DEVICE INSIGHT

SENTIAN.AI

WHITEPAPER

BEYOND PREDICTIVE MAINTENANCE

Intelligent Automation with AIoT

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CONTENT

INTRO

For a long time it was considered the number one scenario for AI and IoT applications in industry: predictive maintenance. There is no doubt that predictive maintenance has the potential to enable you to service machines only when needed and prevent the "worst case" of a production downtime. However, it only has a limited effect as a revenue booster or even as an innovation driver. In reality, companies that focus exclusively on predictive maintenance leave the enormous potential of AI and IoT largely untapped. The full value contribution of these technologies can only be realized when the entire production process is optimized through Intelligent Automation.

With the term Intelligent Automation we mean holistic solutions in the sense of AIoT (Artificial Intelligence of Things), whose goal is to optimize the manufacturing production processes, often through reduced deviations. Fewer deviations mean improved machine and system performance, less scrap and lower costs – and above all, significantly more products in the highest quality class. As a result, the yield and profit of your company, but also the customer satisfaction with your products increases noticeably. In short, your industrial production is transforming into a Smart Factory.

It does not matter whether you produce sensors, pharmaceuticals or automotive parts. Deviations in the manufacturing process hold an enormous opportunity to increase efficiency and profits in every industry and can be identified and minimized with the help of AIoT. For example, the German manufacturer of automation systems and sensor technology JUMO was able to increase the quality of its sensors by 20%, while a European automotive group increased productivity by 25% thanks to AI.

You too can benefit from the new insights into your production and find out which processes are the key to the quality of your products. In an integrated approach we accompany your company on the way to AIoT-optimized production – from the analysis of your AI and IoT readiness to the implementation in your production environment. Take advantage of this opportunity and become an AIoT pioneer.

Your team from Sentian and Device Insight

> In every industry, Artificial Intelligence of Things (AIoT) can be used to realize value-adding opportunities for more efficiency, quality and thus higher profits.

WHY PREDICTIVE MAINTENANCE IS NOT ENOUGH

Everyone is talking about AI and predictive maintenance. Predictive maintenance is one of the most important and most discussed technologies at the interface of Internet of Things and Artificial Intelligence. The expectations of the industry for predictive maintenance are enormous. Failures and maintenance requirements are to be predicted precisely, thus preventing the failure of machines and significantly reducing service and maintenance costs.

However, if one takes a closer look at the industrial manufacturing process, one finds that predictive maintenance does not cover all AI scenarios by far, as it only increases the availability of machines, but not their performance. On the one hand, predictive maintenance serves to prevent the "worst case scenario", i.e. a production standstill – a situation that occurs relatively rarely due to the high reliability and quality of the machines and which is partly even excluded by contract. On the other hand, machine maintenance – even without the use of predictive maintenance – is in most cases already well controlled and accounted for. Here, AI and IoT merely act as "observers" and do not go beyond mere alarming in case of damage, especially since the failure of electronic components often occurs suddenly and is practically undetectable in advance.

25%

higher productivity
through process and quality improvement with AI at an automotive manufacturer in Europe

Source: Artificial intelligence (AI) in manufacturing. An overview and four applications transforming manufacturing (in German), IBM 2018

At the same time, AI and IoT technologies can contribute a much greater value to industrial production if one moves away from the focus on predictive maintenance and instead looks at the entire AI potential. At present, companies are largely ignoring the enormous potential of artificial intelligence for optimizing production. This is also due to the fact that the scope for improvement seems to be supposedly limited. However, it is precisely the gradual improvements and fine adjustments of the manufacturing processes with AI and IoT that offer promising business value, with the prospect of an efficiency increase, typically ranging between 3 and 30%, according to McKinsey (Manufacturing's control shift, McKinsey 2018). With new applications of AI and IoT, companies can therefore significantly improve the performance of production and make the combination of these technologies their competitive advantage. The keyword here is: intelligent automation.

5%-20%

Source: IBM

lower labor costs
for quality control with AI at an electronics manufacturer

WHAT IS INTELLIGENT AUTOMATION?

Intelligent industrial systems are high dimensional, non linear, and stochastic in nature, while classic industrial systems are linear and non adaptive in general, and reactive instead of proactive.

Industrial control systems started being developed 50-60 years ago and current systems have not evolved that far. Standards and protocols sacrifice performance for robustness to avoid costly interruptions. And, in day to day business, data is often noisy, dirty data and in many cases biased.

Moreover, traditional control systems in production are programmed by humans. They were designed to solve a specific task and are not able to learn and adapt over time. The latest in machine learning, on the other hand, is more creative, capable of quickly exploring as many combinations as necessary to find an optimized state. In short, AI algorithms look for optimal solutions, not preprogrammed set points and rules.

Another challenge is that machines are becoming increasingly complex and well-trained specialists to operate them are hard to find on the job market. There are a few experts who have developed a great deal of experience and intuition over the years. However, these experts are not always and everywhere available.

As a result, there are often considerable differences in performance between the various teams and machine operators within a production facility – with varying reject rates and varying quality of the parts produced. In addition, humans make mistakes or sometimes decide on the basis of gut feeling.

Here's an anecdote directly from an industrial company: a long-time employee checks the functionality of a system by placing his coffee cup on it. If the vibrations of the liquid in the coffee cup are too strong, he believes that there is a defect. AI tries to replicate this intuition and proposes deterministic approaches in machine programming.

Therefore, a new generation of industrial systems is needed that solves these kinds of challenges. This means a fast, much more dynamic and accurate – yet also robust – system that does not sacrifice efficiency for speed.

This is where intelligent automation comes in ensuring machines and systems work closer to their optimum, regardless of being autonomous, or who is operating them and where they are located. This is achieved by using artificial intelligence, more specifically by means of **Model Based Reinforcement Learning**, a relatively new form of Deep Learning, which has the dynamic capability and precision that was hard to achieve before. In this way, AI becomes the perfect complement to humans. The advantage for companies: more efficient production, higher quality results and thus an overall increase in profits.

TYPICAL AI USE CASES

INTELLIGENT AUTOMATION TO INCREASE QUALITY

#1 PHARMACEUTICAL INDUSTRY

Challenge: *In pharmaceutical production it is important to get the recipe right. This process is run by several systems with multiple steps where a slight deviation can result in not only scrap with its cost but also a cost for destruction. The systems need to be optimized within tight tolerance levels. This may involve several systems such as a DCS (Distributed Control System) and automation systems. However, measurements can sometimes not be taken until the batch is completed resulting in scrap and destruction cost.*

Solution: *With a dynamic, AI powered industrial system that is continuously predicting the future and optimizing the process, deviations can be corrected before the product falls outside tolerance levels.*

#2 POWER PLANT

Challenge: *Power plants can suffer from variable fuel quality. A control system like SCADA/DCS or APC system (Advanced Process Control) can be used to control the process but the output still varies significantly. The goal is to maintain a high performance with low variability while keeping within emissions control and keeping use of chemicals as low as possible. The control systems are however reactive and can struggle to keep a high constant output.*

Solution: *By boosting the control system with a dynamic AI system that is predictive and that explores set points in a more efficient manner, the process improves performance.*

#3 PAPER PRODUCTION

Challenge: *Thickness is an important paper quality measure. The thickness quality is sometimes less than the lower specification limit, due to process variability, resulting in a loss. A solution is to overfeed the machine with more wood fiber resulting in higher production quality but at higher cost.*

Solution: *Reducing the variability reduces the out-of-limit instances and saves material cost. Further, it reduces waste production, and increases the throughput. This is done with quality tests, in time intervals, but lab results are not in sync with production and the later adjustments assume all things remain constant and consistent as at the time of the test. However, most of them will likely have changed, by this time. Instead of the operator making continual adjustments in the dark, or to set the controls to a certain "recipe card" the solution is a dynamic process and variation reduction powered by AI.*

JUMO goes Smart Factory: By integrating AI in production, the Fulda-based industrial company has been able to increase the share of its "highest quality" sensors by 20%.

Intelligent Automation Applied at JUMO

But what exactly is the technological approach of intelligent automation? According to our definition, the basic goal of intelligent automation is to significantly minimize variation from the optimum within the production process. Because: A low variation means a higher quality of the produced parts and therefore also less defect products and an overall higher yield of the production. It also means optimizing the process to run as efficiently as possible, i.e. without interruptions, with as little energy and emissions as possible and with as little additional costs such as added chemicals or other byproducts.

The example of JUMO, a German manufacturer of automation and sensor solutions, shows how the intelligent automation approach works in practice:

// Starting point

For the production of automation and sensor technology, JUMO operates highly automated high-tech production facilities with advanced machines and many robots. Nevertheless, the company found that small but significant fluctuations occur within the production process. This led to deviations in the quality of the sensors produced. Since sensors that did not meet the expected high quality had to be downgraded to lower levels of quality with a lower margin or even rejected as defective, the deviations inevitably led to a lower yield.

JUMO, GLOBAL

Focus:
Automation and sensor solutions
HQ: Fulda, Germany
Founding year: 1948
Employees: 1,300 Germany, 1,100 internationally
Representation: 60 countries worldwide
Production: 13 countries worldwide

www.jumo.de

INTELLIGENT AUTOMATION APPROACH

USE CASE JUMO

GOAL:
YIELD
OPTIMIZATION

MEANS:
VARIATION
REDUCTION

CHALLENGE:
DATA
VOLUME

Virtually all industrial processes are subject to certain fluctuations as a result of heterogeneity in the materials used, environmental variables such as temperature, personnel or other factors, some of which are unknown.

By adding an intelligent and adaptive solution to the process these fluctuations can be handled and increase the quality of production.

Machine Learning (ML) solutions derive patterns without being explicitly programmed by experts in the field. This is an effective approach, but often requires large amounts of data. Data that is often not available. In order to solve that, solutions can be made to be very sample efficient.

In other cases, however, huge amounts of data are generated in the production process. Then the challenge is to deal with the data volume, time-critical data and possible interruptions in communication.

USE CASE JUMO

At JUMO, one of the most important measures of yield is the percentage of temperature sensors that meet the quality requirements for the highest of three tolerance classes. The aim was to use AI to increase sensor accuracy and thus the quality of the sensors, as well as the overall yield.

JUMO's sensors are produced in batches. The production settings for each batch can be adjusted to reduce slight anticipated variations in average sensor precision.

An AI system was installed for this purpose, which was able to carry out these adjustments better than an experienced process engineer.

Since the production settings at JUMO are applied at batch level rather than to individual sensors, only a small amount of data (by AI standards) is available. This requires a very high sampling efficiency, both in the imputation and prediction models.

INNOVATION:
IMPUTATION MODEL FOR MISSING DATA

No data set is perfect, and many industrial time series lack very recent data points because they have not yet been added to the system. Filling these gaps is called imputation.

It takes several weeks for the final tests to be carried out on each batch of sensors, creating significant lags in the available data. A simple imputation – e.g. using averages to fill in the gaps – was not powerful enough to solve the problem. Therefore a special imputation model with its own architecture was set up.

SOLUTION:
AN ADAPTIVE SYSTEM

Production processes change and evolve, as do the input variables mentioned above – sometimes in an unplanned and previously unknown way. An AI system must continuously adapt to such changes without manual re-training of the models or even a new installation.

The approach automatically incorporates new information and optimizes the model after each sensor batch. The software used at Jumo dynamically evolves with the production system.

USE CASE JUMO

// Results

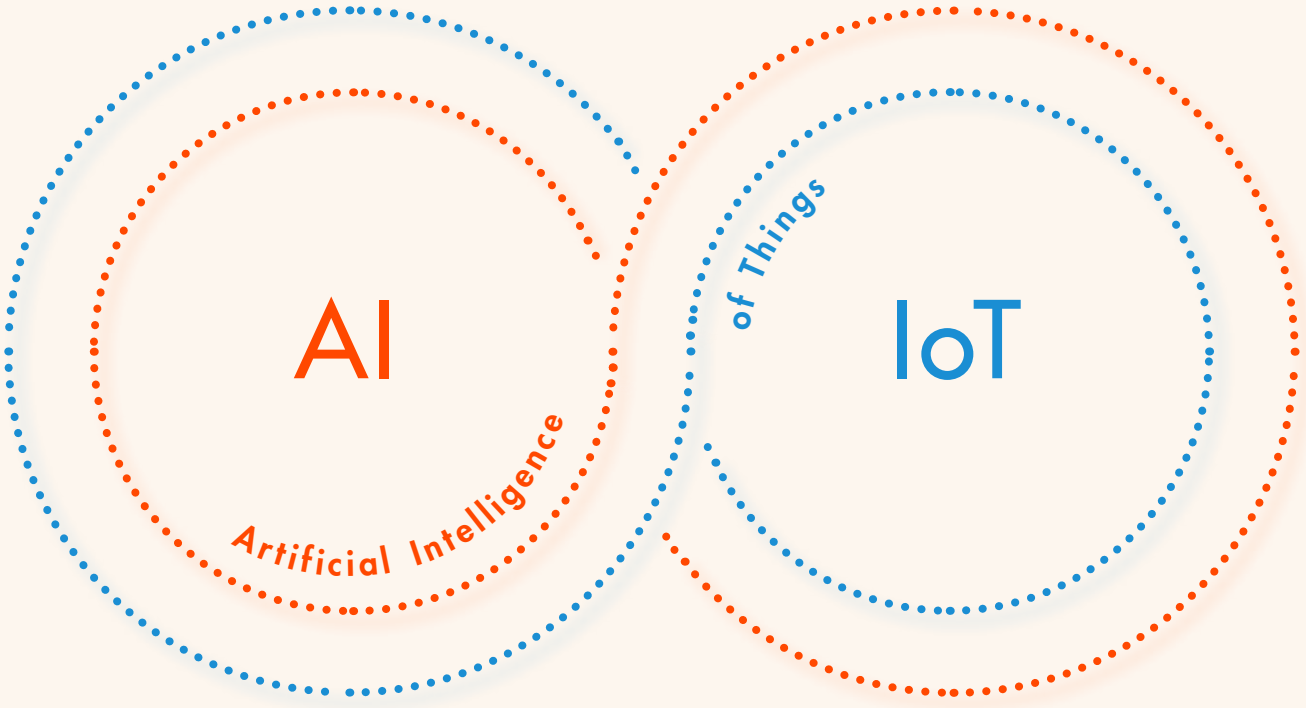
Through the AI-based approach, JUMO was able to increase the proportion of sensors in the highest quality level by 20%. In this way, JUMO's production is developing into a Smart Factory based on intelligent automation.

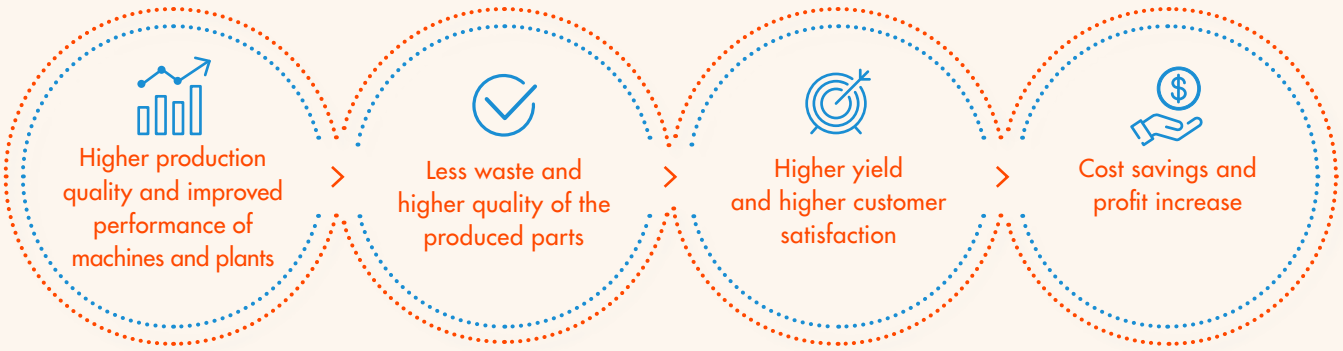
Benefits of Intelligent Automation

Intelligent production is based on the alliance of AI and the Internet of Things. We call it an "Artificial Intelligence of Things".

The most important advantages at a glance:

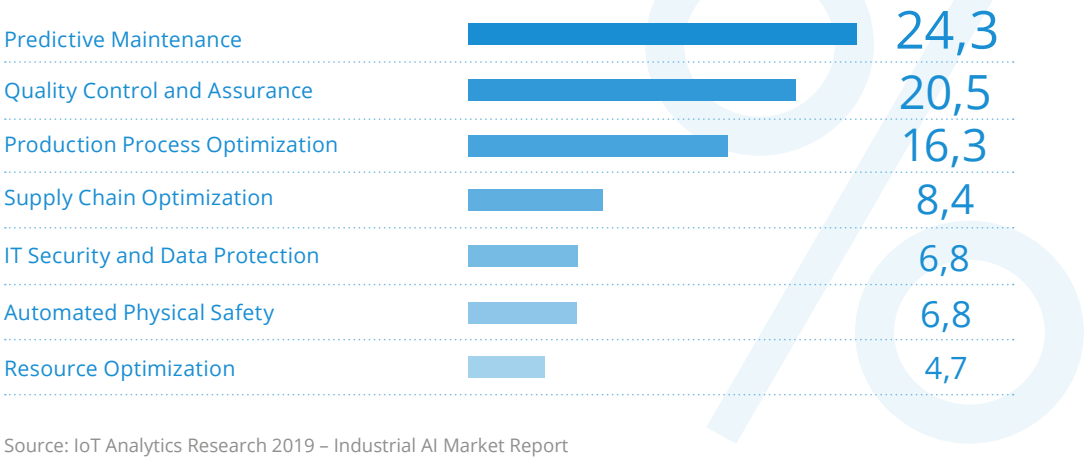
SMART FACTORY:
AI + IoT = AIoT





AI MEETS IoT

In order to use the full potential of intelligent automation, two technologies must be combined: Artificial intelligence and IoT. But what makes this combination so unique? The first companies have already begun to integrate artificial intelligence into IoT environments to improve the quality of their industrial products. As the study by IoT Analytics 2019 shows, the topic of quality has become the most important area of application for AI and IoT after the "entry-level scenario" of predictive maintenance. Around 21% of companies use AI and IoT for quality assurance, 16% use it to improve their production processes – which ultimately also pays off in terms of quality.



Source: IoT Analytics Research 2019 – Industrial AI Market Report

However, the majority of companies are still working on individual solutions that are intended to achieve selective improvements in production. However, optimization at a single point in production remains locally isolated and can, for example, result in a machine's performance being increased by 5%, but the parts produced are left lying around longer because the downstream process continues to run according to the old scheme. Far more promising is a horizontal approach, which encompasses several machines, processes and systems. Powerful machine learning algorithms are integrated into the entire production landscape and rely on a broad database. Only then, the path to a Smart Factory is paved and the desired efficiency increase of 3-30%, as forecast by McKinsey, becomes a realistic business goal.

The decisive factor here is the combination of AI and IoT. After all, the full potential of artificial intelligence can only unfold if well-maintained, high-quality data is available centrally, on the basis of which ML models are applied to initiate a "learning process" within the production processes and derive automated measures. IoT technologies provide the basis for first-class data. All relevant process and production data are recorded and pre-processed in real time – always under the condition of avoiding information silos. Unstructured data from text files, documentation and other sources can also be included. The meaning of the data is in turn decoded with the help of AI technologies – and in a way that goes beyond typical human thought and problem-solving patterns.

For this reason, there is still a touch of mystery surrounding the idea that – and especially to what extent – industrial processes can be disclosed, digitized and optimized by means of AI. In fact, the methods required are already available: Mature IoT technologies and AI solutions have passed the practical test in recent years and can be used in a scalable way in a company-specific context.

You too can benefit from completely new insights into your production processes and gain a unique understanding of the processes that tip the scales for the quality of your products. Use the potential of AI and IoT and gain smart yield optimization.

// AIoT = Sentian + Device Insight

The Swedish Industrial AI company Sentian and the Munich-based IoT specialist Device Insight have joined forces as project partners to support companies in developing and implementing holistic solutions in the sense of AIoT (Artificial Intelligence of Things). The goal is nothing less than the intelligent automation of industrial manufacturing processes, which can help to achieve an increase in production efficiency of typically 3-30%.

SENTIAN

Main focus: AI solutions for industry and manufacturing
HQ: Malmö, Sweden
Founding year: 2016
Employees: 21
www.sentian.ai

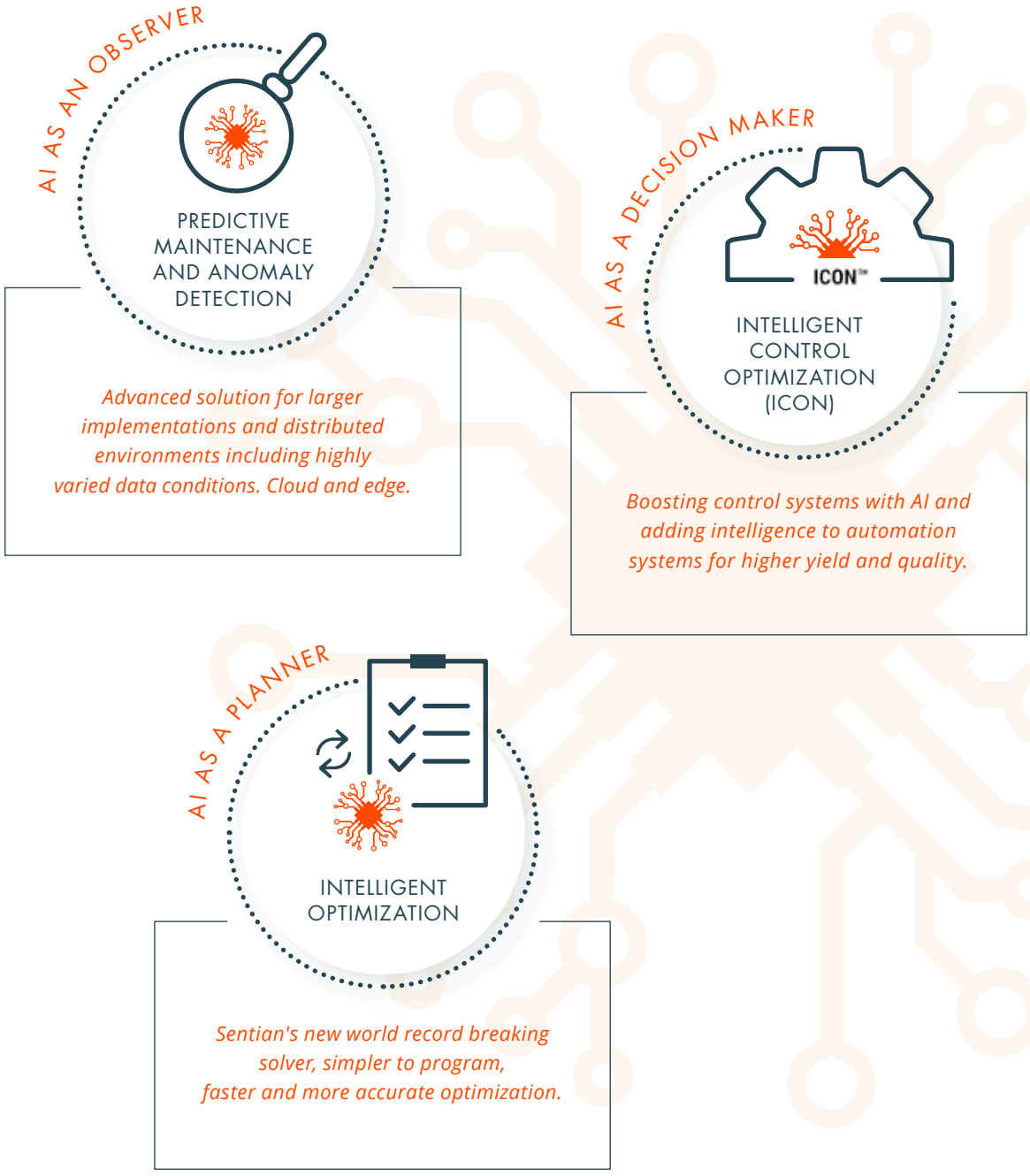
DEVICE INSIGHT

Main focus: IoT and IIoT solutions incl. system integration for industry and manufacturing
HQ: Munich, Germany
Founding year: 2003
Employees: 100
www.device-insight.com

// AI technology stack by Sentian

Sentian is the partner at your side for all matters concerning artificial intelligence, machine learning and smart algorithms. The Swedish AI specialist accompanies you in the adaptation and further development of your industrial processes towards smart manufacturing / industry 4.0. regardless of the degree of digitization of your company, Sentian delivers customized AI solutions that enable you to achieve real business value. The applications are designed for single or already networked machines, plants and cross-plant setups.

Sentian's adaptive product suite encompasses the following solution areas:



Four key technical breakthroughs at the core of Sentian's innovative AI solutions:

- **Model-based Reinforcement Learning Engine for intelligent control and automation systems:**
  Using a model-based reinforcement learning approach, Sentian creates an intelligent control system that is scalable and automatically adapts to changing conditions. Model-based reinforcement learning is the latest evolution of deep learning and is used as existing methods were not adaptive enough.

- **Nonlinear "Optimization Engine":**
  The Optimization Engine is a nonlinear solver, allowing fast and highly accurate planning and flexible replanning within a manufacturing facility. API based and easy to work with. The solver is very flexible and can be used cross-sectorally, using a technology that broke the current non-linear record for the QAP family*, used for among other things route optimization, production planning and supply chain optimization.

- **Support for little data:**
  In order to deal with cases where there is a lack of data – a typical challenge in the industry -, Sentian has developed support for very high sample efficiency.

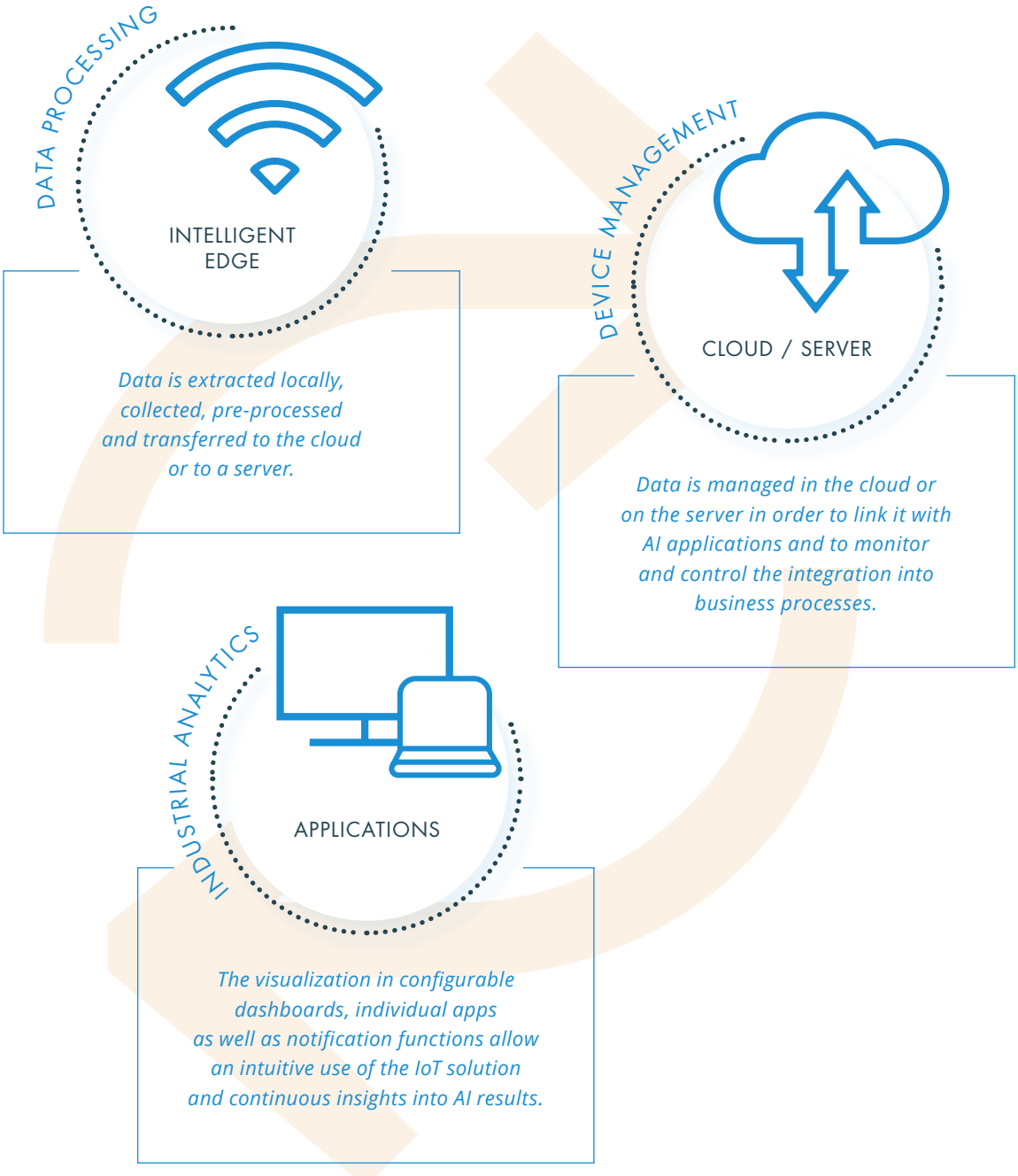
- **Automated machine learning for high scalability:**
  Traditional development of machine learning models is very resource-intensive. With Sentian's automated ML engine, production-ready ML models can be designed and deployed easily and efficiently.

Sentian brings technical achievements into our AIoT approach enabling scalable solutions for industrial customers targeting both cloud and edge solutions.

* The QAP (Quadratic Assignment Problem) is a mathematical method from the field of combinatorics. It deals with the (combinatorial) optimization of an interaction between several interacting variables such as a rail network, factories and the goods to be transported in a region. The method is especially applied to planning problems.

// IoT technology stack by Device Insight

During the implementation of an AI and IoT project, the German IoT specialist Device Insight accompanies you through all phases of data usage: from aggregation, management and linking with AI applications up to analysis and presentation of results. Device Insight offers a flexible IoT framework that can be equipped with tailored components and extensive functions to develop and implement a tailor-made, scalable IoT solution.



At the same time, Device Insight works as a system integrator, developing custom services and applications that support the platform services of all PaaS providers. The solution stack of Device Insight is modular.

Numerous ready-to-use microservices offer an additional plus in terms of independence and flexibility for the application:

- **Edge processing**
  Standardized and customized protocol adapters for data extraction. The data can be preprocessed and buffered locally. Permanent synchronization of AI models or results from the cloud keep the local systems up to date.

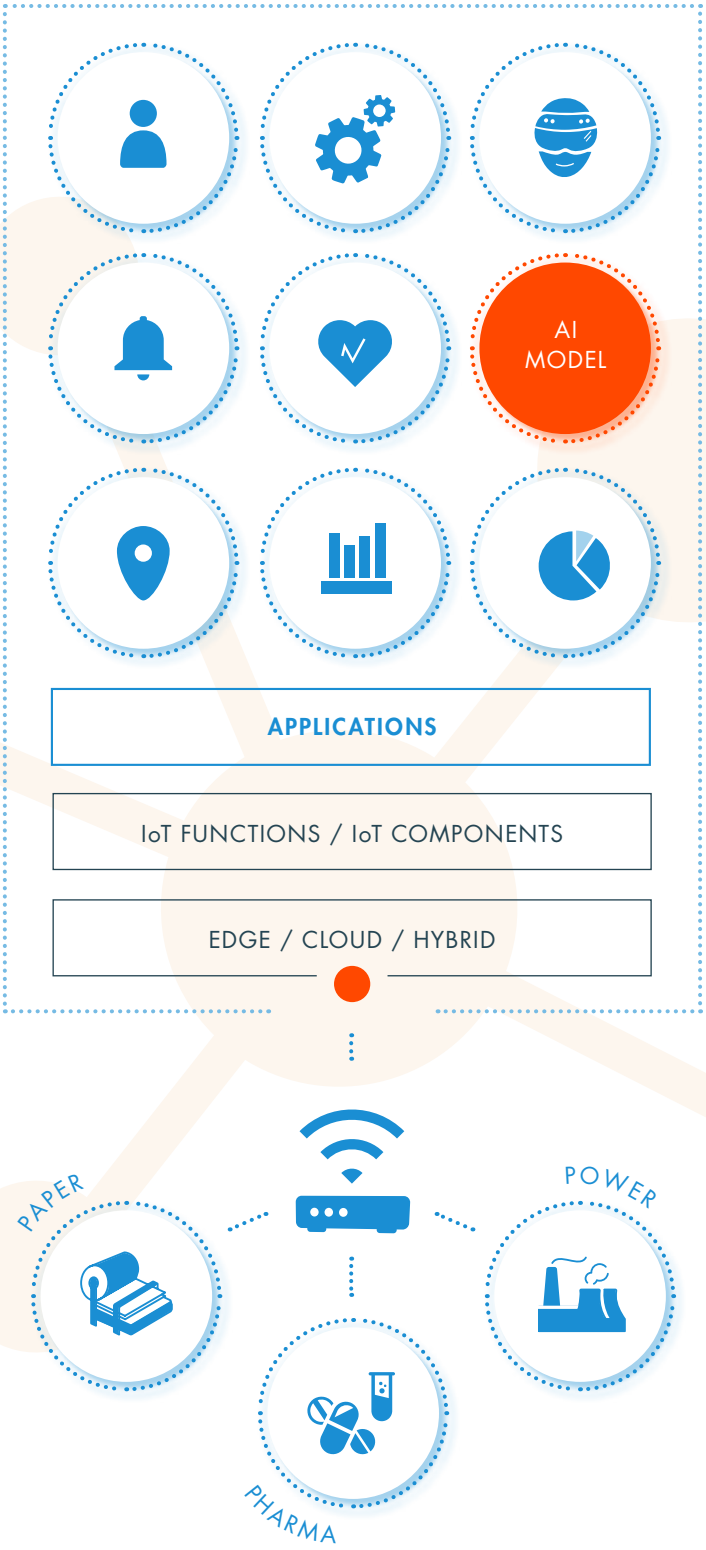
- **User interface**
  Modern, responsive and expandable frontend with a wide range of services.

- **Application core**
  Core of IoT applications development including an integrated multidimensional tenancy and role-based access model.

- **Rule engine**
  Configurable rules as basis for data analysis and also actions and "events" derived from it.

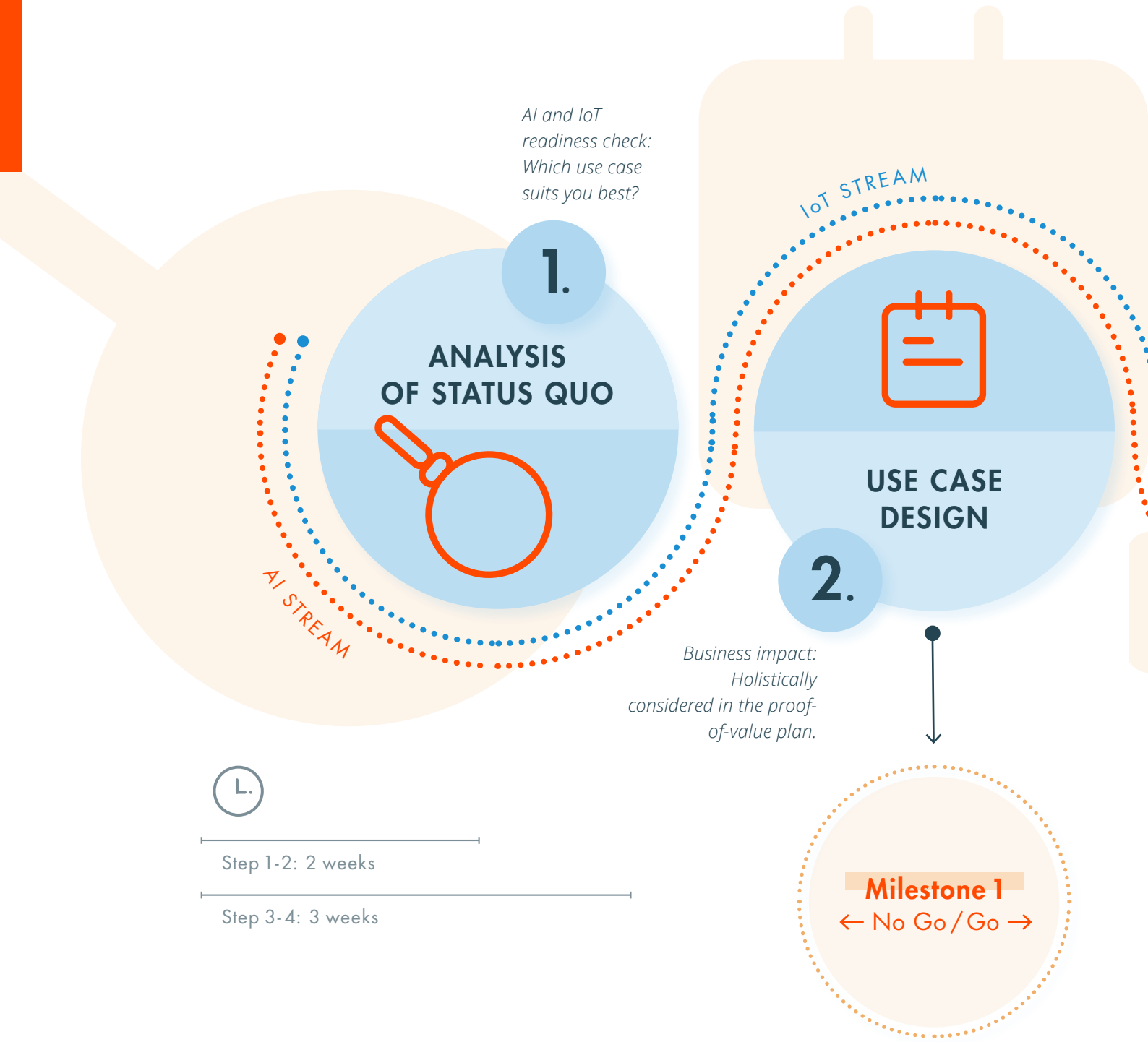
OUR FRAMEWORK

AI AND IoT WORK TOGETHER
HAND IN HAND



We put great emphasis on open architectures and standardized concepts. Having a lot of experience with message brokers, service bus technologies and industry standards such as OPC-UA, we manage to avoid data silos and isolated solutions. The use of both cloud and open source technologies enable flexible deployments for any smart factory scenario.

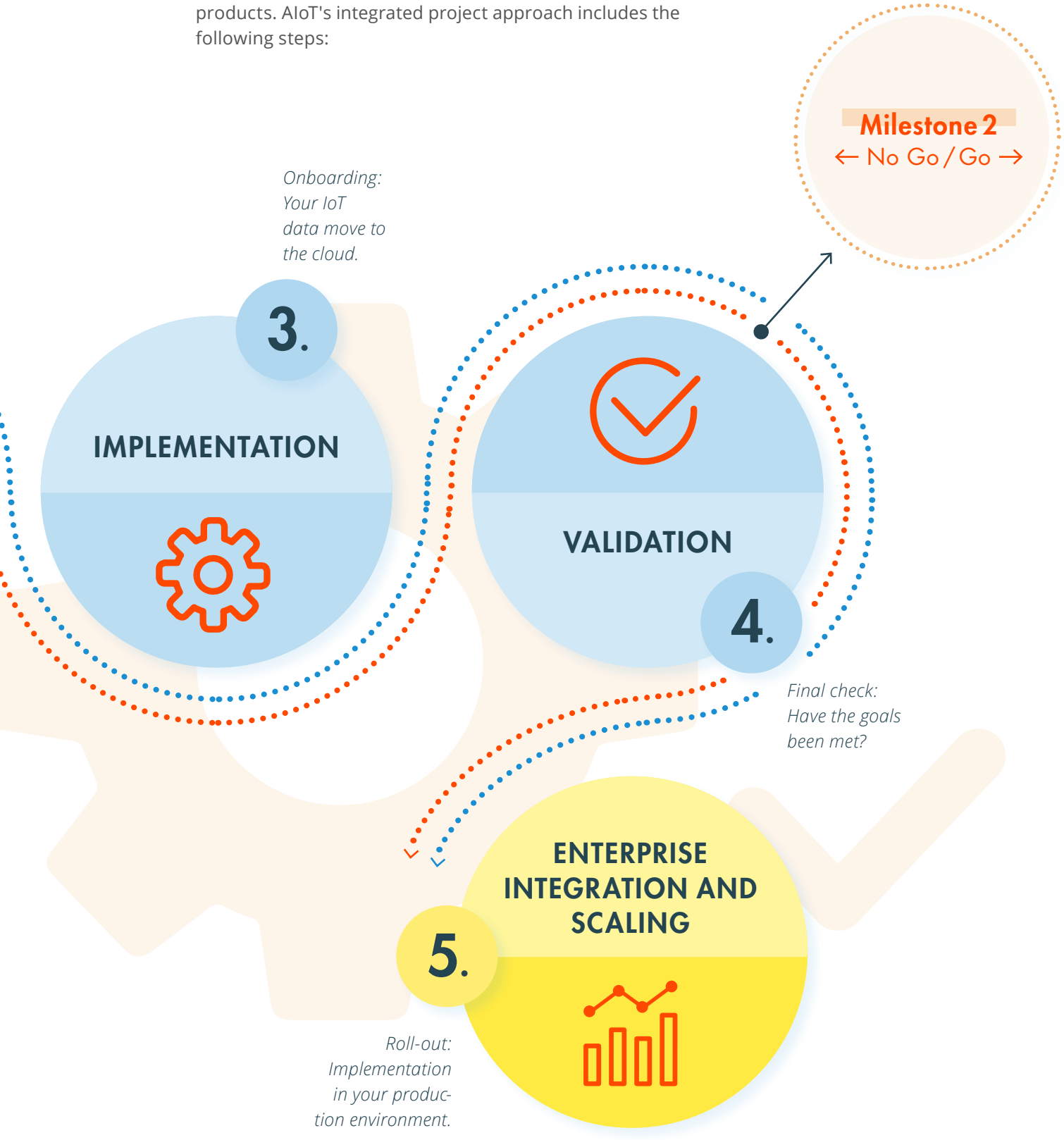
5 STEPS TO BECOMING AN AIoT LEADER



Step 1-2: 2 weeks

Step 3-4: 3 weeks

Using AI, IoT and Intelligent Automation, Sentian and Device Insight enable companies to identify previously hidden production problems, improve the manufacturing process and significantly increase the quality level of their products. AIoT's integrated project approach includes the following steps:



Step 1: Analysis of status quo

At the beginning of the project we evaluate your individual initial situation: What does the IT architecture of your company look like? What is the data availability? How AI and IoT ready is your company? In parallel running AI and IoT streams we analyse the status quo and identify suitable use cases and their value.

AI and IoT readiness check: In order to find out to what extent your company is technologically and organizationally ready to change established processes by using innovative AI and IoT solutions, we apply an AI and IoT readiness check. In doing so we examine the scope, quality and availability of your IoT data. The aim is to ensure the smooth integration of IoT data into your individual AI solution.

Creating a data foundation: The main building block of an AI and IoT project is a first-class database containing all the important production or process data from which you want to benefit with intelligent automation. This is easier said than done. Often there is very little data available, because in the past it was not stored systematically. Or the opposite is the case: The connected devices and machine parts generate huge amounts of data (big data), which must first be filtered and structured. Another challenge is the delay of data transmitted by sensors, gateways or PLCs, which requires data cleansing, structuring and often imputation, i.e. filling the gaps based on the available data sets. This is especially true for manually collected data in a production facility where no sensors are installed and the steps for quality acceptance are performed by employees themselves.

As a preparatory measure, we recommend companies to answer the following questions in this setup phase:

- What data is available?
- Do the data contain errors or gaps?
- Where has the data been stored or kept?
- How can they be extracted?
- What pre-processing and standardization is required?
- Is there a central access to the necessary data?

› TIP

If you do not know yet which data you really need and what the greatest potential is, we will advise you in advance and screen your industrial production for possible adjustments for a noticeable quality and process optimization.

Step 2: Use case design

In the next step we work out a clearly defined use case, based on the structures in your production, supplemented by a proof of value plan. This plan ensures that your production processes are viewed and optimized holistically. Therefore we establish pre-defined KPIs and milestones, on the basis of which the business success of the use case can be measured.

Identifying pain points:
Based on your operational situation, your requirements and your IoT dataset, we identify the decisive pain points and focus on them when setting up suitable AI solutions. In this way, we already know at the design stage of your use case how we can best meet your KPIs in terms of quality.

Business impact analysis:
Together with you, we quantify the business value of the pre-selected AI solutions and examine the impact on your operational business. In doing so, we forecast how we can best influence your business figures in terms of revenue and profit.

At the end of the design phase, an initial Go vs. No Go evaluation of the proof of value and the decision on the further course of the project is made.

Step 3: Implementation

Once the proof of value has been provided, the concrete development and implementation of your AI and IoT use case begins.

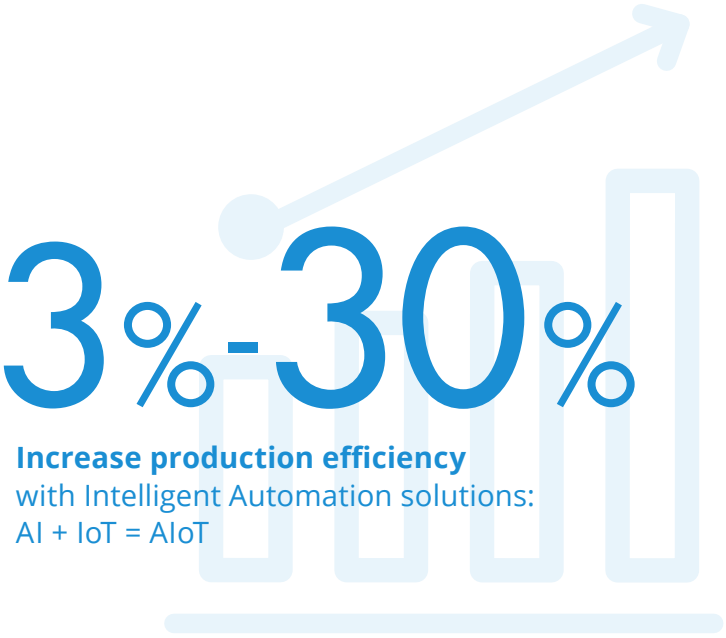
IoT data into the cloud:
At this point we start with the onboarding of your machines and systems, i.e. we connect them with the cloud, accompany the collection and aggregation of your collected data and, depending on your requirements, deliver the appropriate applications and features for the visualization of your smart factory. This gives us a deep insight into your manufacturing processes and prepares the basis for the subsequent integration of your AI solution.

Step 4: Validation

After the implementation of your use case, we check whether the proof of value has been confirmed. Have the goals and milestones previously set been achieved? If this question can be answered with a clear "Yes", then we are ready to integrate the AI solution into your production environment in the next step.

Step 5: Enterprise integration and scaling

After the technical and organizational requirements for a rollout have been successfully checked, the integration of the use case into your production environment follows. The solution is brought to a production grade standard and professional operations concept is established. All systems in scope can now be integrated. Further, the solution can now be scaled to more machines, lines, location and additional use cases.



3%-30%

Increase production efficiency
with Intelligent Automation solutions:
AI + IoT = AIoT

Source: McKinsey 2018

TURN YOUR PRODUCTION INTO A SMART FACTORY

At this point, you already know how an AI and IoT project is set up and when to expect first results keeping an eye on the business value of your use case. Well, then there is nothing more standing in the way of intelligent automation of your production and smart profit optimization for your company. Get started now - and benefit from the combined expertise of Sentian and Device Insight.

Get a quick check on what makes our integrated approach so special:

- **End-to-end support:**
  We accompany you from the assessment of your individual use case up to implementation and scaling.

- **Proof of value instead of proof of concept:**
  We follow an iterative and agile approach and, based on agreed milestones, we validate again and again whether the approach fits your goals. The focus is not only on the technical feasibility (proof of concept), but above all on the real added value (proof of value) to your business case.

- **Think big, start small:**
  Our credo is "Think big, start small". We start with a clearly defined first use case. What proves itself "on a small scale" can be scaled up further. In this way we reduce your risk and guarantee real business value.

- **Transparent planning and documentation:**
  Our work is no "black box". You have full control over the project at every point in the process. On the basis of clearly defined milestones and transparent documentation and planning, you can always see what progress has been made and where improvements still need to be made.

Interested in AIoT?

Do your personal AIoT Business Assessment

Free of charge and without obligation:

Schedule an assessment appointment now

DEVICE INSIGHT

SENTIAN.AI

ABOUT DEVICE INSIGHT

Founded in 2003 in Munich, Device Insight GmbH is an IoT specialist, accompanying companies in their digitization in the fields of Internet of Things, Industry 4.0 and Artificial Intelligence. Based on a flexible IoT framework, Device Insight combines ready-to-use IoT building blocks and microservices with individual applications for customized IoT services. System integration based on common cloud providers and development are combined to create tailored solutions that are both fast and scalable. Device Insight supports global networking of machines, vehicles, plants and devices and provides applications in the fields of Data Acquisition, Condition Monitoring, Predictive Maintenance, Machine Learning, Industrial Analytics and AIoT (Artificial Intelligence of Things). Device Insight is active in more than 15 countries, working together with large enterprises and mid-size customers from various sectors, including machinery and plant engineering, HVAC, commercial vehicles, vending, transport, energy as well as the Connected Home environment. Services range from business case analysis and implementation to secure IT operations. The company has been awarded “Internet of Things (I4.0) Leader Germany” on numerous occasions by the ISG Provider Lens study. Since 2019, Device Insight has been a subsidiary of automation specialist KUKA AG.

www.device-insight.com

ABOUT SENTIAN

Sentian.ai is an industrial AI company that provides AI solutions and services to both manufacturing and process industries. Sentian.ai has an extensive research program in applied AI to be able to deliver leading edge products that give its customers a competitive edge. Sentian.ai offers three products: ICON (Intelligent Control Optimization) that boosts existing control and automation solutions with AI, Predictive Maintenance for large scale implementations in distributed environments as well as factory floor, from cloud to edge and its world leading nonlinear optimization solver for production planning, supply chain optimization and personnel planning optimization. Sentian.ai has been recognized for its leading AI technology and solutions multiple times.

www.sentian.ai