SIEMENS
Ingenuity for life

**TURNING THE
INTERNET OF THINGS
INTO REALITY**

*A practical approach to your
unique IoT journey*

The Internet of Things (IoT)
is changing the way we live.

Having become ubiquitous in the
consumer economy, IoT is now
emerging as a force in every industry
including manufacturing, energy utilities,
healthcare, transportation and building
technologies. This is no coincidence.

The Internet of Things creates
measurable value for private and
public organizations alike.

The prospects are exciting. By enhancing resources with IoT, employees and organizations generate new value. Notable examples include improved air quality in cities and increased availability and reliability of rail vehicles of up to 99%. Other IoT implementations cut non-technical power losses in half, saving $150 million for an electric utilities company in Brazil, and reduce delivery days in electronics manufacturing from 25 to less than 7, improving quality at the same time. As new business models emerge, they create new ways to capture value.

It's tempting to jump on the bandwagon, as IoT brings exciting opportunities. But successfully leveraging the IoT for one's own business implies finding a suitable and mean-ingful use case, managing a full implementation and changing processes and organizations alike – while safeguarding cybersecurity from day one. Most businesses do not have all the required capabilities in house and need partners along the way.

A full changeover to an IoT-enabled business consists of several phases ranging from developing a strategy, ideating a use case, and prototyping for a proof-of-concept to design-ing the solution and connecting assets, including adapting existing systems and integrating them into a bigger system. At its core, successful implementation depends on analyzing and leveraging the data that is collected from the assets and using suitable business models.

Operating and maintaining the system is an on-going activity after the technical implementation, while efficient change management and cybersecurity concepts are required from the very beginning and throughout the whole process.

For organizations embarking on the IoT journey, what's needed most is a place to start, information, and a practical guide. This paper aims to provide all of these.

» The Internet of Things (IoT) is undoubtedly one of the largest enablers of responsible digital transformation. «

World Economic Forum, 2018

Everybody talks about self-driving cars, fridges that manage your grocery shopping, and smart speakers that read out the recipe for your Italian pizza. Even though there are many examples of how the IoT is becoming reality in the consumer space, it is still in its infancy in the industrial environment due to tough technical challenges. The IoT is still a little like the Internet in the 1990s. Even though people were already talking about online shopping, very few were able to fully imagine it in real life. Similarly, everybody is talking about the IoT – but only a few can fully appreciate its future impact; not in private life, and even less so in an industry context.

However, frontrunners like Amazon and Walmart have already proven that data can be used to generate incredible value. The World Economic Forum estimates that industrial IoT alone could add US$14 trillion of economic value to the global economy by 2030.[1] "Data is the new oil" *(Clive Humby, Tesco)* – but how do we convey it? How do we have to refine it? And what are the engines we use it for?

Market research company Gartner estimates that 8.4 billion connected things were in use worldwide in 2017, with 3.1 billion devices connected in businesses alone. By 2020, Gartner predicts, businesses will have 7.6 billion IoT connections.[2] But much like the Internet, connected devices do not generate any value on their own. It's all about finding the right use cases. We should stop talking about the IoT as a technology, and instead consider the value it creates and the applications it is used for. Or would you describe the Internet as a network of networks of connected nodes, as we did in the 1990s?

Most of the businesses are still in the exploration phase. But it won't be long before IoT is indispensable. IDC, a market research firm, states, "The IoT market is at a turning point – projects are moving from proof-of-concept into commercial deployments."[3]

While the IoT unquestionably affects our businesses today and will accelerate the digital transformation of organizations, its wider impact on our society as a whole is still opaque. This should be a sufficient reason to look systematically at the tasks and phases required for a successful implementation of IoT in a corporate context.

Everybody is talking about IoT – but only a few are actually doing it.

Connected devices do not generate any value on their own. It is all about finding the right use cases, that do!

THE INTERNET OF THINGS
IN A NUTSHELL

Before an app can provide insights, data needs to be collected from things, communicated via a network and processed using machine intelligence. Therefore, the Internet of Things provides the link between the physical world, the analytics and the app on the end user's device.

UX

UI

APP
INSIGHT PROVISION

THINGS
DATA COLLECTION

GATEWAY
DATA COMMUNICATION

INTERNET
DATA TRANSFER AND STORAGE

MACHINE INTELLIGENCE
DATA ANALYTICS
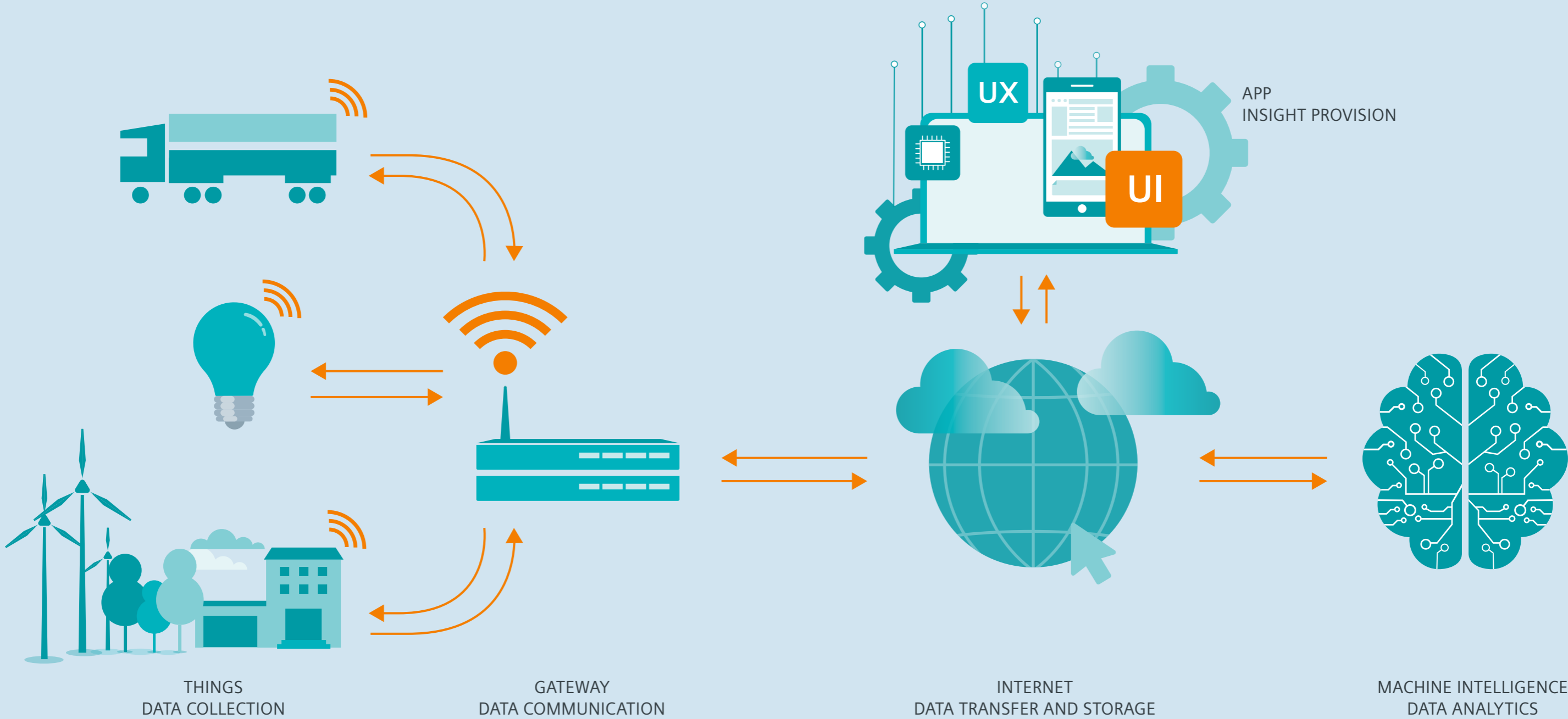
The IoT links the physical world with the digital world, collecting data from assets in order to create value.

Value like product improvement, enhanced efficiency, customer satisfaction and new revenue streams through data based business models.

The collected raw data (which can be provided by a refrigerator, a car or an industrial valve) is transmitted via a communications network and processed to derive new information. The value is created as soon as the information is used to trigger an action such as placing a shopping order, jamming the brakes, or closing the valve. This action can, but doesn't necessarily have to be automated. Several examples demonstrate how value can be created by the IoT:

PRODUCT IMPROVEMENTS

In the food industry, monitoring of food processing temperatures, as well as the age and chemical make-up of raw material, impacts the quality, safety, and shelf-life of products.

MAINTENANCE EFFICIENCY

Unplanned down time in factories or in transportation systems is not only an efficiency killer; it is expensive and dangerous. By detecting sub-optimal asset functioning (factory equipment, for example), maintenance can be performed before the equipment fails, thus avoiding expensive or dangerous unplanned failures.

DISRUPTIVE BUSINESS MODELS

Changing the way business is conducted (e.g. Uber).

WASTE REDUCTION

Real-time information about resource consumption, be it electricity moving through a smart grid, gas flowing through pipes or material required in a factory, makes it possible to apply resources as needed as well as identify leaks, thus reducing or eliminating waste.

SUSTAINABILITY

IoT-enabled smart cities use sensors to collect data about weather and air quality. When air quality is deemed poor, the city takes immediate action (such as offering free public transportation) and can easily measure the impact of corrective measures.

CONVENIENCE

The ability to switch on the lights in your living room via voice recognition is not necessarily efficient or sustainable. But it is probably convenient.

(ENERGY) EFFICIENCY

A solar paneled shopping mall generates some of the energy it uses. An IoT-enabled solution collects and analyzes data about weather, energy consumption, and energy market prices. The system then automatically determines the most cost-effective way to use energy generated by the mall. Options included consuming the energy immediately, storing it, or selling it at a high market price.

DIGITAL TRANSFORMATION
AND THE INTERNET OF THINGS

IoT is the largest enabler of digital transformation.

Leveraging the capabilities of the IoT is all about connected assets that support use cases, resulting in operational efficiencies, increased competitiveness, or even new revenue streams. It generates actionable information both on a private level – imagine your fridge sending you a text message when you're running out of milk – or for your organization. Wouldn't it be reassuring to know in advance when a transformer in your factory is about to overheat, and that a technician is already informed and on the way to fix it?

But how exactly does this link to a digital transformation?

At its core, the digital transformation means a fundamental change of how value is created within an organization. This may comprise a change of business model, including a completely new customer experience, a change of processes, and/or a change of organizational set-up that in turn increases the overall capabilities and consequently often leads to a change of strategy.

Uber and AirBnB are some of the most prominent examples that revolutionized the taxi and hotel business by transforming a product to a service driven business model. German steel distributer Klöckner, which has built a platform to become the "Amazon.com" of the iron and steel trade, is also a role model for digital transformation. Vaillant, a heating technology company, adapted new technologies in various respects – offering digital sales support as well as connected devices for smart home applications and service.

Implementing your first IoT use case may set the ball rolling for further digitalization projects potentially leading to a fundamental transformation of your business.

An Internet of Things implementation is often the driver of digital transformation. The World Economic Forum has identified the IoT as the largest enabler of digital transformation. Therefore, the implementation of your first IoT use case may set the ball rolling for further digitalization projects that may eventually lead to a fundamental transformation of your business. Imagine single devices negotiating autonomously with other devices, using blockchain technologies to settle contracts without third-party intermediaries. Cutting out middle men, traceability and improved efficiency alone could save you enough money to embark upon and fund the next IoT project.

It is crucial that these prerequisites and mechanics be taken into consideration before embarking on the IoT journey. We recommend developing a clear vision of a company's digital strategy when starting to implement IoT.

CHALLENGES
AND CONCERNS

» Security, integration with existing technology and uncertain returns on investment are the three biggest barriers to great IoT adoption in the enterprise. « [4]
Forbes, 2018

New technologies rarely have only positive aspects, but always entail uncertainties and concerns as well, as their full impact and associated risks are not yet fully understood. Therefore, many companies take a cautious stance on new technologies – especially when it comes to concrete implementation. Concerns can relate to a wide range of issues, from technical to business-related and ethical matters.

In the case of IoT, concerns currently mainly relate to defining the return on investment (ROI), cybersecurity, legal aspects, and dealing with organizational change and legacy equipment. What should be done with existing assets, such as 50-year-old trains that are still running perfectly? How should data be handled? Can I connect data from my US branch with data from my Chinese branch? Will the change expose my core operations to cyberattacks?

Most forms of IoT implementation in a corporate setting will, and should, have an impact on your business – whether it be a new strategic direction, a change of organization and processes, or the need to acquire new skills and competencies.

IoT is a cross-cutting topic that requires breaking up silos – which is a complex challenge in itself. Imagine linking the product design data, production line data, and operations data of a gas turbine, for example. To leverage the full value, product management, R&D, manufacturing, and service units have to collaborate much closer than today. In addition, job profiles will change accordingly, while mindset shifts to that of providing service may be key when leveraging data for service driven business models.

All of these topics need to be taken into account and addressed before, during and after an IoT implementation. They will be explicitly discussed throughout the next pages.
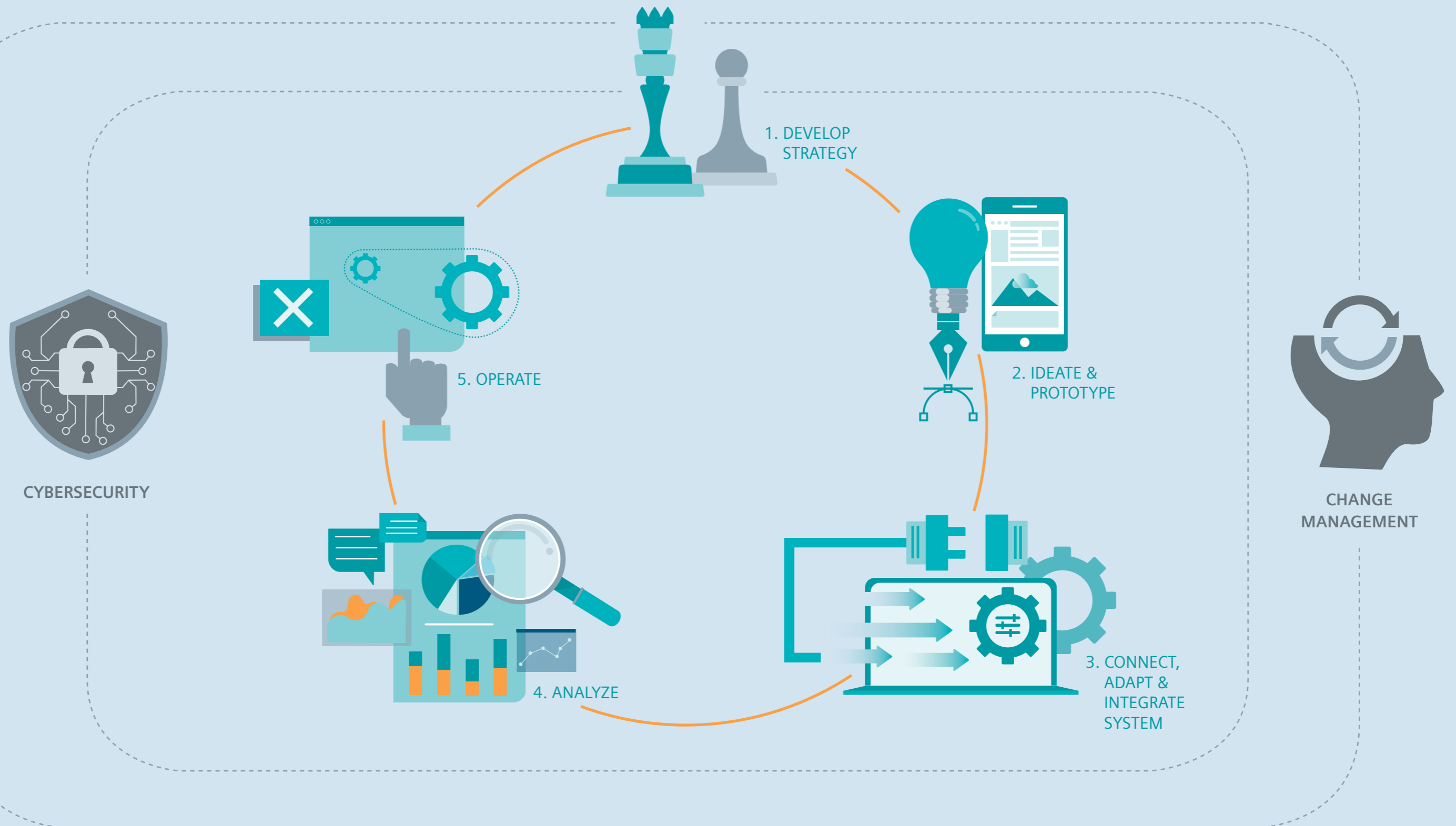
TOP CHALLENGES
AND CONCERNS

- ◆ Cybersecurity
- ◆ Legacy systems and technology
- ◆ Investment decisions and ROI
- ◆ Managing organizational change
- ◆ Breaking up silos in organizations
- ◆ Data ownership and privacy

IoT is a cross-cutting topic that requires breaking up silos – which is a complex challenge in itself.

THE FIVE PHASES OF SUCCESSFUL IOT IMPLEMENTATION

Your unique IoT Journey – getting started

At its core every IoT implementation consists of 5 subsequent phases covering everything from use case ideation to development and operations. To make it a successful and sustainable implementation, cybersecurity and change management must be prioritized right from the start and integrated into all phases.

1. DEVELOP STRATEGY

2. IDEATE & PROTOTYPE

3. CONNECT, ADAPT & INTEGRATE SYSTEM

4. ANALYZE

5. OPERATE

CYBERSECURITY

CHANGE MANAGEMENT

In our experience, all organizations that have successfully implemented IoT use cases have three things in common. Firstly, they enjoyed a high degree of leadership attention, which is essential for driving digital change. Secondly, a meaningful, i.e., value-creating use case was identified. Third, implementation was conducted pragmatically and iteratively.

From our perspective, a full implementation consists of five phases. These include developing a strategy, ideating a use case, prototyping for a proof-of-concept and designing the solution, connecting assets including adapting existing systems, and integrating them into a bigger system. Furthermore, a successful implementation also includes analyzing and leveraging the data collected from the assets. Systems should operate continuously after the technical implementation, while efficient change management and cyber security concepts are required from the very beginning and throughout the whole process.

Depending on your organization and the use case, these five essential phases can be executed with widely varying time-frames and effort. Some may be surprisingly simple, others longer and more complex and some run in parallel.

On your IoT journey, there is much to be considered along the way: Customer expectations, business model, strategy, existing assets and legacy systems, cybersecurity, people, processes, and many more factors all play a role. Therefore, each IoT journey is individual and depends on the specific situation of a company.

FIVE PHASES

1. Develop a Strategy
2. Ideate and Prototype
3. Connect, Adapt and Integrate Systems
4. Analyze Data
5. Operate
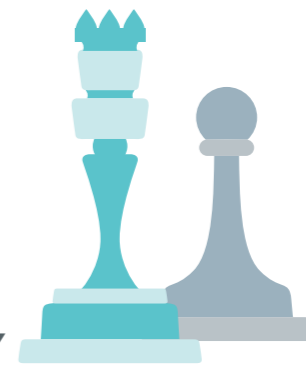
1. DEVELOP A STRATEGY

The disruptive nature of IoT fundamentally changes markets, transforming the way businesses create value and make money.

Aligning strategy, operations, and technology with (new) business models requires attention from the start. Therefore, strategic concerns should be addressed before the start of IoT implementation and might need to be revisited throughout the process.

Threats and new opportunities that arise in the market through IoT have to be evaluated and thoroughly understood. On this basis, a clear strategy can be developed, including distinct unique selling points, which may confirm existing business models – or define completely new approaches of how business is done.

As a consequence, existing strategic assets may have to be reshaped, adapted, or even eliminated. Others have to be developed, defined, and implemented. Existing resources might have to be linked and silos opened up in order to address the cross-topical complexity of digitalization. Under all scenarios, companies need to ensure that all of their assets are leveraged to their full extent.

The result of this phase is a clear company strategy, incorporating opportunities that arise through IoT and digitalization. The strategy guides the development of IoT use cases as well as new business models and a full IoT implementation.

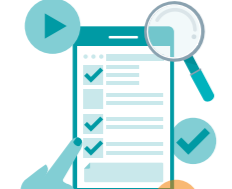Start with the "why" and build a holistic digital strategy around it.
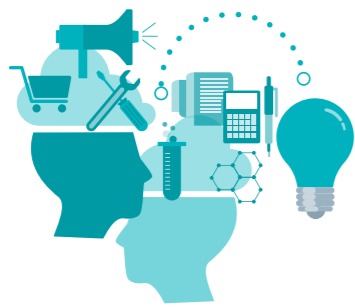
UNDERSTANDING
& IDEATING
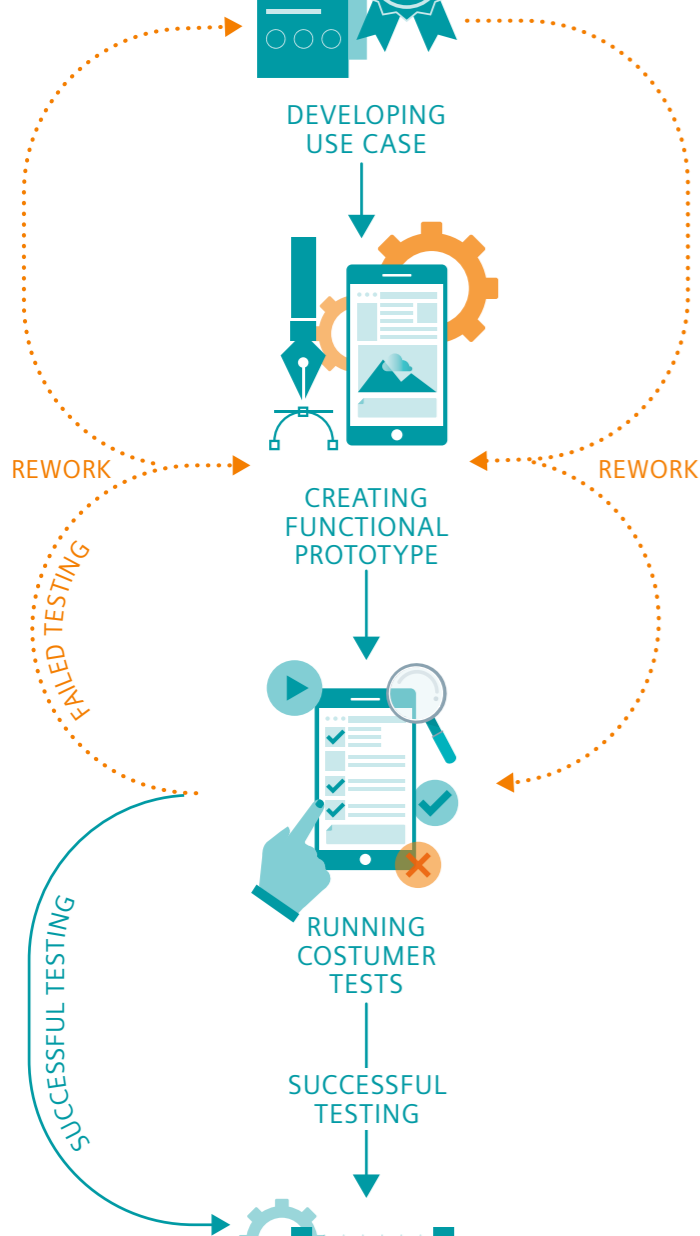
DEVELOPING
USE CASE

CREATING
FUNCTIONAL
PROTOTYPE

REWORK   REWORK

FAILED TESTING

RUNNING
COSTUMER
TESTS

SUCCESSFUL
TESTING

SUCCESSFUL TESTING

SCALING

2. IDEATE AND PROTOTYPE

Do you already have the perfect use case in mind? If so, perfect.

You know your business best and you can start with technical implementation straightaway. Do you need help in generating ideas for improving processes, or do you want to go even further and change your whole business? Whether a use case is developed internally or created with outside assistance depends on the capacities and skills available. But even if you have all the required resources within your organization, it is often useful to work with a knowledgeable, external partner who brings an outside perspective to challenge your ideas and brainstorms with you.

There are many ways to generate ideas and create use cases – generally, a structured approach is helpful. One of them is Customer Value Co-Creation. The first step of this collaborative approach is an attempt at understanding business drivers and pain points. By using a design thinking approach, the customer is at the center of the process. The key to success is to bring a variety of competencies and mindsets to the same table. These teams can consist of engineers with domain expertise, IT experts, data scientists, sales and marketing professionals, and user experience designers, to mention just a few roles. This allows the project team to test assumptions, ensure usability, check the (technical) feasibility, and to evaluate the ROI right at the spot, but also to address concerns of stakeholders. Digitalization is cross-functional and requires teamwork.
A first outcome is a value proposition that addresses the customer's major pain points. It forms the basis for

The basis for developing an innovative business model is a concise value proposition that puts the customer at the core.

CUSTOMER VALUE CO-CREATION: THE ADVANTAGE OF CLOSE COLLABORATION

SIEMENS
(co-creation) experience, plus deep industry and technical knowledge

CLIENT
competition, market dynamics, aspirations, pain points, people, processes and technical infrastructure

JOINT
creative collaborative teams uncover high-value use cases in the areas of increased competitiveness, operational efficiency, reduced costs, new business opportunity, or a combination thereof.

developing an innovative business model for the co-created solution, detailing how value is captured and revenues are generated. Going one step further, teams should also question and evaluate factors such as existing work processes, available skill-sets, culture, legacy equipment, competition, market dynamics, and so on.

The ideation phase is all about gaining a deep understanding for the addressed challenge, potentially identifying first use cases and empathizing with future users. Creating value propositions and developing business models ensures the true purpose for the IoT integration. This can be a hard ROI – to be gained, for example, by achieving improved efficiencies, optimization of processes, reduced costs, or increased revenues. But the goal can also be another, less easily quantified value, such as increasing work safety, improving the company's image, or boosting employee satisfaction. Such intangible benefits shouldn't be forgotten in a value calculation.

The purpose of ideation is to reveal hidden opportunities and to define one or more specific use cases that generate a tangible benefit. As soon as the desired value is identified, the detailed technical implementation can be worked out.

An initial prototype provides a concrete proof-of-concept and serves as the nucleus for broader IoT implementation.

An initial prototype, once developed, provides a concrete proof-of-concept and serves as the nucleus for broader the IoT implementation. Continuous iterations diminish the risk involved in the development, especially when testing and improving are ongoing, constant processes undertaken together with all stakeholders, including potential customers.

At the core of every IoT implementation is the process of crunching data, deriving information, and triggering action accordingly. Consequently, the first step for prototyping is to evaluate the available data, assess its quality, and draw possible conclusions.

The good news is that in many cases, data is already available, in one form or another. Historic system data gives a good understanding of information that can be extracted and which additional data is required. Do we need weather data with relative humidity information to understand malfunctions in our electrical system? Or is it enough to evaluate the timestamps of a windshield wiper? Is an additional sensor necessary? Or can the desired information be extracted from other sources? If no data is available at all, the recommended first step is to connect a sample of relevant assets and start collecting data.

The good news is that in many cases, data is already available, in one form or another – it just needs to be used!

For some use cases, the transparency of a given process or situation is key, and raw data presented in a user-friendly format is all that is required. Location-based use cases are a good example – where is my equipment? Other use cases require complex analytics or even artificial intelligence. During prototyping, suitable mathematical and statistical methods are determined, and algorithms are developed to extract information from, and identify patterns within data sets. Where machine learning is used, models are continually trained, tested, and improved until the code processes raw data into the desired information.

But data and analytics are only half of the story. The user experience and interface design are equally important. An algorithm may be able to identify a critical error in a machine, but this information must then also be immediately brought to the operator's attention. In time-critical and stressful situations,

a clear, easily comprehensible, and smooth user interface is of the essence.

Data and analytics are only half of the story. The user experience and interface design are equally important. If the user cannot digest the data presented, it will remain worthless.

We often start by researching user profiles to fully understand the routines and needs of future users in their natural environment. Defining personas and customer journeys are helpful tools to explore users' expectations, actions, and feelings. To define the layout, navigation, and the overall look of the product, mock-ups and click dummies are iteratively improved – and filled with the final data as soon as available.

Within the ideate and prototype phase, the technical feasibility and concept need to be considered and evaluated as well. Beyond (business) models and algorithms, this includes how data is transmitted from assets to the final device. A concrete plan of the solution architecture is developed within the next phases, where components of the IoT technology (stack) are adapted, connected and integrated into the existing IT and operational technology (OT) landscape.

Prototype development and solution architecture are often interdependent. At the stage where a data analytics prototype is developed, certain design parameters of the technology infrastructure are already defined: How often is data transmitted? What type of data is required? How reliable must measurements be? Accordingly, requirements include legacy times, frequency of data, granularity, and installed equipment. All of these are needed in order to meet (cyber)security, safety, reliability, and durability expectations.

On the other hand, it is necessary to take certain technical or legal circumstances into consideration. For example, consider the difficulties involved in sending full HD videos from a remote site in Mongolia as part of a face-recognition system.

The result of this phase is not only a proof-of-concept for the technical feasibility and the overall concept for further implementation and integration. It is also a proof-of-concept for the use case definition, ensuring evaluated pain points are addressed and the implementation pays off.
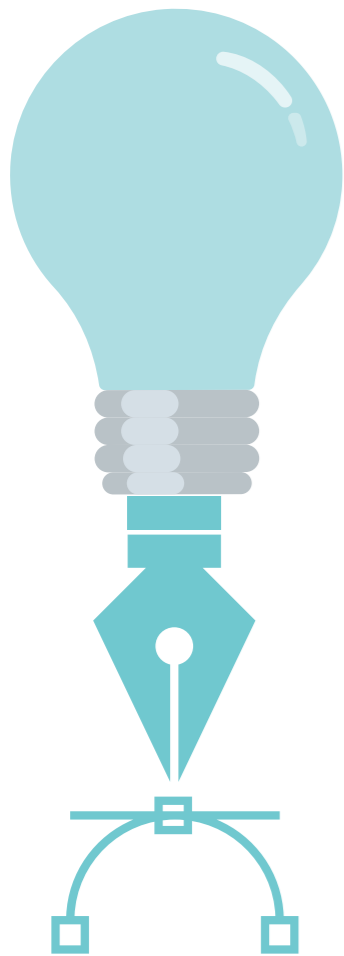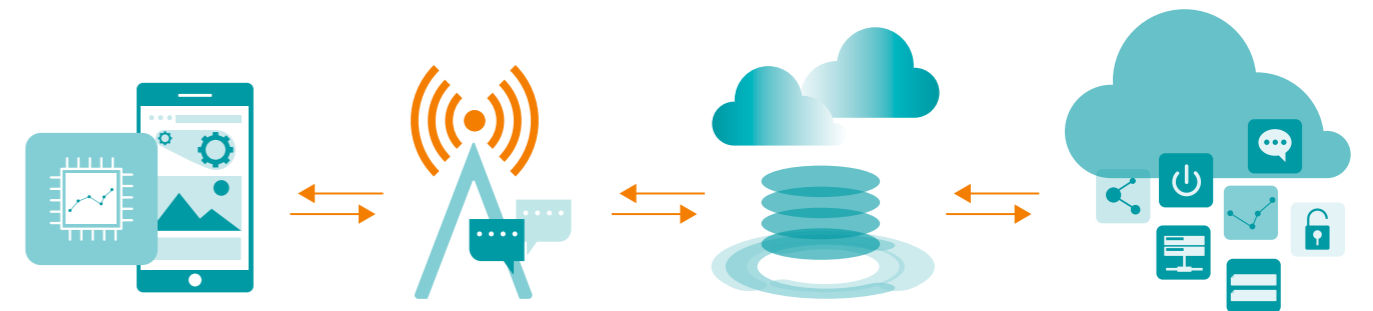
3. CONNECT, ADAPT AND INTEGRATE SYSTEMS

What it takes to set up an IoT suitable technology stack: sensors, devices, communication networks, cloud infrastructure, IoT platforms, and applications.

In order to transmit data from assets to the final device, several components of the IoT technology (stack) need to be connected, adapted and finally integrated into the existing IT and operational technology (OT) landscape.

The main components of the IoT technology stack include sensors, devices, communication networks, cloud infrastructure, IoT platforms, and applications:

IOT PLATFORM

As an open, cloud-based system, a platform needs to provide the whole IoT stack, from connecting, transmitting, processing, analyzing, and viewing data in any form to acting on the insights gained from it. Siemens has already gained broad experience in the platform business with the development of MindSphere, an industrial IoT platform, and its related services.

While MindConnect provides a connectivity solution, MindSphere applications offer analytics services to derive insights and generate value, once data is available on the platform.

In addition, a variety of services enable users to create and implement in-house, vendor-neutral applications. As a complete digital solution, an IoT platform should enable customers to make decisions and drive actions.

DEVICES AND ASSETS

This includes both hardware and software. The assets (or systems) of interest are equipped with sensors and actuators, edge devices that enable processing power or even smartness close to the assets, as well as gateways that allow data flow from one network to another. Software can adapt the data itself and/or the way the data is transmitted over the IoT network.

COMMUNICATION NETWORK

Both the transmission medium and the protocol types have a strong influence on data volume, latency, and transmission frequency. A wide range of options is available for data transmission, from ubiquitous internet and cellular technologies to analog telephony, and even radio or telegraph.

IoT PLATFORM

Data processing and storage on IoT platforms can be premise-based, cloud-based, or a hybrid of both, with the hybrid model becoming increasingly popular. There are advantages and disadvantages to all three approaches. Which model is best suited for your specific implementation depends on the use case, performance, privacy, scalability, and operational costs of your individual use case.

APPLICATIONS

In most cases, the added value offered by the IoT implementation is the intensive use of advanced data analytics and machine intelligence. Applications that run on platforms and are fed by data collected by devices present the resulting information to users in an easy-to-understand way.

3.1 CONNECT

In this phase, physical assets are outfitted with sensors – if they are not already in place – and adapted to the IoT environment. As soon as sensors are connected to the network, initial data can be collected and transmitted.

As soon as sensors are connected to the network, initial data can be collected and transmitted.

The difficulty of physically connecting assets and optimizing them for accurate data collection varies considerably for each use case and environment. For example, measuring meaningful data on a gas turbine can be a challenge, due to vibrations produced while in operation. For such an implementation, knowledge of the asset itself is key. On the other hand, a common smoke detector can be installed with little background knowledge or skill. Furthermore, not every sensor is suitable for every environment. High temperatures, significant humidity, electromagnetic interference, or moving parts can significantly restrict the range of feasible sensor choices. All of these aspects should already be taken into account during the ideation phases of the project.

Depending on the location of the asset, transmitting the data can be a challenge in itself. In addition, legacy communication networks often fail to provide the required bandwidth or latency for sophisticated sensor readings. Consequently, evaluating and, if necessary, upgrading the communications infrastructure is an important part of connecting assets.
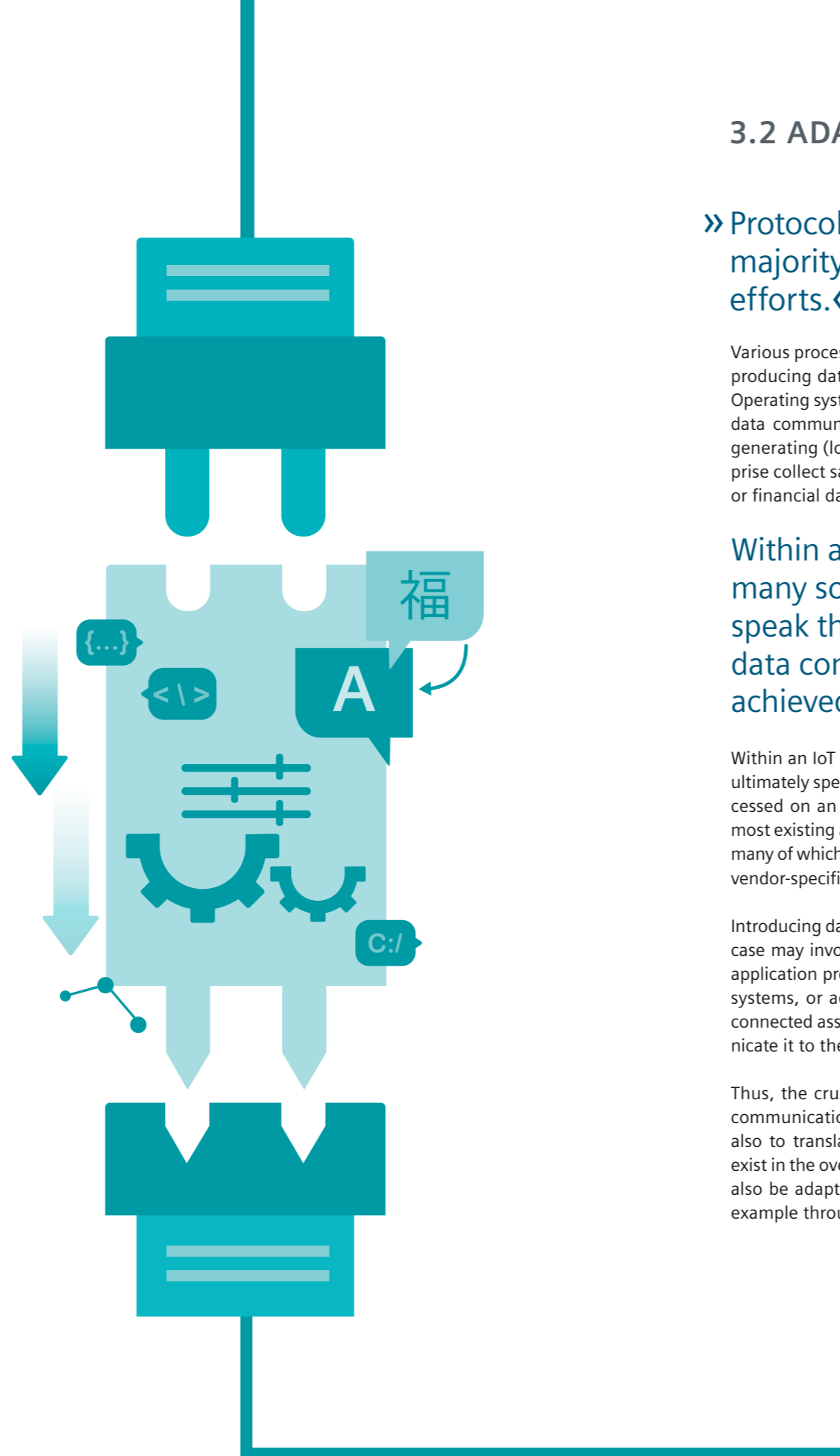
3.2 ADAPT

» Protocol translation still takes up a majority of today's IoT development efforts.« [5]

Various processes within an enterprise are supervised producing data, which are often stored in data silos. Operating systems and control systems use networked data communication to control and steer processes, generating (log) data. Other systems within an enterprise collect sales, production planning, logistics and/or financial data.

Within an IoT network, data from many sources must ultimately speak the same language and data compatibility must be achieved across all assets.

Within an IoT network, data from many sources must ultimately speak the same language in order to be processed on an edge device or jointly in the cloud. As most existing assets are managed by superior systems, many of which pre-date the IoT era, multiple and mostly vendor-specific languages are in use.

Introducing data compatibility across all assets of a use case may involve changing asset interfaces, adapting application programming interfaces (APIs), upgrading systems, or adding gateways that receive data from connected assets, adapt the information, and communicate it to the cloud.

Thus, the crux of the matter is not just to establish communication links between different sources, but also to translate between the various protocols that exist in the overall IoT technology landscape. Data may also be adapted in the interests of data security, for example through encryption.

+ A SIMPLE ADAPTATION

IoT adaptations are often effort-intensive, due to the multiple communication possibilities. However, they can also be simple, as was the case with the adaption of this transformer.

A transformer at an electric equipment factory converts electricity from the local utility to the voltage required for use in the factory. Transformer temperature readings are taken regularly and stored on a computer located next to the transformer. In order to include temperature readings in an IoT solution, the implementation team must adapt the system to do two things.

1.
For this particular use case, temperature readings must be aggregated from readings stored on the local computer.

2.
The converted temperature information must be transmitted to a central cloud for inclusion in an analysis with other data. To make the transmission possible, the team connects the previously off-line transformer computer to the factory's intranet.

3.3 INTEGRATE SYSTEMS

In this phase, IT and OT systems as well as the new IoT technology stack are integrated. This effort often requires additional bespoke development of APIs. Participants in this phase may include software developers, interface programmers, solution architects, and domain experts. Systems to be integrated may include:

◆ IoT network of connected, data-transmitting assets, incl. edge devices

◆ Operational technologies (such as factory control functions, metering systems, interlockings, …)

◆ Information technology systems resident in the organization (such as ERP)

◆ IoT platform that houses the central data storage and processing functions (such as data analytics).

The central storage and the main analysis of data typically takes place on an IoT platform hosted in a cloud environment. This means systems must be connected to the cloud and to one another, as required. In complex cases, clouds need to be connected to other clouds.

Accordingly, by the end of this phase, assets are connected physically, legacy OT systems are updated and integrated. The result is a fully functional system, including data transmission, storage, and processing.

When the "marriage" between IT and OT has taken place and all subsystems are integrated, the IoT technology stack starts working – this is when the magic happens!
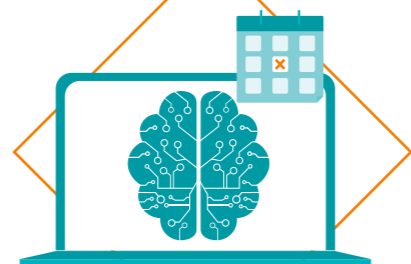
WHAT HAPPEND!
DESCRIPTIVE

WHY?
ROOT CAUSE
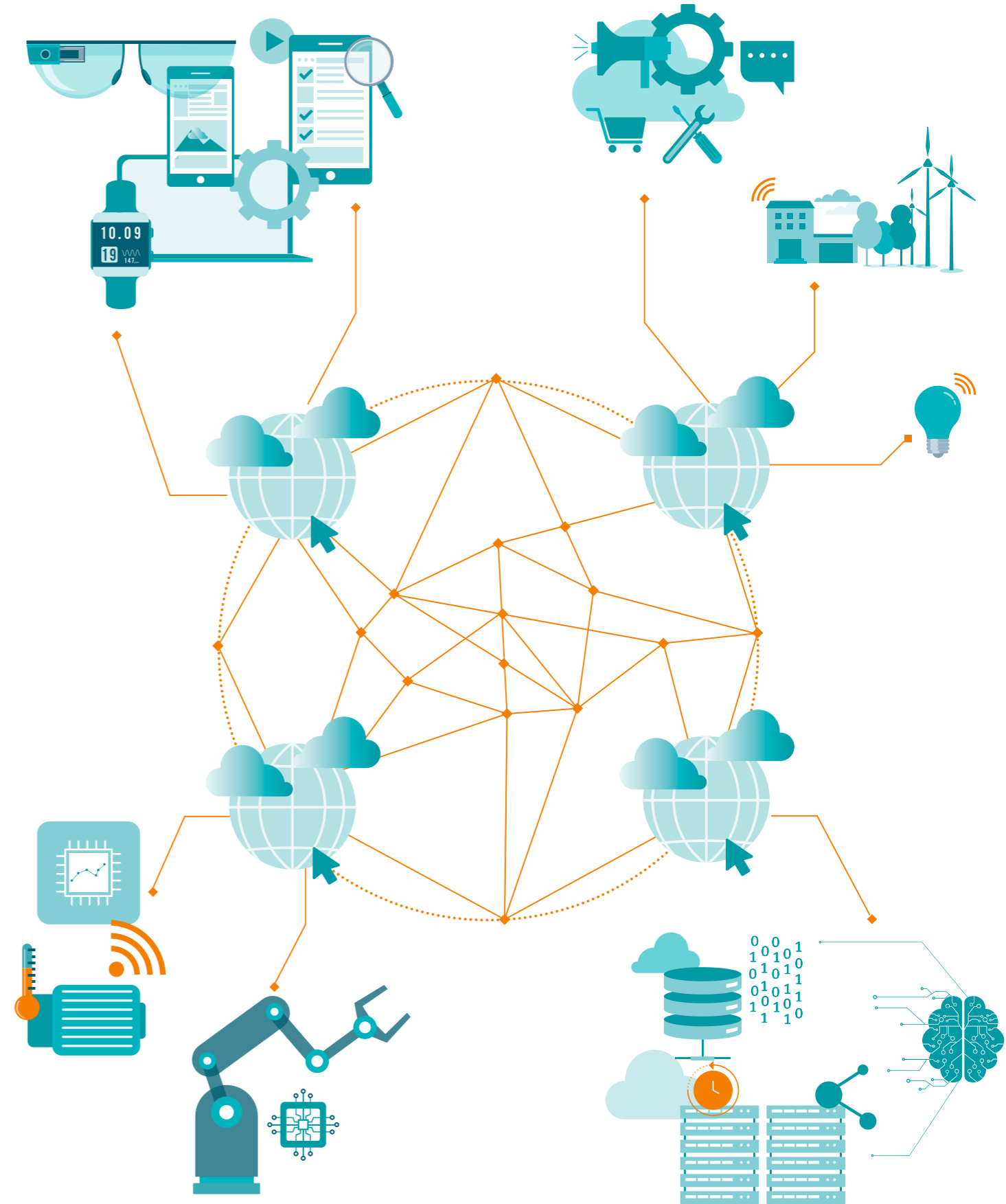
GIVE INFORMATION ON SITUATION

WHAT WILL HAPPEN?
PREDICTIVE

WHAT SHALL WE DO?
PRESCRIPTIVE

RECOMMEND ACTION

CONCLUSION!
DEDUCTIVE

4. ANALYZE DATA

The main purpose of the previous phases was to gain and transmit information that can be used to drive actions, as defined by the value proposition. The collection of data is a necessary pre-condition but creates little value in itself.

Data can take many forms, from videos, database files, e-mails, and Excel files to all types of machine data, log files and voice records. But irrespective of format, in most cases, further processing is required. This may include decoding, aggregating, selecting, and/or translating. Once the data is nice and tidy, the analytics can begin – either directly on an edge device or in a cloud environment.

If data is not processed into actionable information, it remains well – just raw data.

In our experience, mixed teams deliver the best results. Without the interaction of data scientists and domain experts, the development may end up in a vacuum. Domain experts can give a full interpretation of the data and distinguish between correlation and causality. It's up to the data scientist to choose or develop the right algorithm for the use case.

More simple examples include descriptive analytics to gain information about the location of a train, the temperature of a building, or the aggregated milk consumption as determined by your fridge. Root cause analysis can diagnose reasons for faults or an unusual status. More resource-intensive advanced data analytics and machine intelligence may predict the status of machines or recommend actions to prevent future malfunctions, shortages, or inefficiencies. Continuous learning about the outcomes of recommended actions can improve and optimize processes across the whole system.

The result of this phase is an application that analyzes data and derives valuable conclusions fulfilling the value proposition of the initial phases.

+

CORRELATION VS. CAUSALITY

Correlation is a statistical measure expressing the relationship between variables. This relationship can be random, without a causal reason and therefore is often called "noise" in the data (that might detract you).

Causality is a cause-and-effect relation, e.g., one event is the result of the occurrence of another event. Variables with high correlation do not necessarily have a causal relationship.

FOR EXAMPLE
there is a correlation between ice cream consumption and the number of sunburns. But it would be a fallacy to assume a causal relationship – that eating ice cream leads to sunburns. So: don't mistake correlation for causality!

5. OPERATE

It's natural to assume that once a new system is operational, the work is done. However, to derive maximum value and security from an IoT implementation, the system must be maintained. This work may involve configuration adjustments, software bug fixes, renewed asset connections, security patches, and any other desired actions or changes. Additionally, the information that an IoT network provides must remain relevant and may require changes over time.

This ongoing phase ensures the availability and security of the use case over its lifetime.

To derive maximum value and security from an IoT implementation, the system must be maintained.
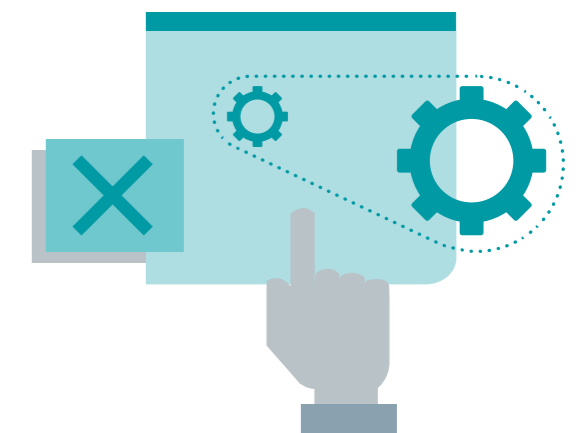
CHANGE MANAGEMENT

The blind side of digital transformation.

The digital transformation of an organization requires far more than just technical implementation. It is the change and adaption to the new technology that makes it a success story. When we look back to the 1990s, it is evident that the internet required changes in many dimensions, starting with business models and ending with the need for new skill sets. Who would have thought back then that companies would hire social media managers?

Change management should be integrated in the project to create a functioning organization that leverages and incorporates IoT to generate value.

Whether it is a full digital transformation or individual, small use cases that are to be implemented, work processes may be altered or replaced altogether as a result. New skill sets are required, and organizations must consider options for training, hiring, and outsourcing. Inspiring all stakeholders to join and support the IoT journey is one of the greatest challenges and far too often, it is the blind side of digital transformation that is overlooked in the process. Purpose, a clearly communicated vision, and the opportunity for short-term success are crucial elements that enable employees to adapt to the new technology and embark, step by step, on a journey of digital transformation.

The good news is, it is a step by step approach and hiring the social media manager of the future is not the starting point. Top management needs to lead the change. In order to manage change successfully, management should appoint a team that manages the change effort and that drives constant implementation of use cases as well as commensurate adaptions of processes.

Change management should start right at the beginning of an IoT implementation project and run in parallel to the other phases to create a functioning organization that leverages and incorporates IoT to generate value competitively.

WHAT'S YOUR PLAN?

Your organization now knows when equipment is functioning sub-optimally. Predictive analytic software can even estimate the timeframe when equipment will cease to function. You have the information you need to prevent costly downtime, but what exactly are you going to do with this information?

- What needs to happen?
- Who carries out the action?
- What tools, information, or equipment are required?
- Do technicians need to be called?
- Do parts need to be ordered?
- Do we have the necessary skills in the organization?
- Do we need to hire new technicians, or work with a partner?

Your organization needs concrete answers to questions like these before your IoT implementation can become a success story. Helping clients understand which questions to ask and to arrive at meaningful answers is a significant aspect of our work together.

CYBER SECURITY

Cybersecurity must be prioritized and build in right from the start.

Cybersecurity risks are increasing significantly with each connected device. Previously closed systems and isolated assets are now connected to networks. This increases the attack surface and makes them potential new targets accessible from remote. Furthermore, the potential consequences of security breaches are becoming ever greater due to highly automated processes and interconnected systems.

The degree of connected industrial control systems has increased significantly over the last few decades as the use of IP-based, wireless, and mobile devices in industrial environments has increased. This is even multiplied with the use of IoT. Nevertheless, the risk of cyberattacks targeting connected devices is often underestimated.

When thinking about implementing an IoT solution, cybersecurity must be prioritized and build in right from the start. Even if sophisticated cybersecurity systems are present within the existing structure, IoT will alter the situation. Accordingly, cybersecurity should already be considered in the strategy and a threat and risk analysis should be conducted during the ideation and prototyping phase. This ensures that the implications of IoT are fully understood and reflected in existing cybersecurity measures.

IoT cybersecurity has a wide scope. Risks vary tremendously, ranging from customer data theft to industrial espionage and full-blown cyberattacks with severe consequences. Furthermore, it is not only newly connected assets that must be protected, but all the IT and legacy OT systems to which they connect as well. Risks evolve and change rapidly, even daily. Therefore, sustainable cybersecurity requires constant adaption and a systematic approach building up processes and an organization that may handle cybersecurity over the entire lifecycle.

In doing so, the topic of cybersecurity is multifaceted – it should include preventive, detective and defensive measures. All of which need to be built into a holistic concept protecting the entire IoT solution – on a system and on an enterprise level. International standards provide guidance for set-up, implementation, certification, and continuous improvement. Topics to consider in an IoT architecture and its surrounding ecosystem of services include:

- Demilitarized zones, identity management, and data security in order to build up various lines of defense.
- Asset management and intrusion detection monitoring aim at creating visibility on cyberattacks.
- Updates and patch management to continuously protect devices and close vulnerabilities.
- Risk assessments, organizational audits, security and penetration tests, and vulnerability scans to assess the attack surface.

Beyond preventive measures, a plan for responding to cyberattacks is also critical. For a coordinated response, it is critical to understand what needs to happen (e.g., shutting down systems), who needs to take action (skilled employees), and how damage can be mitigated.

Only once all the above is in place, an IoT solution can be leveraged to its full extend. Benefits go beyond mere cybersecurity – monitoring solutions for example also shed light on data streams overall, allowing to optimize the connectivity layout and in turn the overall IoT solution.

In the end, only secure implementations can strengthen trust in the digital world – a crucial factor for sustainably offering digital services to you customers.

ORGANIZATIONAL SUCCESS FACTORS

Cybersecurity is often a question of mindset and company culture. Key success factors include:

- The extent to which top leadership prioritizes and invests in cybersecurity
- The understanding that cybersecurity is a never-ending, ongoing task
- The understanding that cybersecurity is everyone's job

THE GERMAN RAILWAY

*leverages existing data for
high-tech predictive maintenance*
A Siemens Mobility use case

SITUTATION
PREDICTION OF POSSIBLE SWITCH-FAILURES
WAS NEEDED

In a recent IoT implementation at a German rail opera-
tor, analytic models were developed to predict the fail-
ure of switches in the railroad's network. As the word
suggests, switches are mechanical devices that allow
trains to switch tracks. Large railway systems include
thousands of switches, which must be operational at
all times; unexpected switch failure can be costly and
cause extreme delays.

SOLUTION
DATA ANALYTICS PREDICT SWITCH FAILURE

**USE DATA OF
CONNECTED ASSETS
TO ACT BEFORE IT
GETS COSTLY.**

A known indicator of switch failure is the slowing of
operational speed over time as the switch performs
the 'open and close' function at a decreasing rate and
thus operates sub-optimally. At the time of the project,
the railway network had been routinely producing
data on switches for years, but neither stored for
longer nor evaluated for predictions. The data was
available on servers at the operator's interlocking
plants, which could be connected to a cloud.

RESULT
REPAIRS HAPPEN BEFORE SWITCHES FAIL

With access to a wealth of current and historical da-
tasets, the team developed an analytics application
that predicts predictable switch failures up to eight
hours before. Simple traffic light-style software alerts
maintenance coordinators of an impending failure.
With this information, maintenance and repair teams
can act before a switch fails, thus increasing railway
safety and reducing costs associated with rerouting
trains. Additionally, the railway deploys maintenance
teams only as needed, thus making more efficient
use of these resources.

Switch failure analytics have proven so effective that
further railway companies, for example in Austria and
Finland, have adopted similar systems.

CITY OF NUREMBERG

reduces air pollution
A Siemens Global Center of
Competence Cities use case

SITUATION
AIR QUALITY DIDN'T MEET WORLD HEALTH
ORGANIZATION (WHO) RECOMMENDATIONS

The German city of Nuremberg had been working for
years to reduce air pollution and emissions of green-
house gases. Local traffic, however, made it difficult for
Nuremberg to consistently meet WHO recommenda-
tions, especially for nitrogen dioxide.

SOLUTION
IOT-ENABLED AIR QUALITY MONITORING
AND PREDICTIONS

**USE DATA TO SIMULATE
APPROPRIATE ACTIONS
FOR BETTER DECISION
MAKING.**

In an effort to reduce pollution, the city is testing an
IoT-enabled system that collects air quality data from
sensors placed around the city. Using historic data on
air pollution, weather, and traffic patterns, the system
forecasts air quality for the upcoming five days by using
neuronal networks.

Furthermore, the city air management tool can sim-
ulate the impact of corrective actions, such as man-
dating low-emission zones, speed limits, and reduced
prices for public transportation. A total of 17 short-term
prevention measures are available, from which a city
specific preselection is made and can be selected in
the software. By simulating the five day's impact of the
selected preventative action on air quality, the city is
empowered to evaluate measures and to remain pro-
actively within daily and even hourly air pollution limits.

RESULT
BETTER DECISION MAKING

In addition to the Siemens City Air Management, the
City Performance Tool provides simulation capabilities
to make long-term predictions, taking into account the
potential impact of new environmental legislation and
technology. Nuremberg can simulate air quality predic-
tions through the year 2030 with surprising accuracy.

Simulations predict how policy changes will lower
levels of specific pollutants, by how much, and in what
timeframe. For city officials and policy-makers, these
capabilities are a game changer. Officials can make an
immediate impact on air quality while developing
long-term policy and legislation.

SELLO SHOPPING MALL
IN FINLAND

A virtual power plant
A Siemens Smart Infrastructure use case

SITUATION
A SHOPPING CENTER WANTED TO INCREASE
ITS ENERGY EFFICIENCY

The Sello shopping center is Finland's second-largest shopping center, with over 170 shops and an average of 24 million shoppers per year. To increase the profitability and efficiency of the mall, new role and revenue models were developed. By turning the shopping mall into a virtual power plant, the operators enabled it to automatically offer the whole Sello shopping mall as a load for Finnish demand response markets.

SOLUTION
THE SUPPLY AND DEMAND OF ENERGY WAS
BALANCED THROUGH CONTROLLED GENERATION
AND FLEXIBLE CONSUMPTION

START SMALL AND SCALE FAST.

This was achieved by installing solar panels, a 2-MW battery and electric systems for the demand response use and microgrid functions in combination with smart building automation and cloud analytics.

Converting the mall to a virtual power plant was an iterative process over several years. It started with a few small use cases right after the construction phase. The very first approach (and app) was an effort to determine the number of customers within the mall. Successively, further use cases were developed, all of which went through the five phases. The building management system was equipped with additional sensors and connected to the cloud via a VPN connection.

RESULT
TODAY, OVER 20,000 SENSORS COLLECT DATA AND
ENERGY EFFICIENCY ENHANCED ON ALL LEVELS

This includes weather data, energy consumption, energy price, weather forecast data, and the amount of energy stored in the battery, among others. By using smart analytics, energy requirements can be predicted, and algorithms determine whether energy for the mall is drawn from the solar panels, the 2-MW battery that is recharged when energy generation is optimal (i.e., when the sun shines), or the national energy provider, when energy prices are low.

Implementing the use cases described above required a broad range of know-how about building automation, microgrids, connectivity solutions, IT platforms, energy storage, smart metering, and financing – resulting in a reduction of carbon emissions and creating a business case worth €643,000 per year for the customer.

The IoT is already changing the way we live. However, its real potential has not been exploited yet. Benefits can be manifold, reaching from increased output, lower costs, enhanced transparency and more sustainability to new, data driven business models. Digital products and services can complement the traditional business, service driven business models evolve even in traditionally product driven industries and completely new customer interactions are enabled. Some companies are already demonstrating the great potential of digital business models and the exciting opportunities created by the IoT. But finding the right access to this technology is complex, as each IoT journey is unique. Defining a meaningful use case and determining a value proposition is one thing. Scaling and managing a full implementation is a completely different matter. This should also include a change management and cybersecurity concept for the entire organization.

Furthermore, the effort involved in adapting business processes and organizational structures should not be underestimated. Organizational change requires leadership from the top and professional change management.

EACH IOT JOURNEY IS UNIQUE – FIND THE RIGHT PARTNER TO GET STARTED!

At any rate, driving an IoT implementation is a cross-functional task that requires many skill-sets and a great deal of technology expertise to make it a success. Few companies will be able to do it alone. The majority will look for partners and form ecosystems of complementary capabilities.

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ABOUT SIEMENS IOT SERVICES

The IoT Services Unit is part of Siemens and
was founded April 1st 2019 with its headquarter
in Munich to offer customers end-to-end solutions
for their digital transformation. With more than
7,000 employees in 10 countries and 21 offices,
the unit offers a global network of employees to
implement projects of various scale – from project
based IoT consulting to a fully digitalized organization.
Further information is available on the Internet at

www.siemens.com/iot-services

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THANK YOU

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