old network. In addition, a large proportion of the hardware and software used were reaching their end-of-life and would no longer be supported by their original providers.

There was a need to replace the existing system with something more modern while keeping costs down, ensuring reutilization of the sensors already deployed, and taking the following customer requirements into consideration:

- Continuity within the two systems had to be guaranteed
- The new system had to allow for flexibility and scalability for future growth
- Reuse as much as possible of existing building blocks
- Reusable architecture
- Use of commercial off-the-shelf hardware (no new hardware developed for this)
- Quick adoption of new sensors and no new coding required
- Creation of a data exchange based on a national standard

The project presented some additional challenges that the IT vendor had to address: the coverage area was vast, as it had to include the entire country; the replacement cycle for existing equipment had to be respected and incorporated into the project timescales; end-to-end security was paramount; and the reliability and robustness of the system had to be ensured.

During 2019, IT vendor SAS worked with this agency to integrate SAS Event Stream Processing, SAS Data Analytics, and SAS Visual Analytics capabilities into the system. This enabled the agency to collate information from the more than 2,000 IoT water sensors deployed across the network with a combination of LTE and LoRa connectivity. The creation of a high-availability dual datacenter facilitated centralized data processing and data sharing across multiple third parties such as the National Meteorological Agency. The project allows the water agency to identify certain patters and enable certain aspects of predictive maintenance and alerts system to flag problems in the network before they become too costly to repair.

The initial results were extremely positive with a more reliable, future-proof system in place, aligned with and running in parallel with the original system. A remote management decentralized infrastructure and software has made the system more resilient. Although the agency has no plans to monetize the data it is collecting for now, providing detailed, aggregated data to other agencies, corporations, and citizens could potentially become a revenue generator for the organization in the future.

Shell Uses Machine Vision to Improve Safety at its Retail Sites

Royal Dutch Shell is the largest company in the energy sector and one of the largest in the world. Headquartered in the Netherlands and the U.K., the British-Dutch company (i.e., Shell) operates in 70 countries. Its main activity is the production and distribution of oil and gas through its vast number of service stations around the globe. Naturally, a company this large comprises an enormous network of people and processes, from the point of extraction until the moment when a car tank is filled. To manage this efficiently, Shell must be up to date with the latest technological innovations to remain competitive.

An aspect Shell is not willing to compromise on is safety at its retail sites. Goal Zero is Shell's goal to achieve no harm or leaks across its entire operations. In its service stations, Shell is relying on a solution powered by Microsoft's Azure cloud services that combines Internet of Things and artificial intelligence. Using a closed circuit of surveillance cameras connected through IoT technology, the solution identifies potentially hazardous situations and immediately acts, reducing the response time to the minimum and increasing the level of safety at its stations.

This project is known as video analytics for downstream retail (VADR). Several services from the Microsoft cloud platform such as Azure IoT Edge, Azure IoT Hub, and Azure Databricks have been deployed to assure the workflow of the solution. This encompasses image capture, risk detection, and information transfer to the cloud where AI models will analyze the data and be trained.

With Azure IoT Edge, Shell can move the intelligence from the cloud to the edge, leading to a much lower latency and intervening in near-real-time to potentially dangerous situations. Using cameras that support machine vision technology, the image is processed and analyzed on the edge, automatically recognizing a safety hazard situation. With Azure IoT Hub, all IoT devices are connected and images are transferred to the cloud in which deep learning models run by Azure Databricks detect patterns and trigger actions. By incorporating artificial intelligence on the cloud, Shell aims to not only detect but also predict events, leading to a solution that enables preventive measures and not merely mitigation.

Being a solution that consists of filming clients, Shell is aware of the potential privacy issues that may emerge and is working to ensure it complies with GDPR regulations.

Kaiserwetter Uses AIoT to Help Fight Climate Change

Nowadays, sustainability is a global concern and a priority for a vast and increasing number of companies. The answer to the climate change emergency will depend a lot on how technological solutions can be used to serve this purpose. Kaiserwetter is an "IntelliTech" company — with headquarters in Germany and presence in other countries such as Spain and the U.S. — that operates in the renewable energy sector, and it allies IoT and AI technologies to contribute to its expansion. More concretely, Kaiserwetter developed Aristoteles, an IoT cloud-based platform based on SAP HANA and SAP Leonardo IoT technology to manage renewable energy assets. Leveraging the data collected from its IoT capabilities and combining it with data analytics, the company aims to minimize investment risks associated with wind farms and solar farms. By convincing investors to inject capital in the sector, the adoption of emission-free energy as an alternative to fossil fuel will accelerate, which is instrumental to achieve the Paris Agreement goals.

The offer includes two versions. Aristoteles targets corporate and uses smart data analytics, predictive analytics, and machine learning, while Aristoteles Sky is aimed at public sector and relies in IoT, spatial data, and machine learning. The combination of capabilities seeks to minimize risks, maximize returns, and create high transparency standards. For governments, it helps to mitigate energetic transition issues. Aristoteles aggregates and establishes patterns between technical meteorological and financial data, providing the ability to detect eminent failures or underperforming assets and act accordingly.

For example, the platform gathers historical technical data from a wind turbine. That data is used to create a unique model through machine learning algorithms for that specific asset. Data utilized can include wind speed, pitch angle, ambient temperature, rotor speed, and so on. By collecting real time on different parameters and comparing them with previous performance, the solution can identify a potential outage and intervene to minimize downtime. The deployment of Aristoteles resulted in 5%-10% increased performance, two times fewer downtimes of wind turbines, and a 15% increase in weather-based production forecast accuracy.

Smart Hearts Project: Manchester Heart Centre Transforms Care for Heart Failure Patients

In the face of rising rates of chronic diseases and the emerging paradigm of value-based healthcare in Europe, the convergence of AI with IoT is becoming critical to inform personalized clinical decisions, intelligently automate workflows, and support integrated personalized and proactive care models to maximize value delivered to patients.

There is a surge of interest in leveraging the AIoT for early sensing of diseases and engaging patients in their own healthcare for proactive management of various (especially chronic) conditions. Applying AI to data from various biosensors has huge potential to identify subtle changes in health-related parameters and behavior, and it can help predict and prevent unwanted events as well as prompt personalized action. AIoT can thus enable proactive management of various acute and chronic health conditions; improve the effectiveness and safety of care; reduce medical errors; improve patient outcomes, experience, and quality of life; and yield significant cost-savings (e.g., by reducing length of hospital stay and hospital admission rates).

Being a major cause of death and disability worldwide, heart failure represents an increasing burden for European healthcare systems due to repetitive hospitalizations and costs of care. In Greater Manchester, for example, hospitalizations due to heart failure have been estimated to cost over £16 million in treatment each year.

Spotting the early signs of worsening heart failure can help reduce health deterioration, avoid unplanned hospitalizations, and cut down costs of care. In February 2019, Health Innovation Manchester developed the Smart Hearts project that leverages AIoT for managing heart failure patients through an innovative partnership between Manchester University NHS Foundation Trust, the University of Manchester, and medical devices company Medtronic. The project has been allocated £338,000 from UK Research and Innovation (UKRI) as a part of the government's bigger investments in innovative data solutions.

The new Smart Hearts project builds on the existing heart failure service at Manchester Heart Centre, at Manchester Royal Infirmary. The project aims to apply AI and machine learning to near-real-time data from 1,000 heart failure patients (captured from their implanted devices) to monitor their conditions and spot the signs of worsening heart failure. By identifying patients earlier, it creates an opportunity to optimize therapies, prevent deterioration, avoid unplanned hospital admissions, and improve patient experiences.

The Technology Integrated Health Management (TIHM) Project for Dementia

To enable proactive management of dementia patients and support them in longer independent living at home, an AI-enabled remote health monitoring technology was developed as part of UK's large-scale technology integrated health management (TIHM) project for dementia patients. The project is led by Surrey & Borders NHS Foundation Trust, in collaboration with the University of Surrey and other partners from academia and 10 technology companies.

The TIHM system combines IoT-based devices and artificial intelligence for remote monitoring and management of dementia patients. The sensors track vital signs (such as blood pressure, hydration, and temperature) and activity, and AI is used to spot subtle changes in patient health signs and behavior, predicting possible health status deterioration. Based on the data from sensors and devices, machine learning algorithms were developed to identify early signs of urinary tract infection (a very common cause of hospital admissions among this patient population), while behavioral patterns predict neuropsychiatric deteriorations. Alerts are displayed on a digital dashboard, that are followed up by a centralized monitoring team.

The system has been found to significantly reduce neuropsychiatric symptoms associated with dementia (such as depression and anxiety). With insights and alerts, the solution offers clinicians the opportunity to act early and prevent adverse health events, avert hospital admissions and clinician visits, improve clinical outcomes, reduce financial pressure on the healthcare system, enable patients have greater control of their own healthcare, and improve quality of life of patients as well as their family caregivers.

The technology has been developed by Surrey & Borders NHS Foundation Trust in partnership with the University of Surrey and the smart home monitoring solutions provider Howz. The system is part of the NHS Test Bed Programme led by NHS England and the Office for Life Sciences. The first trial phase was completed in 2018 that led to the launch of a second phase in April 2019 to refine the range of home monitoring devices deployed and further develop the AI algorithms. The current phase involves about 700 patients, with the view of scaling up across Surrey and North East Hampshire.

The Vendor Landscape

One of the key challenges most organizations seeking to deploy AIoT currently face is understanding the extremely complex and crowded ecosystem of AIoT technology vendors. The complete list of providers is vast, and their capabilities differ significantly. The following list is by no means comprehensive, but it provides an overview some key providers' offerings in the AIoT landscape.

Oracle

Oracle realized early on that an IoT solution required an analytics component to make the most out of the data collected. The company's IoT platform was introduced in 2015, and from the get-go, it had the capability to provide customers with the analytical component to generate insights from data collected at the edge. For Oracle, IoT as a standalone solution was unproductive. Many organizations spent millions in generating lakes of data, but they fail to drive decisions based on that. This means they are also failing to see the ROI, leading decision makers to question the utility of such investments. Ultimately, innovation is not a goal but a means to obtain a beneficial solution to a business problem. For Oracle, real innovation comes from blending technologies, particularly complementary technologies such as AI and IoT.

Oracle's IoT platform as a service is a cloud-based solution that aims to address very specific use cases within the industrial IoT spectrum: asset monitoring, fleet monitoring, service monitoring, production monitoring, and connected worker. Its built-in features enable the connection, analysis, prediction, and action, encompassing a full AIoT solution on which digital twins modelling, domain-specific dashboard, and KPIs and AI algorithms are featured. The key aspect for Oracle is a deployment that can be scalable and flexible. This enables the integration of the platform regardless of a company's stage of maturity in its IoT journey. Some might be in a higher maturity phase and need to integrate the prediction and action aspect, while others require the whole end-to-end solution. Flexibility also refers to the capacity of customizing KPIs, thresholds, and algorithms. In the latter case, these are constantly being monitored and perfected. For Oracle, the value of AI in IoT applications can range from detection of trends and anomalies, recommendations, and predictions.

Microsoft

For Microsoft, the message around AIoT has been gaining momentum, particularly by stressing the importance of an intelligent edge for digital transformation. More precisely, bringing the computing power closer to where it matters and therefore enabling real-time intervention while hurdles such as poor connectivity and latency are mitigated. Microsoft believes we are living in the era of intelligent cloud and edge, and companies will have to increasingly rely on hybrid technologies that combine both to take the organization to the next level of its digital journey. Microsoft has a myriad of Azure-based services that enable seamless integrations of edge devices, IoT platforms, and edge computing capabilities, all connected to the core and with built-in artificial intelligent modules. This enables the deployment of end-to-end solutions on which simplicity and scalability of deployments are key aspects.

Several examples have been presented that illustrate the benefits of adopting AI with IoT solutions. Minsur, a mining company, uses intelligent video analytics to train modules to identify foam. In its operations, Minsur collects water that is returned to nature after treatment. This treatment process creates foam that, with the help of video recognition technology, can be identified and dealt with accordingly. Video analytics at the edge is a prevalent usage scenario, often presented by Microsoft to promote its intelligent edge solutions and one that reflects the potential of converging AI with IoT. With connected cameras capable of performing video analytics at the edge, more information can be extracted, and in combination with AI capabilities at the core, the solution can act in real time and models can be trained to increasingly provide more accurate and valuable insights. Microsoft is committed to contribute to the democratization of AI as a key element to bring its solutions forward. By making available capabilities such as Studio or AutoML to a larger number of professionals such as developers, data scientists, or data analysts, Microsoft expects to increase the number of personas building models and therefore augment intelligence at the edge.

SAP

SAP understands the core value from the deployment of IoT solutions comes from the speed and quality of the insights derived from the data. The real business value lays on the combination of such devices with deeply embedded intelligence. Leonardo, SAP's IoT platform, brings capabilities such as digital twins model representations and machine learning to enrich the IoT-generated data.

SAP identifies several challenges in converging AI with an IoT solution. The lack of connectivity infrastructure in brownfields and how to connect them can be an inhibitor in certain use cases. An additional challenge relates to that of transitioning from legacy SAP applications and onto new ones, and finally, the challenge of how to apply the solution and adapt it to the daily business. There is no clear distinction between the challenges faced by SMBs or corporate clients, but they can differ in the way they approach it. SAP finds the midmarket more receptive to the message around AIoT as these solutions can reduce costs associated with the manual data analytics process such as hiring a data scientist. The most common use case SAP came across is related with preventive maintenance. By integrating sensor technology with advanced analytics, the predictive element can be added. By establishing patterns in large amounts of the data generated by IoT devices, models can anticipate potential failures of equipment, translating into more efficiency in dealing with outage.

SAP estimates that between 30% and 50% of its client base is transitioning into a combination of AI and IoT technologies. The attitude toward innovation is changing into adopting end-to-end solutions rather than assembling technologies. It is a matter that increasingly extends outside the CIO's jurisdiction into the whole organization, as deploying AIoT solutions fundamentally changes the way companies operate. The most futuristic the use case, the more C-level positions must be involved.

SAS

SAS' business proposition has always evolved around data and the importance of understanding the life cycle of data analytics: **managing** data, **discovering** insights, and **deploying** analytical models into the organization to gain value through efficiency gains, increased accuracy, and automation. Incorporating this principle into its IoT proposition, SAS tools enable organizations to ingest data from any source – at any level of complexity, size, or speed – and cleanse the data, such as inferring some missing data. SAS uses a suite of tools, including AI-augmented data management, to ingest and prepare the data for the next step of discovery.

SAS aims to make discovery simpler and automated. The company's intent is for analytics to be useful throughout an organization, not just to data scientists. Therefore, the company is developing tools for different kinds of functional users. Two key types of data in which SAS uses AI to greatly improve discovery are in natural language comprehension and image interpretation.

SAS has developed a portfolio of IoT-specific technology, including its Event Stream Processing (ESP), that enable clients to develop, manage, and deploy models that utilize streaming analytics in the core or at the edge. The company is also working to integrate SAS technology with several key IoT platform providers, enabling companies to leverage SAS analytics within widely used platforms. For further information on SAS' offering, see IDC's *SAS: The Value of IoT Data* (IDC #EUR145332519, July 2019).

IBM

Watson IoT is IBM's platform that combines the capabilities of IoT with advanced analytics to extract valuable insight. Through gateways, sensors, or connected devices, data is collected and analyzed in real time, enabling timely actions through analytics and machine learning. The possibilities provided by the platform range from the creation of new revenue streams and business models, to the understanding of patterns that enable preventive and smart maintenance. The solution offers adaptability, scalability, and openness to all devices, enabling total privacy control over the customer's own data and versatility regarding the deployment of the platform in different realities.

Asset performance management is where IBM sees the full potential of AIoT, and the message lays heavily on the benefits that asset-intensive businesses can gain from adopting these technologies. The port of Rotterdam is a notable use case. Leveraging the potential of digital twins in IBM IoT solutions, the port wants to create a digital replica of all its operations to track all movements related to cargo, ships, and infrastructure, in addition to climate, sea, and geographical conditions. The coordination required to guarantee efficiency and security of processes is key to the success of this project. Thus, it is in the volume of data generated by IoT devices in such complex operations on which AI-based insights can generate incredible gains in time and cost effectiveness. In addition, IBM is working with Finland-headquartered engineering and services company, KONE, in deploying sensors and monitoring over a million elevators and escalators. The data collected is analyzed in real time through Watson IoT capabilities to notify relevant technicians if problems are identified. With this predictive maintenance solution, the engineering firm can transition to an as-a-service, customized model.

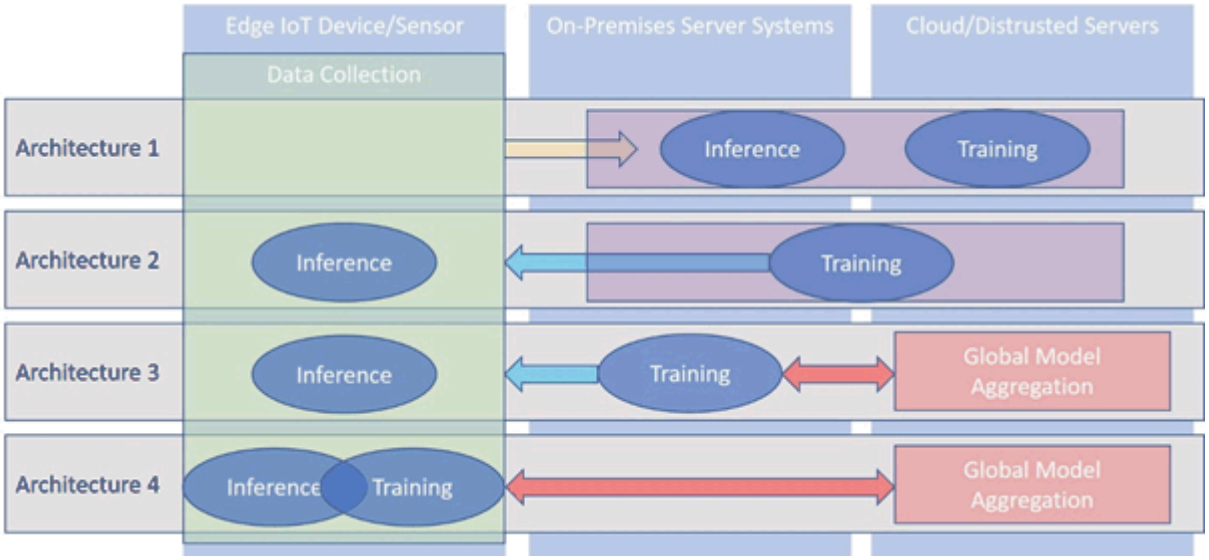
AIoT and Edge

The increasing uptake of edge capabilities across IoT use cases bring to the table considerations about AIoT and how edge impacts different deployment architectures. Organizations need to be mindful of the fact that inference and training refer to compute workloads that are specific to AI, but they should still be considered when building AIoT systems.

Deployment Architectures

FIGURE 3

AIoT Deployment Architectures



Source: IDC, 2020

Like all AI deployments, the location of training and inference have a significant impact on the architecture of an AIoT system. Training involves exposing data to a model, so it can then learn underlying trends of that data. On the other hand, inference is the process of running the trained model and passing it on new data inputs. Training and inference both present specialized workload challenges. Consequently, the locations at which inference and training happen require compute resources capable of running the workloads at speed and accuracy levels necessary for a particular use case. The dynamics of where a developer chooses to locate inference and training will depend on the nature of the intended use case. For instance, if the AIoT use case requires that inference takes place in near-real-time, then it may not make sense to locate inference anywhere other than on the device itself, so that there will be no delay for inference to take place. The amount and complexity of the data that will need to be transferred across a network, the compute required to perform inference, the compliance regulation relating to the data, as well as the required speed of inference are essential factors to consider when choosing where to locate inference. Although use cases do not typically demand training take place in real time, the same elements will underpin the location of training in an AIoT system.

Figure 3 describes four possible architectures for and AIoT system. There are three possible locations for the performance of inference and training in any AIoT system.

- At the edge IoT device collecting the data
- Local on-premises server systems of the developer
- In the enterprise's distributed server systems or on the services of a cloud provider

The possible approaches to distributing AIoT training and inference are as follows:

- In Architecture 1, the arrow demonstrates that data is being sent from the edge device to either local on-premises server systems or cloud services in which inference and training are both running. Architecture 1 is the approach most AIoT deployments are currently relying on, given that there is often no requirement to process data in real-time, and that most edge devices do not have the compute capabilities to reliably perform inference.
- Architecture 2 is also a widespread approach in which inference is performed at the edge device, while training is performed at the local on-premises server system or in the cloud. As previously mentioned, if inference takes place at the edge device, then it can happen in something closer to real-time. It also means it will not be necessary to send all data across a network to a separate location where inference can take place, potentially reducing the costs of the overall system. In many cases, system designers do not want to use all data picked up by an edge device in the training process, instead, pushing out updates to an inference model periodically based on a select amount of data. In this case, Architecture 2 also makes sense.
- Architecture 3 sees inference located at the edge device, with training situated at a local on-premises server, and then a global aggregated model sits across a distributed server system or cloud service. This type of architecture enables training and inference to occur on a single site, but also for the learning of that site-specific model to get aggregated with a global model that can get shared across an entity or group of organizations. In certain sectors, the data involved in a use case can be highly sensitive; rules often ban the organization from sharing the data beyond a site-specific location, such as in the healthcare sector. In this type of use case, it can make sense to locate training and inference on the same site, and then send the local updates to a global aggregated model. Given that model updates will be abstract from the original data, organizations can protect the privacy of the data, while still retaining the improvements in the training to be leveraged at other sites. Architecture 3 is not an approach that is pursued widely in AIoT, but it makes sense for several use cases.
- Architecture 4 pushes the location of both inference and training to the edge device and situates an aggregated model in the cloud or on distributed servers. An edge device must have compute resources to deal with both the training and inference of the AI model to be capable of Architecture 4. The advantage of locating training and inference at an edge device is that it enables the device to develop a personalized model of that device scenario in near-real-time. The aggregated model enables significant wholesale changes to be pushed to the device and for any new situations encountered at a device level to be learned from in the global model. Architecture 4 is not widely used in the AIoT space, but has been deployed by Google in Gboard, its mobile keyboard software. The Gboard uses AI to recommend words in the autocorrect and type function. These can be a user's regularly entered words that Gboard's AI model has not encountered before. Gboard can locally train its autocorrect and type function to learn the context of when the new word is used and then incorporates it into its recommendation systems. Architecture 4 enables the Gboard system to learn changes in real-time, without sharing the data of a user's messages beyond the device.

ADVICE FOR THE TECHNOLOGY USER

Technology users must consider the following recommendations when seeking to maximize results from their AIoT implementations:

- **Analytics by design.** End users must recognize the need to deploy both technologies in combination to maximize the value of their investments. Greater intelligence and the ability to deliver insights at scale will define the value of the technology and will determine competitiveness. Building a data life-cycle road map is key to accelerate the ability to deliver insights at scale.
- **Time to value.** Initial results of AIoT projects show a quicker time to value than when the two technologies are deployed in isolation, hence generating quicker ROI. This ability to shorten the necessary time to deliver results can become a key differentiator for organizations deploying AIoT.
- **Adequate corporate structures.** Insights are worthless unless proper response systems are in place. While data scientists and analytics capabilities are a crucial skill to have, do not overlook the need for a corporate structure that supports acting on the insights delivered by the technology. Lack of action can make projects fail. Ensuring different personas within the user organization can define KPIs and obtain value directly from the applications and models, without the need to rely and depend on data scientists and coders, will facilitate usage ratios and help multiply the effects of the technology across all areas of the business. Implementing low-code solutions, for example, that help minimize coding skills can help drive uptake within the organization.
- **Building the case.** Senior management support is key for success. With AIoT projects being able to show faster time to value, the ability to demonstrate ROI and prove the value of the technology to the board improves. This should enable parts of the business to secure funds and support from senior management.
- **Use case prioritization.** Examine which particular business needs you are trying to address with the technology. Select specific use cases based on those needs and on the potential the combined technologies can offer. AIoT should help augment the capabilities of the human, and not replace humans. Most use cases today fall under the descriptive category (i.e., simply describing what has happened). Diagnostic cases (i.e., looking at why something happens and what will happen in the future) are less frequent, and prescriptive solutions (i.e., offering recommendations on what should be done) are even less frequent. Moreover, prescriptive cases require all previous steps to exist.
- **Solutions with embedded analytics.** Look for solutions with embedded analytics capabilities as a part of IoT offerings to address your needs end to end. Focus on its capability to provide actionable insights that are context-relevant, and address the particular needs of specific personas within your organization.
- **Building analytical skills.** Assess and build internal skills and digital capabilities to maximize the benefits of the technology beyond data scientists. Ensure investments in staff, processes, and technology for governance, compliance, security, and risk management practices. Building an ecosystem of partners to develop such skills (such as universities and education sector organizations) is an option worth considering when building such skills.
- **AIoT at the edge.** Users should consider the specific challenges of AI inference and training when planning AIoT systems. Understanding the various architectures are important even in the early stages of the planning process.
- **Building a data-driven organizational culture.** Nurture data literacy and data intelligence, and build an evidence-based culture organizationwide in which the data at hand informs decision making. Change management programs are a key factor to ensure successful implementations, and educate the workforce on working alongside these technologies.

- **Long-term returns**. Expect the benefits of an AIoT solution to grow exponentially over time. As AI models tend to get smarter with the volume of historical data available, the quality and level of accuracy insights provided will tend to grow faster as algorithms are increasingly fed.
- **Beware of limitations.** Understand the limitations of AI – it is not magic. Ongoing efforts, investments, and continuous learning are necessary for the technology to yield sustainable results.

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Synopsis

This IDC Market Perspective analyzes the multiplying effects of deploying IoT and AI in combination. We examine how the two technologies bring greater benefits to organizations deploying them together than if they were deployed separately.

"Greater intelligence and the ability to deliver insights at scale will define the value of the technology and will determine competitiveness," said Marta Muñoz Méndez-Villamil, IDC EMEA IoT Practice Lead.

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