IoT at the Edge:

HOW AI WILL TRANSFORM IOT ARCHITECTURE

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The vast amounts of data constantly collected by the billions of sensors and devices that make up the Internet of Things (IoT) can pose a serious processing challenge for businesses that rely on traditional intelligence and analytics tools.

An emerging solution is to use Artificial Intelligence (AI) and machine learning to build intelligent systems that automatically gather, process, and extract actionable insights from IoT data - in real time without the need for human intervention.

How are AI-enabled systems transforming IoT devices and applications at the edge, and what are some of the emerging use cases we can expect to see in the near future? What considerations should be kept in mind when designing a system, and what factors can influence the IoT architecture you adopt?

Introduction

Smart devices and sensors are rapidly changing the ways in which all industries operate – from healthcare and telecommunications to industrial maintenance and utilities management, there is virtually no space untouched by this innovation.

Sensors and devices that can automatically generate or capture real-world data for analysis are now available, enabling us to shorten product and service delivery times, better understand our consumers, track assets, plan resource allocations, predict machine breakdowns, lower costs, and streamline production and service delivery processes.

The proliferation of smart devices has not happened overnight, but it is happening rapidly. **Consider the following below.**

Making sense of the vast amounts of information gathered by IoT devices can be a serious challenge, but thanks to advancements in AI and machine learning, we can now use AI to lower costs and improve productivity through data-driven decision-making and smart automation.

GLOBAL IOT MARKET VALUE

$760B → $1.4T

Current → 2025

MEDICAL IOT DEVICE MARKET

$23B → $63B

Current → 2025

IOT DEVICES DEPLOYED GLOBALLY

35B → 80B+

Current → 2024

Understanding the IoT's Building-Blocks

The IoT has quickly progressed from hype to reality. The popularity of smart home appliances and autonomous vehicles demonstrate how transformative IoT networks and devices can be and how ubiquitous they are becoming.

Despite the rapid pace at which these solutions are often adopted, it is vital to first understand IoT architecture before deploying your own network of smart devices or onboarding with AI. Any efficiencies or productivity gains you hope to achieve will hinge on the quality of your underlying IoT infrastructure.

At their core, IoT systems are made up of Internet-connected sensors, devices, or actuators that allow devices to sense or gather information from the environment. This is the first layer of the IoT.

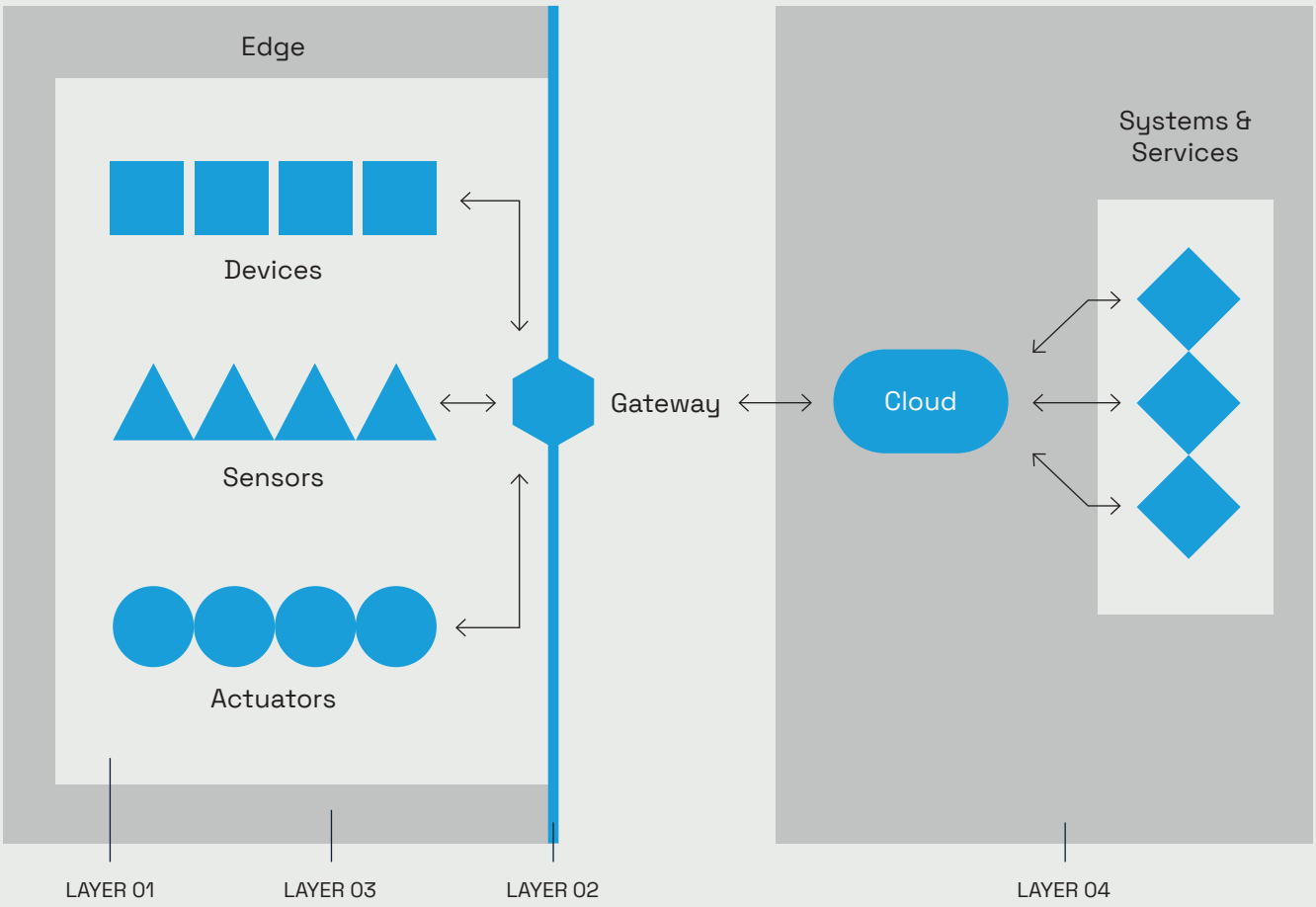
Data from the first layer is passed on to the second layer: an IoT gateway and data acquisition system that collects the unprocessed data and converts it into digital form. Some levels of filtering and pre-processing can also take place here so that the data is ready for analysis.

The third layer consists of edge devices that perform further processing and analysis based on your needs. Devices "at the edge" are those that provide an entry point into enterprise or service provider core networks, examples of which may include routers, routing switches, and integrated access devices.

The fourth layer – data center or cloud solutions – can then be used for data visualization and reporting. In cloud-based systems, machine learning and AI technologies are typically used here. Edge-based systems try to build AI capabilities earlier into the network by providing Layer 3 devices with AI-powered processing and decision-making capabilities.

Additional specifications and requirements that you should have in each layer are outlined below.

Gateways in a IoT System



Connected Devices, Sensors, Actuators

Connected devices and sensors in the first layer should be able to communicate with their assigned gateways or data acquisition systems as well as with other devices that are part of your overall deployment. This is important for extracting the maximum value from your network and for managing processing resources, data, and energy.

Gateways & Data Acquisition Systems

Gateways and data acquisition systems in the second layer must have the right encryption and security tools to prevent unauthorized access to sensors, devices, and data. A compromised gateway can lead to lateral attacks across your IoT deployment and jeopardize your networks.

Edge & Analytic Devices

Edge and analytics devices in the third layer must have the data transfer speeds, response times, and flexibility to meet the rigors of handling a wide variety of data from thousands of devices. If needed, edge devices can be placed closer to the data source to provide real-time outputs to devices and sensors in the field. With the right setup, certain cloud services can be handled by edge devices. Generating actionable intelligence in Layer 3 as opposed to Layer 4 can lower your network exposure and enhance security while also reducing power and bandwidth consumption.

Cloud Services

Cloud services in the fourth layer store, process, and analyze your large quantities of data to extract insights that can guide business decision-making. Advanced services, such as natural language processing (NLP) for chatbots or image recognition or IoT device management services, can be handled by AI-powered automation in Layer 4.

What's Driving AI Adoption within the IoT?

As mentioned above, AI technology is invaluable within Layer 4 as it can provide the IoT system with the creativity and context needed to drive smarter decision-making.

Here are a few benefits of AI-powered smart IoT devices:

Boosting operational efficiency
by detecting patterns, predicting machine breakages, planning downtime, and eliminating or reducing redundant or time-consuming processes.

Improving risk management
by automating system responses to events outside preset parameters. AI-driven IoT risk management can be used to prevent financial losses, enhance employee safety, and detect and respond to cyber threats.

Creating new or improved services
such as chatbots, smart assistants, or custom/curated data feeds.

Increasing scalability
by effectively analyzing and summarizing vast amounts of data, allowing for the deployment of more sensors and the gathering of more data throughout different production or supply chains.

The examples below illustrate how transformative AI-powered IoT systems can be in a wide range of settings and industries.

Travel Hospitality

Current IoT applications:
- Indoor navigation in public places
- Smart ads based on user preferences or location or a user's shopping or browsing history
- Aircraft system health monitoring

Emerging IoT applications:
- Faster check-ins using biometric technology
- Analyzing granular customer data to customize loyalty programs and travel experiences

Financial Services

Current IoT applications:
- Fraud detection and claims management using vehicle sensor data

Emerging IoT applications:
- Replacement of sensitive financial data with unique and secure digital identifiers

Public Sector Services/Smart Cities

Current IoT applications:
- Security and monitoring systems
- Asset tracking
- Smart metering

Emerging IoT applications:
- Fleet maintenance
- Resource optimization
- Integrated services (e.g., using data from garbage receptacles to notify when full, facilitating public reporting issues on damaged roads, etc.)
- Optimized energy and water consumption
- Smart emergency responses

Manufacturing and Retail

Current IoT applications:
- Predictive maintenance
- Real-time error reporting
- Improved field services
- Sensor-equipped wearables
- Smart checkouts
- Connected vending machines
- RFID-tagged equipment to reduce search and inventory costs

Emerging IoT applications:
- Custom manufacturing (e.g., precision machining to reduce waste)
- Streamlined custom ordering
- Smart shelves to improve inventory management

Healthcare

Current IoT applications:
- Remote patient monitoring (e.g., vital signs, heart rate, etc.)
- Automatic medicine refills
- Telehealth services

Emerging IoT applications:
- Smart pill technologies
- Virtual/augmented reality tools to enhance patient care

Automotive

Current IoT applications:
- Integrated vehicle diagnostics
- Communications
- Navigation systems
- Autonomous vehicles
- Smart parking systems

Emerging IoT applications:
- Enhanced interactions between passengers and pedestrians or other vehicles to improve safety
- Smart roads

Challenges and Obstacles

As with any technology system rollout, there are bound to be obstacles to overcome along the way. The challenges that typically arise when launching an IoT solution are one or more of the following:

Sensor issues
including security, power management, and sensor heterogeneity that leads to a lack of interoperability.

Analytics and intelligence
such as a lack of technical know-how regarding the extraction of value from data and an inability to leverage big data tools.

Networking issues
including power consumption, underdeveloped or unavailable standards, the inability of legacy systems to process real-time smart device data, and a lack of machine-to-machine (M2M) communication capabilities.

These challenges create real architecture concerns for your IoT deployment and will require you to address tough questions like:

- How will you minimize your attack surface and handle security issues, updates, and patch management?
- Can you separate the edge and analytics layers to improve data processing or response times? What are the implications of doing or not doing so?
- Will maintenance limitations (e.g., devices in hard-to-reach locations) or power limitations (e.g., battery size and device power consumption) restrict the kinds of sensors or data your systems can use?
- What will your data transmission and bandwidth needs be?
- What telecom bands will your devices operate on, and how frequently will your devices receive or transmit data?
- How quickly will responses be needed, and what kinds of analysis will you need to perform? To put this concern in some context, you can analyze customer preferences from embedded sensors at your leisure, but autonomous vehicle responses to road hazards must be performed in real-time.

Final Thoughts

When utilized the right way, IoT devices – and the AI applications that can help you understand the data that those devices collect – can benefit your business significantly.

From lowering your organization's production costs, improving service delivery, and enhancing customer experiences to improving monitoring, more effectively tracking assets, and optimizing processes, the possibilities are truly endless.

Yet, business leaders must understand that simply gaining access to more data and improved connectivity do not necessarily provide value on their own. You must first assess your needs and your readiness to install and use new tools or devices. Then, you and your team will be equipped to make an informed decision regarding when, where, and how to enhance your operations and connect your devices using existing and emerging AI and IoT technologies.

Kajeet is your trusted partner in managed IoT connectivity services. Contact us today for a consultation with our team and to learn about how Kajeet's connectivity solutions can help your business.