IoT platforms

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Subject

- IoT introduction
- IoT architecture layers
- Key IoT middlewares
- AWS IoT platform
- Cisco IoT
- Google Cloud IoT
- IBM IoT suite
- Microsoft Azure IoT

Introduction

- What is IoT?
  - Physical objects with embedded electronics, sensors and software connected to the internet.
- Types of Internet Connections for the Internet of Things
  - Direct
    - Wi-Fi
    - Ethernet
  - Through a Gateway
    - Phone via Bluetooth
- IoT Examples
  - Smart Thermostat
  - Security System
  - Smart Scales
  - Health Monitor
  - Fitness Tracker
  - Smart Mirror

IoT architecture layers

With an IoT platform acting as a bridge between the physical world and business processes, the IoT infrastructure contains several key layers:

- perception layer (hardware components such as sensors, actuators, and devices)
- transport layer (networks and gateway)
- processing layer (middleware for IoT platforms)
- application layer (software solutions for end users)
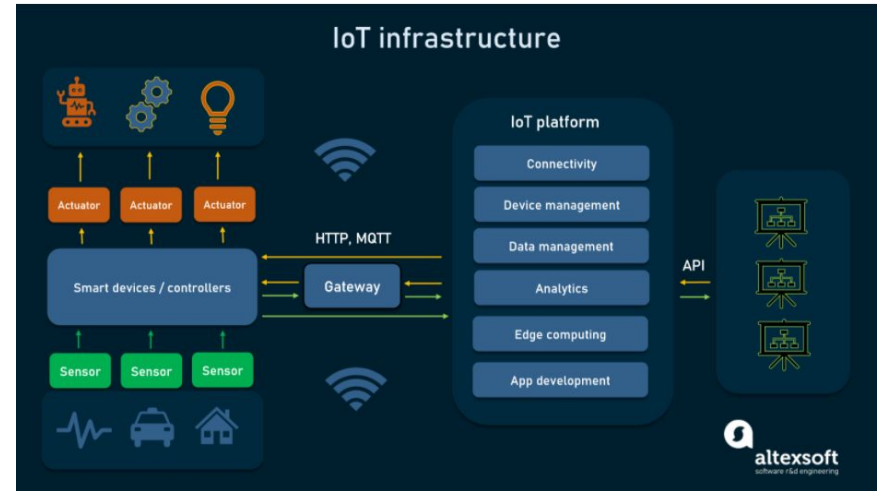
IoT's perception layer: IoT hardware

The hardware or "things" layer includes the following gears that work with signals from the physical world.

- **Electronic sensors** capture signals from the physical world, convert them into digital form, and feed them to the IoT system. You can monitor and manage sensors remotely, using a special application.
- **Actuators** receive signals from the IoT system and translate them into physical actions manipulating equipment. Similar to sensors, actuators can be configured from remote computers.
- **Devices** are connected to sensors or even have them embedded as an integral part. On the other side, devices link to a gateway or directly to an IoT platform. These hardware components cache and preprocess real-time data, reducing the burden on central storages and main processors.

IoT's transport layer: networks and gateways

- The transport layer is responsible for smooth and secure data transmission from perception layer to processing layer. It encompasses wired or wireless networks and a gateway — a hardware or software module that consolidates data from devices, analyzes it, performs translation between different protocols, and forwards information to the cloud. As a rule, the gateway converts all information into MQTT messages — the lightweight protocol most widely used in the IoT.

IoT's processing layer: cloud middleware for IoT platforms

IoT platform or middleware that actually drives IoT, enabling you to get all components and data streams connected. On the one side, it links to gateways or devices, and on the other side integrates with third-party applications and systems via APIs.

- **connectivity** or ensuring smooth data streaming and interactions between all IoT components;

- **device management,** which enables you to control and configure each piece of hardware in the IoT network as well as update software running on devices and gateways;

- **data management,** including data collection, processing, and storage;

- **data analysis** for extracting valuable patterns with machine learning, predictive analytics, and other methods;
- **visualization** or displaying data findings in the form of charts, graphs, 2D or 3D models;
- **digital twin** or creating the virtual representation of a device;
- **IoT app development** — platforms provide a workspace with a set of tools and templates to speed up app designing;
- **edge / fog computing** — the practice of processing and storing data on devices, microcontrollers, gateways, and other IoT nodes to reduce burden for cloud servers.

IoT's application layer: software solutions for users

- IoT software solutions allow end users to gain data insights, monitor and control devices, and, generally, manipulate the physical world through the IoT platform from computers and / or smartphones. Applications can be built on top of the IoT platform or integrate with it through APIs.

Key IoT middlewares

- Amazon Web Service (AWS) IoT platform
- Cisco IoT
- Google Cloud IoT
- IBM Watson IoT platform
- Microsoft Azure IoT

Key IoT middleware at a glance

	Communication protocols	Key offering and its main functions	Edge computing solutions	Top-3 use cases
amazon web services	HTTP MQTT WebSockets	AWS IoT Core: ✓ Connectivity ✓ Authentication ✓ Rules engine ✓ Development environment	FreeRTOS edge operating system IoT GreenGrass edge computing platform	✓ Smart city ✓ Connected home ✓ Agriculture
cisco	MQTT	Cisco IoT Control Center ✓ Mobile connectivity ✓ eSIM as a service ✓ Machine learning to improve security	Cisco iOX edge development platform Cisco Edge Intelligence	✓ Connected vehicles ✓ Manufacturing ✓ Smart city
Google Cloud	HTTP MQTT	Google Cloud IoT Core ✓ Connectivity ✓ Device management	Edge TPU chip enabling deployment AI at the edge	✓ Energy ✓ Smart parking ✓ Transportation and logistics
IBM Watson	HTTP MQTT	IBM Watson IoT Platform ✓ Connectivity ✓ Device management ✓ Real-time analytics ✓ Blockchain	IBM Edge Application Manager platform	✓ Manufacturing ✓ Agriculture ✓ Smart buildings
Microsoft Azure	HTTP MQTT AMQP over WebSockets	Azure IoT Hub ✓ Connectivity ✓ Authentication ✓ Device monitoring ✓ Device management ✓ IoT Edge	IoT Edge as an integral part of IoT Hub	✓ Healthcare ✓ Retail ✓ Manufacturing

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AWS IoT Platform

In 2020, AWS was recognized as a leading IoT applications platform empowering smart cities. It is also in the forefront of building connected home products, powered by Alexa Voice. Among successful use cases in other domains are projects for Philips HealthCare, Rio Tinto (the world's second largest metals and mining corporation), and Bayer Crops Science (agriculture).
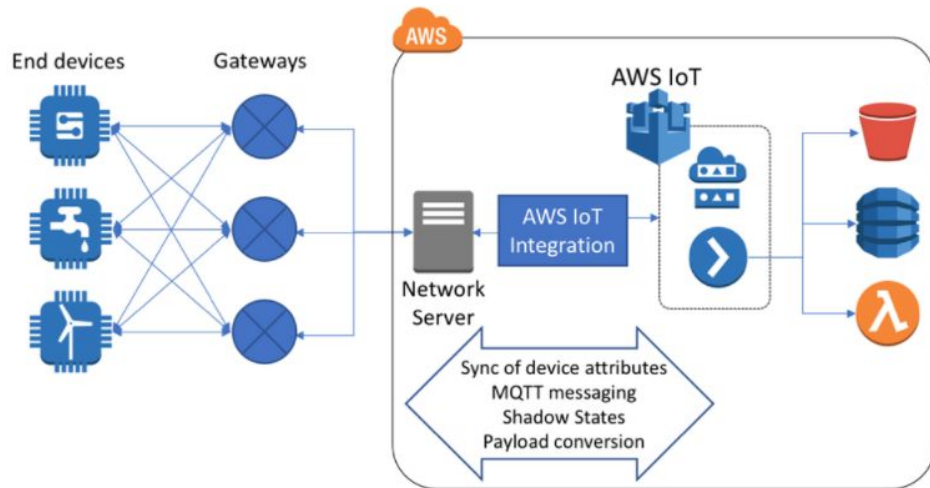
AWS IoT infrastructure. Source: AWS

AWS IoT Core

- IoT Core is the heart of the AWS IoT suite, which manages device authentication, connection, and communication with AWS services and each other. Its entry point — Device Gateway — supports MQTT, HTTP, and WebSocket protocols. Due to authentication and encryption provided at all points of connection, IoT Core and devices never exchange unverified data.

- Vetted messages are processed by the Rules Engine that routes them either to a device or cloud AWS service — like AWS Lambda (a serverless computing platform), Amazon Kinesis (a solution for processing big data in real time), Amazon S3 (a storage service), to name a few.

- Another feature of IoT Core is Device Shadow, which stores the current or desired state of every device. So if the IoT device is offline or busy, cloud applications can still change its configuration or send commands to it. As soon as the device is back online, it synchronizes its final state with updates.useful feature of IoT Core is Device Shadow, which stores the current or desired state of every device. So if the IoT device is offline or busy, cloud applications can still change its configuration or send commands to it. As soon as the device is back online, it synchronizes its final state with updates.

AWS IoT control services

- AWS IoT Device Management allows you to remotely organize, track, control, update, and scale large and diverse device fleets. Agnostic to a device type, the service supports any IoT thing, from microcontrollers to connected fridges.

- AWS IoT Device Defender continuously checks IoT configurations against security requirements and sends alerts when spotting any gaps.

- AWS IoT Events is designed to identify complicated changes in equipment behavior across thousands of devices and react to them based on predefined rules.

- AWS SiteWise comes in handy when you need to collect and organize data at an industrial level. The service connects to a manufacturer's equipment through a gateway, gathers and pre-processes data, and then sends it to the AWS Cloud.

- AWS IoT 1-Click is used to make a group of devices perform specific actions (like sending alert messages) at a button click.

AWS IoT Analytics

- Amazon QuickSight, a business intelligence service to visualize data insights

- Jupyter Notebook that provides powerful tools for machine learning and advanced statistical analysis

- Amazon SageMaker, an environment for building, training, and deployment of machine learning models

Cisco IoT platform

Cisco IoT Control Center

- IoT Control Center is the largest cellular connectivity platform servicing over 160 million mobile devices and 29,000 enterprise-grade customers worldwide. The middleware is also known as the number one service provider for connected cars. That take advantage of the connectivity capabilities such as:
    - machine learning. The Control Center analyzes 3 billion events a day to improve connectivity management, identify anomalies, and proactively address issues, increasing security.
    - eSIM as a service. This tool simplifies SIM portability between different operators worldwide.
    - 5G readiness. The platform already supports 5G non-standalone (NSA) resting upon the existing 4G infrastructure.

Cisco Kinetic IoT operations platform

- **Cisco Kinetic** comprises three components teamed up to connect devices of any type and manage data both at the edge of the network and in the cloud.
  - **The Gateway Management Module** monitors industrial gateways and enables their remote configuration.
  - **The Edge and Fog Processing Module** pushes selected data management processes from the cloud to nodes and devices closer to data sources.
  - **The Data Control Module** performs the opposite function and moves data from devices to cloud-based applications, ensuring that the right information will reach the right place. You can create rules for different apps depending on the data type. The module is cloud-neutral, so you are free to use any cloud provider for data storage and management

Google Cloud IoT

- The IoT suite from the most popular search engine is centered around its flagship product **Cloud IoT Core**, powerful enough to manage data from millions of devices. Teamed up with other Google Cloud services, it is already optimizing operations in manufacturing, building, energy, and other sectors. Its transportation and smart city solutions take advantage of Google Maps Platform allowing for visualization of geographical data.

Cloud IoT Core integrations. Source: Google Cloud
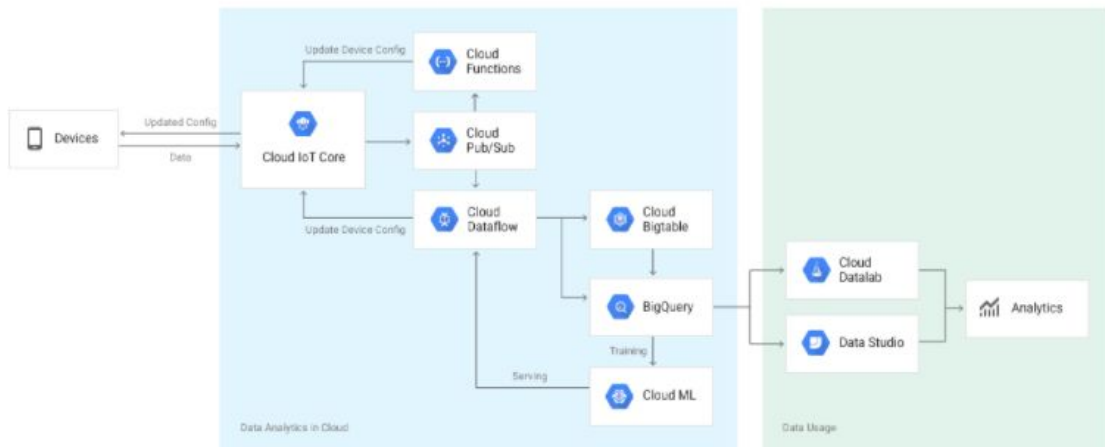
Google Cloud IoT Core

- **Google IoT Core** contains two modules. Device Manager enables you to set up, authenticate, configure, and control individual devices remotely. While Protocol Bridge working with MQTT and HTTP formats is responsible for connectivity. It publishes data streams to Cloud Pub/Sub service that make possible merging messages from different sources into a single system.
- **Cloud Functions** to create independent functions and instruct devices how to react on specific events
- **Cloud Dataflow** to preprocess data in real time
- **Cloud Bigtable** to ingest and store large volumes of data
- **BigQuery** to analyze data in real time, create and train machine learning models
- **Data Studio** to visualize insights extracted from BigQuery, using pre-built templates
- **Cloud Datalab** to develop custom analytics practices and visualizations

IBM IoT suite

- IBM combines IoT with powerful cognitive capabilities of Watson platform — an industry leader in AI and machine learning. Its assortment of AI-driven IoT products includes Watson Decision Platform for agriculture, Watson Supply Chain Insights for connected logistics and transportation, Watson Building Insights for analyzing energy and asset usage, and a set of industrial equipment solutions.

IBM Watson IoT Platform

The IoT platform by IBM leads the pack of industrial solutions supporting predictive maintenance. Built on the highest security standards, it serves as a hub to set up and control connected things that use MQTT messaging.

- **device management service** to add and remove devices individually or in bulk, perform rebooting, update firmware, and receive metadata
- **safe connectivity** and communication between devices based on MQTT protocol messaging
- **data lifecycle management**, which enables you to store data from devices and access real-time and historical data whenever you need it.

Digital Twins

- IBM' s Digital Twins is a separate offering that by far outreaches virtual replicas of devices delivered by AWS and Microsoft Azure. Having worked with the concept since the Apollo space program, IBM creates complex digital twins of huge systems and products.
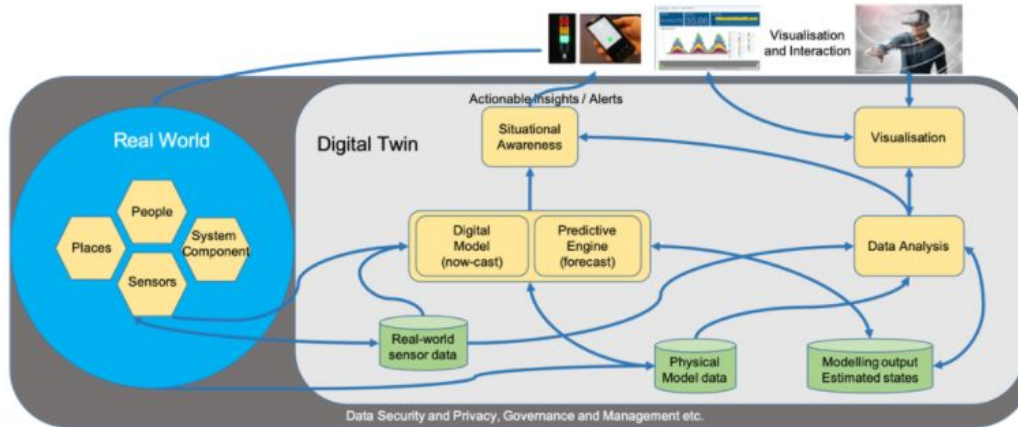
Digital Twin components. Source: IBM Developer

Microsoft Azure IoT

- In 2018, Microsoft declared their intentions to pour $5 billion into IoT technologies within four years. Now, at the halfway mark, its Azure IoT suite features a wide range of tools for all sorts of devices, with more additions to come in the next two years.

- Azure has a strong footprint in healthcare, retail, manufacturing, energy, logistics and transportation. All the solutions come with the highest level of safety as Microsoft spends over $1 billion annually on cybersecurity technologies.

- The presence of Microsoft in the IoT ecosystem is expanded by Windows 10 IoT. The Enterprise version is meant for ATMs, point-of-sale terminals, medical equipment, kiosks. Windows 10 IoT Core runs on small devices and wearables, with or without display.

Azure IoT Hub

- IoT Hub is the foundational PaaS (platform-as-a-service) product, enabling device connectivity, management and communication. It comes in two tiers, basic and standard, with a different number of features supported.

- Azure IoT Central is a scalable SaaS (software-as-a-service) offering rapid design of IoT software with built-in security features. The platform comes with the integrated device monitoring and management functions to connect, reconfigure, and update devices.

- Azure Digital Twins lets you create virtual models of a physical environment based on insights extracted from IoT data. These models can be used to reorganize the infrastructure for better efficiency.

- Azure Sphere is a security solution to protect IoT devices, operating systems, and cloud services. It adds multiple layers of defense, provides continuous device monitoring, and enables returning compromised hardware components to their safe states.

- Time Series Insights extracts data directly from IoT Hub to explore it, spot trends, identify anomalies, and present findings in the form of comprehensive visualizations. The solution easily integrates with other analytics services by Microsoft like Azure Machine Learning and Azure Databricks.

How to choose the best IoT platform

IoT platforms features basically overlap, though they are packaged differently. Along with a rich functionality, all of them offer:

- high scalability, fitting the needs of any business, from startups to enterprises with millions of devices;
- built-in security for every layer of an IoT system;
- tech support and detailed documentation on their products.

Pricing and free tier:

- IoT costs are often hard to predict, as the core solution typically includes only a limited set of functions. Every single service you use on top of basic features involves additional expenses.

Hardware compatibility:

- IoT infrastructure involves numerous devices. If you already use certain equipment, network nodes, and other components, you must check whether your existing hardware is compatible with a particular platform. For example, Cisco IoT software is designed to work smoothly with Cisco IoT hardware.

References

- https://www.altexsoft.com/blog/iot-platforms/