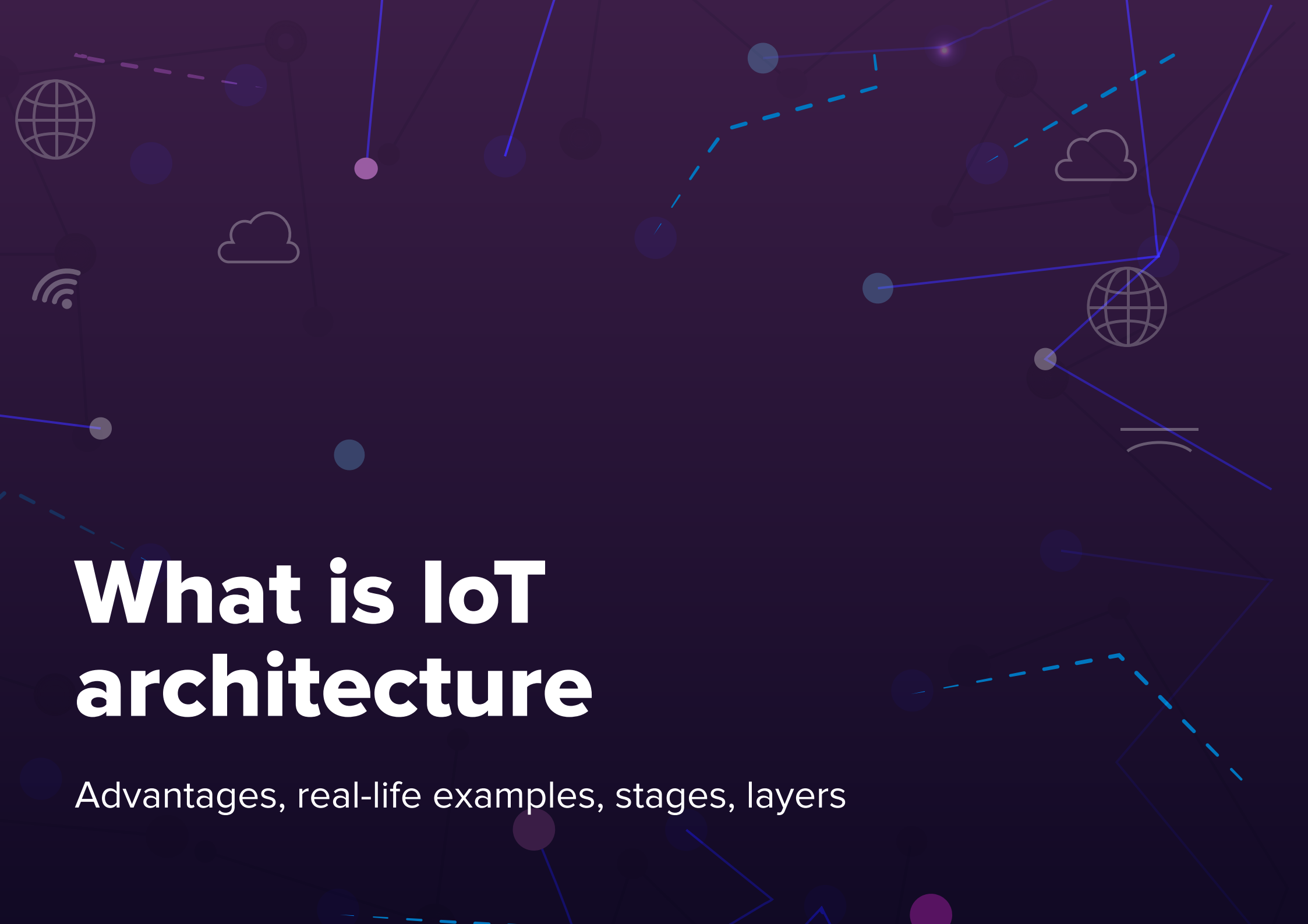


What is IoT architecture

Advantages, real-life examples, stages, layers

1. Intro

“What the Internet of Things is really about is information technology that can gather its own information. Often what it does with that information is not tell a human being something, it [just] does something.”

Kevin Ashton

The “Inventor of IoT” since he is the man who used this term for the first time.

1. Intro

The Internet of Things (often abbreviated as IoT) is a rapidly emerging technology that gains traction worldwide. IoT has already become an integral part of people's everyday lives, and its impact on our lives and businesses cannot be overestimated. We expect that IoT technology in cooperation with other technologies such as 5g, big data, cloud computing will change our lives, our homes, cities we live in. We look forward to seeing that soon...

In the whitepaper, we consider layers in IoT architecture, describe 4 stages, and explain how the IoT system works. The architecture section contains 3 IoT architecture models (3, 5, 7 layers architecture). By describing 3 most popular architecture models in one document, we thus made a comprehensive and exhaustive description of IoT layers compared to other surveys.

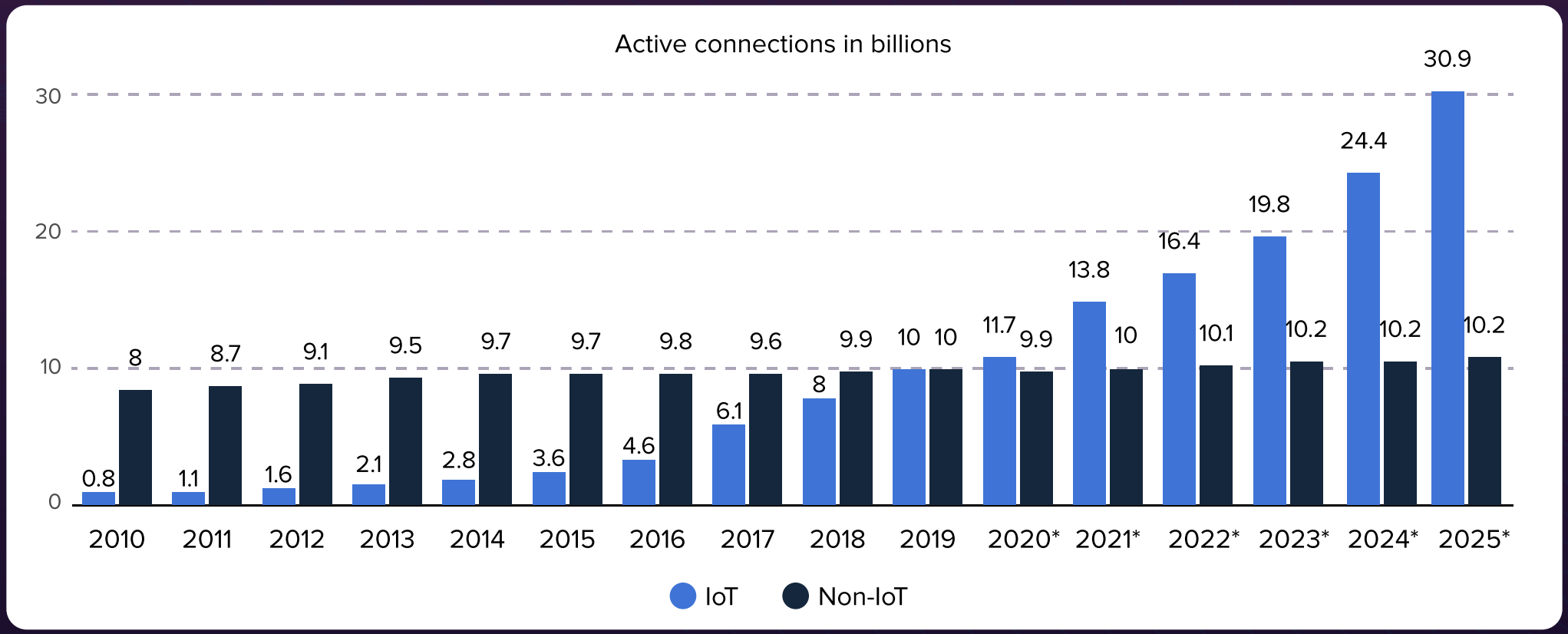
Questions that were considered in our Whitepaper:

- What is IoT?
- Examples of IoT.
- Advantages IoT brings to society and businesses.
- How does it work?
- What are the stages and layers in an IoT system?

2. What is IoT

The Internet of Things (IoT) is a network of physical devices (so-called “things”) that collect and exchange data with other devices and systems over the internet. The devices range from gadgets in the ordinary household (kitchen appliance, thermostat, smart scale, light switches) to sophisticated things such as autonomous cars, industrial equipment, or smart cities.

The number of connected devices is enormous! It exceeded 10 billion in 2019 and is expected to reach the 30 billion mark by 2025, which is almost 4 times more than the projections of the world population for the same period.



The source: Statista - Internet of Things (IoT) and non-IoT active device connections worldwide from 2010 to 2025

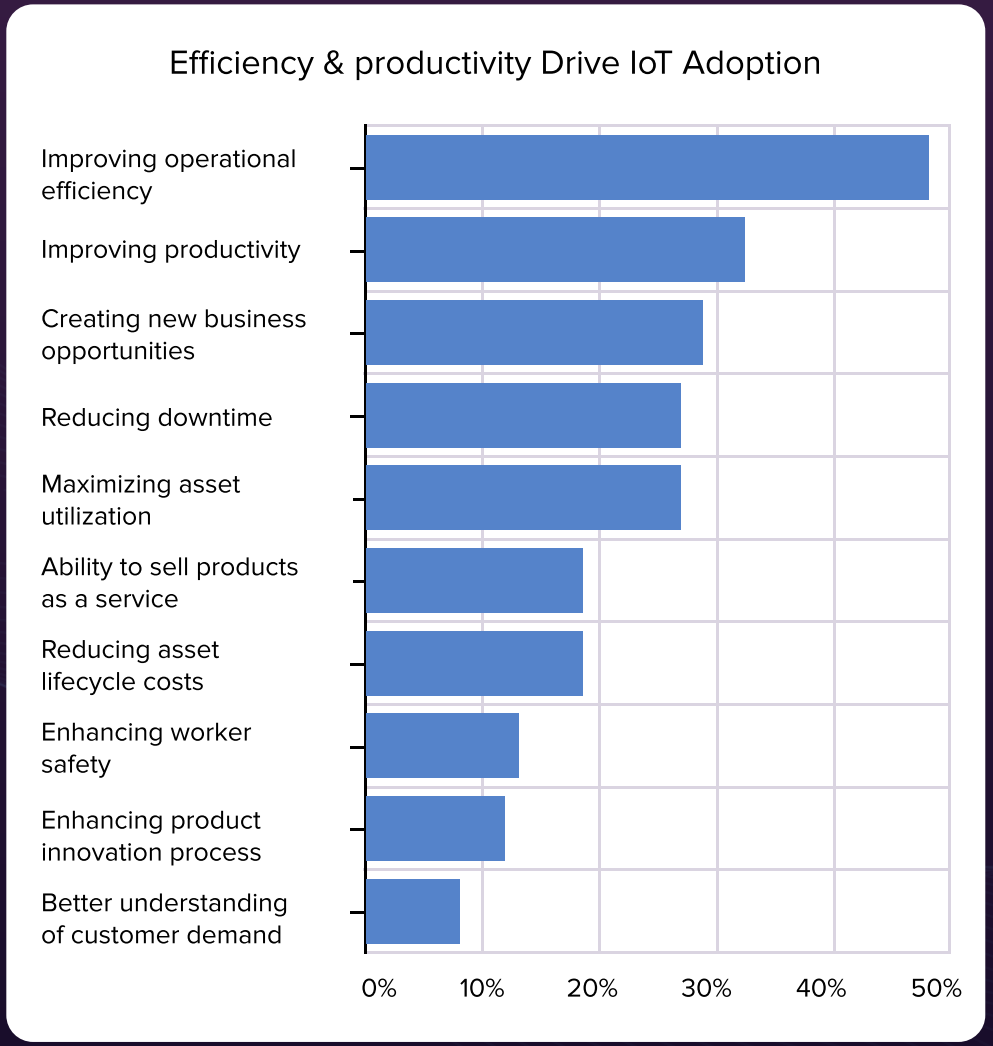
3. Advantages of IoT for businesses

If you wonder what IoT brings to businesses, you find a simple answer: **the data.** IoT brings much more data about everything you work with! **How can it be helpful? Well, it can:**

Improve efficiency & productivity

First, IoT can automate the work of different devices in the IoT network that monitor, manage, or control some functional units. Secondly, deep analytic platforms provide data and insights to managers and business leaders. They get an opportunity to improve manufacturing processes or make supply chains more efficient.

According to the report from Morgan Stanley, the introduction of IoT had the greatest impact on improving the operational efficiency and productivity of the companies.



Source: Morgan Stanley-Automation World Industrial Automation Survey, AlphaWise

3. Advantages of IoT for businesses

Brings new business opportunities:

IoT provides new business opportunities and helps to transform traditional industries. IoT is like another way to look at things and gadgets around you.

With more data on customer preferences available, businesses get new options:

- they can identify and provide real value customers are seeking to
- deliver new products and services based on new information about customer experience or update existing ones.
- innovate traditional business models

More trustworthy image of the company

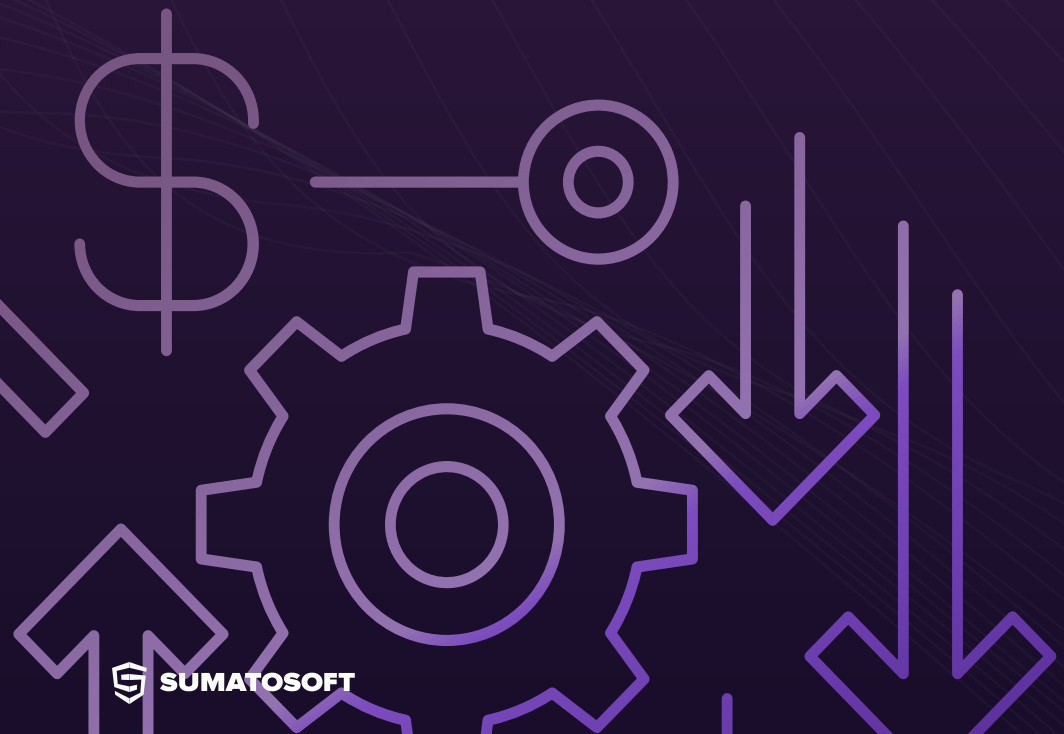
Quite a simple remark: IoT is a trend that will add more reputation to your company if you use it. IoT is a high-tech solution that makes a positive impression on customers, investors, partners, and employees.

3. Advantages of IoT for businesses

Improve customer experience

Smart devices at homes, voice assistance, smartwatches, and all the staff with the “smart” prefix directly communicate with users on a daily basis. That data helps businesses to understand user behavior and develop more accurate targeted advertising, price policy, and marketing strategy in general.

According to Harvard Business Review, 62% of respondents say IoT increased their customer responsiveness after they introduced that technology. That is a great result.



Reduce costs

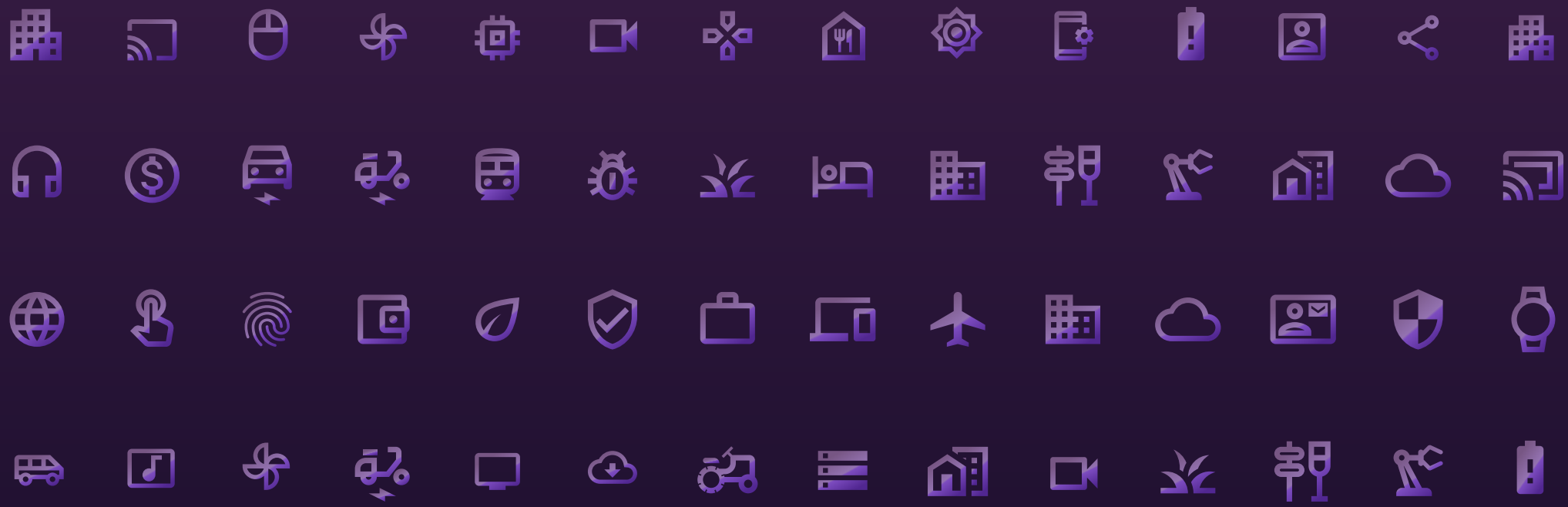
Have you wondered how to keep business equipment running at peak efficiency? Maybe you wonder how to reduce the likelihood of unexpected equipment breakage? How to decrease crop damage from insects?

IoT gives answers to these questions.

IoT architecture can troubleshoot office equipment in real-time and catch errors before they actually happen. The IoT gives you full control over all machinery, tools, and equipment. Detecting a piece of equipment to fall before it happens minimizes costly downtime for repairs.

With the help of a network of video sensors placed all over the crop fields, farmers can identify crop damage early and make necessary decisions quickly.

4. Examples of IoT Architecture



- Smart homes and gadgets for smart homes;
- Traffic surveillance and management applications;
- Smart city lights;
- Smart smoke detector;
- Air quality sensors;
- Digital finger, which is used to turn on/off the switches;
- Smartwatches and fitness trackers;
- Health monitoring patches;
- Helmet crash sensors;

And much more.

5. Stages of IoT architecture. Overview

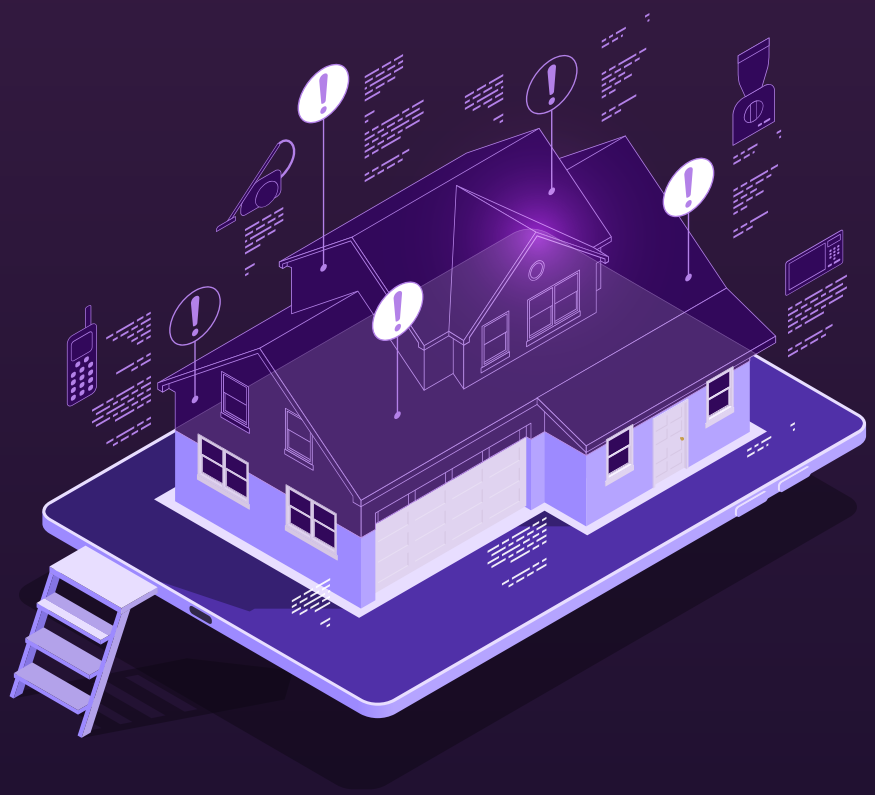
1. Sensors and Actuators

Sensors and Actuators are the basic “things” of IoT architecture. Sensors are physical devices that collect information such as temperature, chemical composition, blood pressure, air quality, people flow, status data from the real-world environment. In other words, sensors convert some physical phenomenon into a digital form.

A great example of a **sensor** is an infrared sensor that can measure the distance to nearby objects. This type of sensor is used in many technologies, like smartphones, motion detectors, robot vacuums, etc... Another example is any smartphone because it contains all types of sensors, like a high-resolution complementary metal oxide semiconductor, GPS, accelerometer, magnetometer, microphone, and ambient light sensor.

IoT sensors are mostly battery-powered devices. Some of them may have huge compute and storage capacities, like smartphones. Other devices feature minimal compute and storage resources, like environmental sensors.

Actuators are devices that can take electrical input and turn it into physical action. An example of sensor-actuator collaboration is switching off the light in a smart home when nobody is around. Ordinary electrical sensors and actuators have been around for decades, however, other technologies like machine learning, big data, 4g, and 5g networks bring that collaboration to a new level.



Stages of IoT architecture. Overview

2. IoT Gateway and Data Acquisition Systems

A data acquisition system (DAS) collects raw data from sensors, aggregates, and stores it before transferring it to an IoT gateway. The biggest challenge here lies in providing support for multiple connectivity sensor protocols that different types of devices use. The DAS system should be hardware and OS-agnostic.

An IoT gateway is an intermediary between connected devices and the cloud. It is a device or platform that gets the data from DAS and compresses it before transferring to the cloud. IoT gateway and DAS serve several purposes:

- **ensure the security** of the data travel between the devices and the cloud
- **to pass the data** from devices to the cloud
- **to transmit control commands** going from the cloud to things

DAS and the internet gateway aggregate and compress a great mass of data before passing it to the cloud platform for further analysis. All the information and control commands inside IoT architecture go through an IoT gateway.

Stages of IoT architecture. Overview

3. Edge IT: fog computing

An edge IT system is a platform that filters and pre-processes incoming data from the IoT gateway to minimize the volume of information that will be transferred to the cloud. It is also called fog computing or fog network.

The fog can be viewed as a cloud that is close to the ground. The fog architecture is physically located near the data source. It allows to filter and analyze data from sensors through locally placed fog nodes before the data goes to the cloud.

It can also make some minor decisions based on the information obtained from data sensors, hence reducing the response latency in the system.

Stages of IoT architecture. Overview

4. The cloud: in-depth analysis

The cloud is a cloud-based system (less often - a corporate data center) that provides the processing power for the data that came from an edge platform or an IoT gateway. The cloud can be powered with analytics software, visualization tools, AI, and machine learning for in-depth analyzing and processing of the data.

The cloud element is what makes IoT architecture useful for businesses and people. The gathered information is expected to provide insights for making crucial business decisions and identifying trends and patterns.

Two main functions of the edge IT system are:

- **Data accumulation.** Data comes to the edge IT in various forms, sizes, and through different transfer protocols. The edge IT transforms unstructured data from sensors into compact homogeneous sets of information.
- **Data abstraction.** Once the accumulation is finished, the edge IT filters the data sets and separates the essential data that will be sent to the cloud, hence minimizing the flow of transferred information and decreasing its cost.

IoT architecture can exist without an Edge IT platform, however, an edge platform brings significant benefits for IoT projects:

- decrease the cloud network load
- reduce the transmission cost of the data
- real-time response to “things”
- provide monitoring of IoT devices and their activities

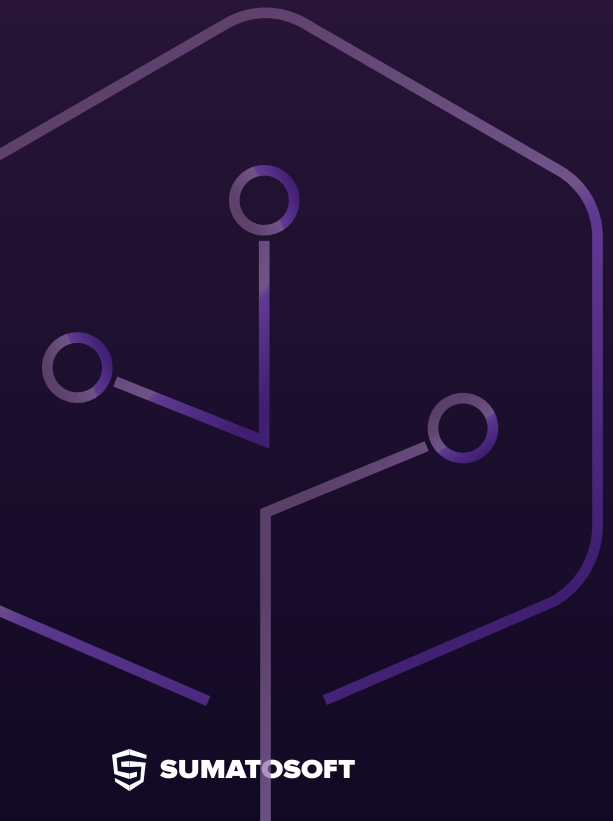
6. Layers in IoT architecture

	3-level architecture	5-level architecture	7-level architecture	
Perception	+	+	+	The layer of physical devices, that gather information about the environment
Network	+	+	+	The layer is responsible for the communication within IoT (between smart things, gateway, the cloud)
Application	+	+	+	The layer where users interact with the IoT through the graphical user interface.
Middleware (the cloud)	-	+	+	The layer is responsible for data storage, analysis, and management. It is enhanced by powerful analytic tools, Big Data algorithms, Machine learning.
Business	-	+	+	The layer where businesses manage the whole IoT system. It declares business goals and vital postulates that will become the basis for the IoT system.
Edge (or fog computing)	-	-	+	The layer performs data preprocessing before the information will be transferred to the cloud.
Security	-	-	+	The layer is responsible for access control to the IoT network, the security of data transfers, preventing data breaches, and tracking malicious software.

Layers

Before we start, it's worth mentioning that there is no single, officially recognized architecture of IoT layers. In the whitepaper, we consider three types of IoT architecture that vary depending on the number of covered layers. There are 3-level, 5-level, and 7-level architectures. The more level architecture includes the more focus it has on finer aspects of the Internet of Things.

The most basic architecture that defines the main idea of the Internet of Things is a three-layer architecture that comprises the perception, network, and application layers.



The first layer (the perception) is the layer of physical devices, the layer of sensors, actuators, and smart objects, that gather information about the environment and measure physical parameters.

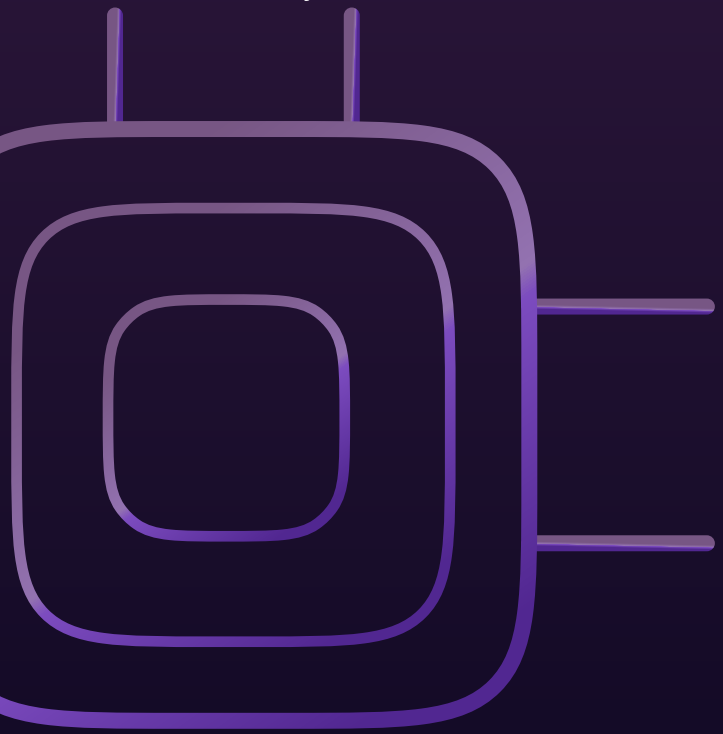
The second layer (the network) is the core logistics part of the IoT system. The layer is responsible for all communication within the IoT system: connection of smart things to each other, transferring data and commands between IoT stages, connection to the cloud.

The third layer (application) defines the space where users interact with IoT systems. It's called an "application layer" because the interaction between an IoT system and users becomes possible thanks to the graphical user interface of any application. Users can look at analytics, reports, and control devices within an IoT system on this layer. Home automation systems and fitness tech are great examples of widely used IoT applications.

Layers

You may think of an IoT system as a human body. The human brain represents the third “application” layer. The human spinal cord is analogous to the distributed network of data transfer nodes and smart gateways. The last is the human nervous system, which is a combination of sensors and actuators.

If we add two more layers, we get the 5-level architecture of an IoT system. These layers are a middleware layer and a business layer.



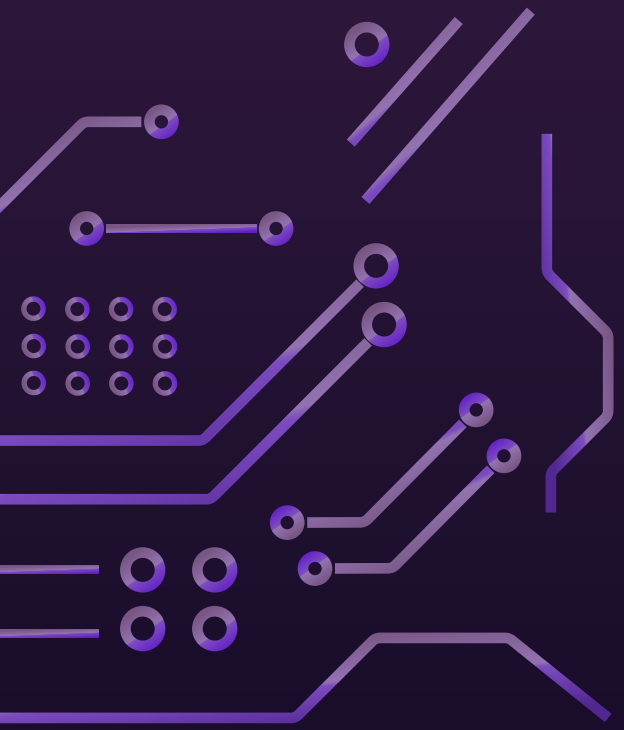
To complicate things further, we introduce a 7-level model that includes two more layers.

The middleware layer is responsible for data storage, analysis, and management. This layer is the cloud server with a huge compute capacity with big data algorithms that are used to analyze data from sensors. The middleware layer also serves as the backbone of the application.

The business layer is where businesses manage the whole IoT system, define requirements for it, and capitalize on the data. It declares what charts the application should generate, the frequency of data collection from sensors, the structure of the IoT system, the used analytic tools for the system, and its architecture model.
The 5-level model is more precise and reveals more sides of the IoT architecture than a 3-level model does.

Layers

The edge or fog computing layer performs data preprocessing before the information will be transferred to the cloud. It's the level where the IoT system transforms data streams from the perception layer into structured arrays of the information to make it easier for further analysis.



The security layer encompasses all other layers, provides security of data transfer and prevents unauthorized connections outside the system. In recent years the number of IoT-based DDoS attacks grew dramatically. That is why any IoT system needs a strong security level that protects at least from the most common vulnerabilities. The security level has a wide array of responsibilities, like:

- **Tracking malicious software.** In some cases, software bugs can result in the attackers running their own code on the IoT device. It's necessary to patch software versions when any vulnerability is discovered.
- **Access control to IoT network.** IoT devices may trust the local network to such a level that no further authentication is required. Anyone who connects to the network gains access to all devices within it, making broken authentication issues especially acute
- **Preventing data breaches** while transferring data across the network. The data must be encrypted across the IoT system with protocols, like AES, DES, DSA, and others

Thanks for your attention!

In conclusion

IoT brings businesses **the data.**

This data is gathered by sensors and transferred through the smart gateways to the cloud for further analysis. Thanks to IoT, new business models emerged, like crop monitoring with connected video sensors, and existing businesses get an opportunity to improve their efficiency.

IoT brings smart homes and smart cities, smartwatches and fitness trackers, remote health monitoring opportunities, and many more smart networks of devices.

The IoT market is enormous, and it continues to grow. Smart devices (that are called “things”) that perform the role of sensors or actuators are the basis of any IoT architecture. While the collaboration between sensors and actuators is not new, the future of IoT technology is very promising.

IoT has already made a great contribution to businesses and our day-to-day lives, but the future impact on all spheres will be much bigger. This is the start... and we are about to see a new wave of IoT popularity and transformation it will bring.