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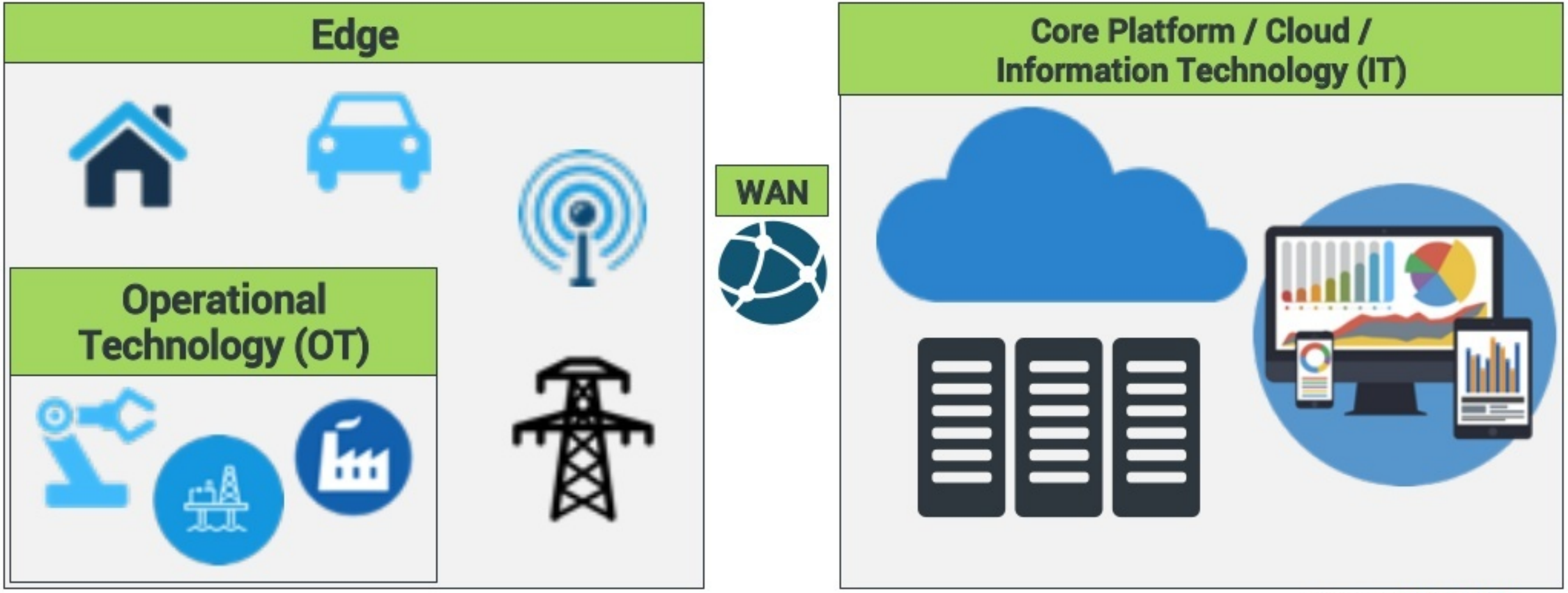
# The **Internet of Things**: Beyond Data Management & Analytics

**Jonathan Cooper-Ellis (JCE) // Solutions Architect**

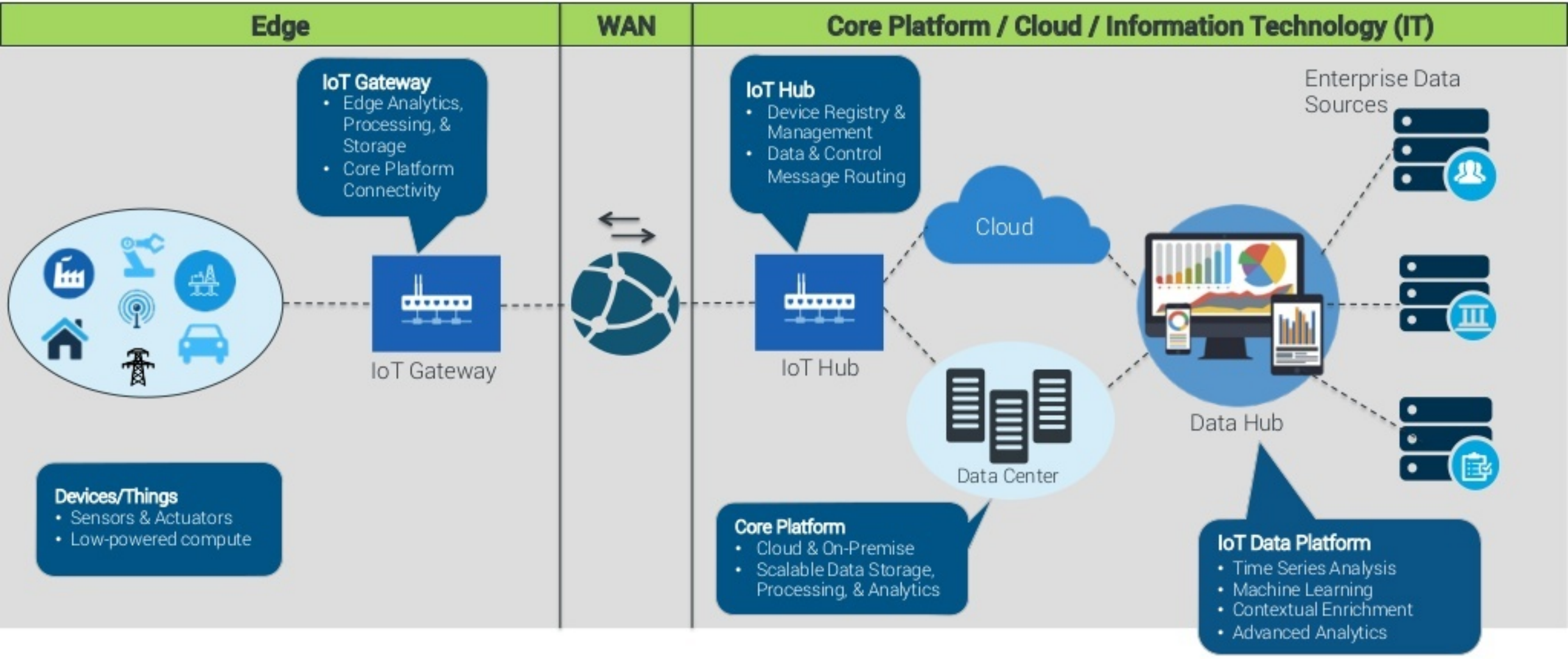
# Top Level Concepts in IoT



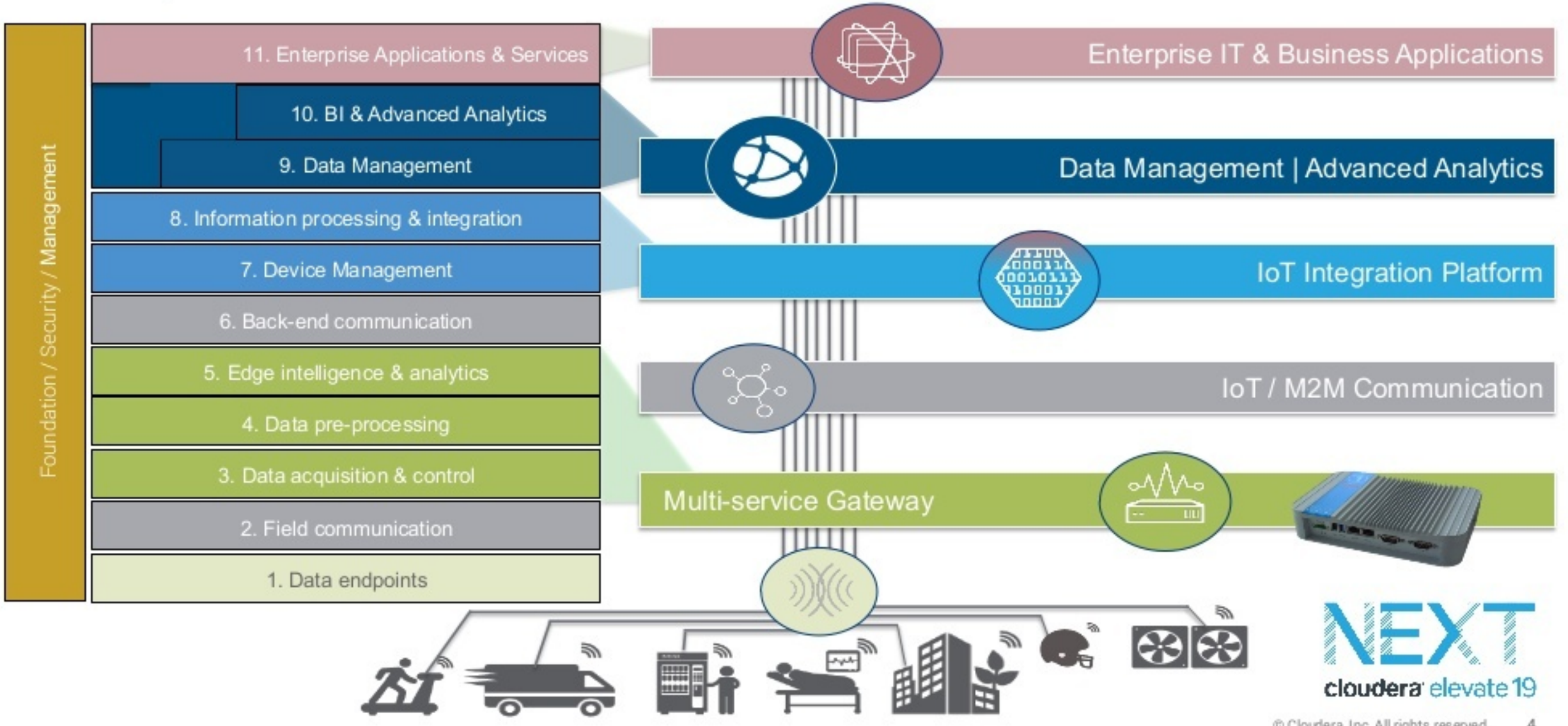


# End-to-End IoT



# Complete IoT Stack

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# IoT Device

A computer **integrated with the physical world**
through one or more connected sensors or actuators.

# Sensors

Sensors **detect changes** in the physical world.

# Sensor Examples




# Actuators

Actuators **affect changes** in the physical world.

# Actuator Examples

# Controller

Sensors/actuators are physically integrated with a computer, called a **controller**.

- Sensors require a computer to **collect** the information they generate.
- Actuators require a computer to **control** what they do.

Often (though not necessarily) the computers that sensors and actuators are integrated with are very low powered, known as **microcontrollers**.

# Controller/Microcontroller Examples


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# Controller + Sensor and/or Actuator = IoT Device


# Controller + Sensor and/or Actuator = IoT Device



 

# Field Communication

Connectivity technologies and communication protocols used by IoT devices to **exchange information within a remote local- or personal-area network** (LAN/PAN).

# Edge Network

Multiple IoT devices communicating with each other over a local-area network (LAN) or personal-area network (PAN) form an **edge network**.

This type of communication is commonly known as **machine-to-machine (M2M)**, and the enabling technology was the predecessor for modern IoT. Often this falls under the category of **Operational Technology (OT)**.

In the OT world, **Supervisory Control and Data Acquisition (SCADA)** systems are extremely common.

# Edge Network Example: SCADA System

# Edge Network Example: Smart Home



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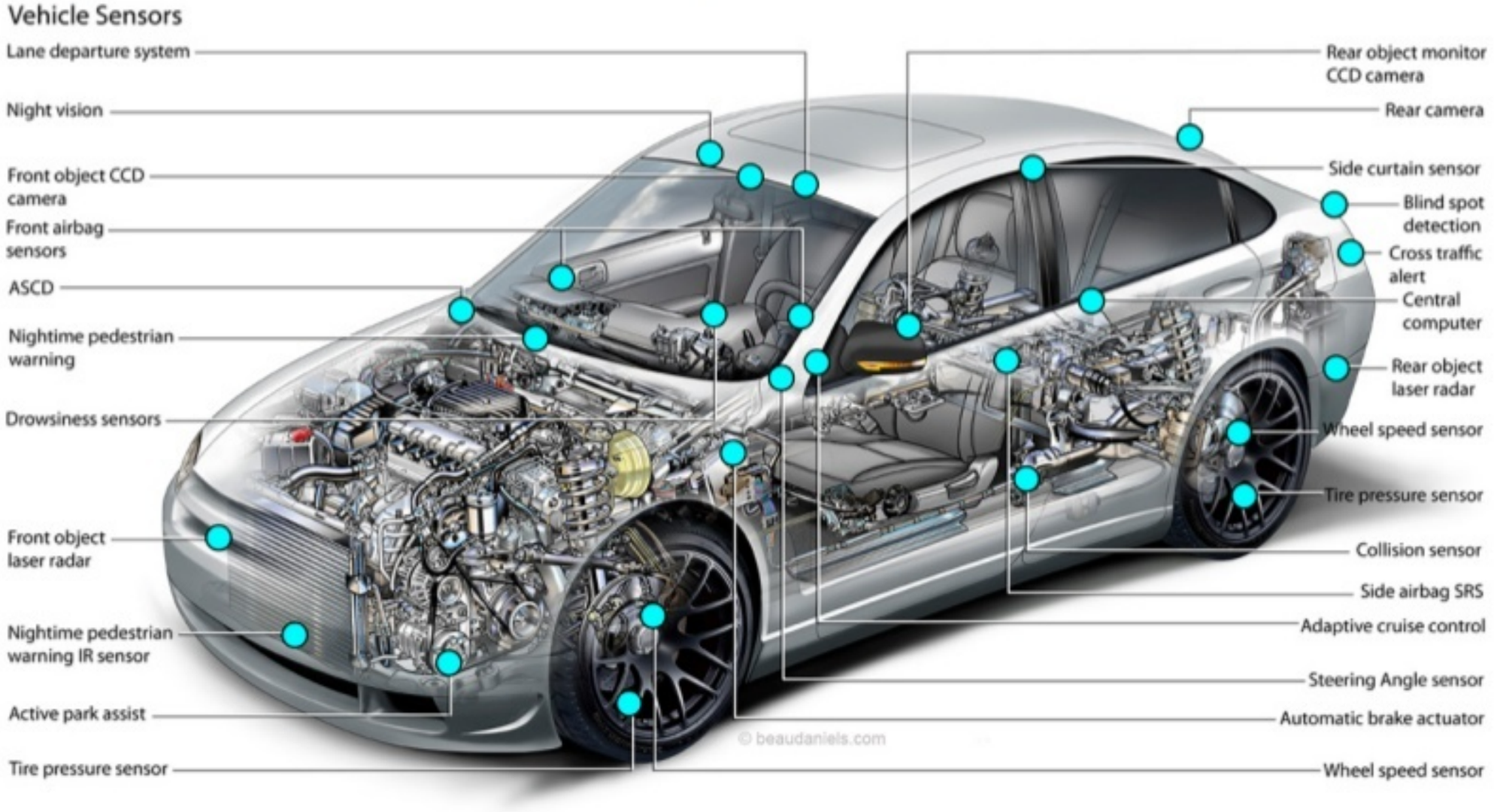
# Edge Network Example: Connected Car

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# LAN/PAN Connectivity

Short-range (~10cm–150m max. distance) connectivity technologies:

- Ethernet
- WiFi
- RFID
- Bluetooth / Bluetooth Low Energy (BLE)
- ZigBee
- Z-Wave
- 6LowPAN
- Thread
- NFC

# Field Communication Protocols

OT:

- OPC / OPC-DA / OPC-UA
- Modbus
- S7
- BACnet
- DDS

Automotive:

- Controller Area Network (CAN)

Modern IoT:

- MQTT
- CoAP

***And so many more…***

# IoT Gateway

A computer connected to one or more IoT devices, or being itself an IoT device, capable of **communicating with a core platform over a wide-area network** (WAN).

# IoT Gateway: Common Functions

In addition to communicating over a WAN, IoT gateways are often responsible for:

- ✓ **Collecting data** from local IoT devices
- ✓ Sending **control messages** to local IoT devices
- ✓ **Routing** messages to/from a core platform
- ✓ Local **data storage**
- ✓ Local **data processing**
- ✓ **Filtering** messages
- ✓ **Edge analytics / intelligence**

# Why the obsession with edge analytics?

The WAN is always the bottleneck.



# IoT Gateway: Edge Analytics

Traditionally, edge analytics has generally meant **applying rules**.

More recently, edge analytics has evolved to include **ML model serving**.

***But wait, where do the models come from?!***



# Core Platform Training & Edge Serving

- **Insufficient resources at edge** for training (lacking storage & compute)
- **Inadequate network** for streaming data to core platform for serving
  - **Bandwidth** too low
  - **Cost** too high
  - **Latency** too high



# IoT Gateway: Hardware Specifications

IoT gateway hardware requirements **varies significantly** depending on use-case.

# Back-End Communication

Connectivity technologies and communication protocols used by IoT gateways to **exchange information with a core platform over a wide-area network** (WAN).

# WAN Connectivity

Long-range (~30km–10000km+ max. distance) connectivity technologies:

- Cable / Fiber
- Cellular (GSM / 3G / 4G / 5G / LTE / LTE Cat-M)
- Satellite
- Sigfox
- LoRa
- NB-IOT
- LPWAN

# Back-End Communication Protocols

Back-end communication protocols are relatively well standardized.

**Messaging** protocols:

- AMQP
- MQTT
- Kafka

**REST** protocols:

- HTTP
- CoAP

# IoT Hub

A core platform service (or collection or services) responsible for **device management** and enabling **secure communication** between IoT gateways and other core platform services.

# IoT Hub: Common Functions

IoT hubs are generally responsible for:

- ✓ Maintaining a **device registry**
- ✓ **Device management** capabilities
- ✓ Ensuring **secure bidirectional communication** over an untrusted WAN
  - ✓ **Authentication**
  - ✓ **Authorization**
- ✓ **Routing** messages to/from other core platform services

# Data Hub

The component within the core platform responsible for **scalable storage, processing, and analysis** of IoT data (i.e. telemetry, audio, image, video) and contextual data.

# IoT Analytics

The goal of IoT analytics is generally to leverage a **combination of IoT data and contextual data** to create actionable insights for both humans and machines.

- **Human intelligence**
  - ✓ Operations monitoring
  - ✓ BI/reporting
- **Artificial intelligence**
  - ✓ Machine learning
  - ✓ Automated decision-making

# IoT Data Characteristics

IoT data is:

- Mostly **time-series**, increasingly **image/video/audio**
- High **volume**
- Generated from a **variety** of data sources
- Diverse data **structures** and **schemas**
- Either in **streams (real-time) or batches**
- Often **perishable**

Combining sensor data with contextual data is the key to value creation from IoT.

# Digital Twin

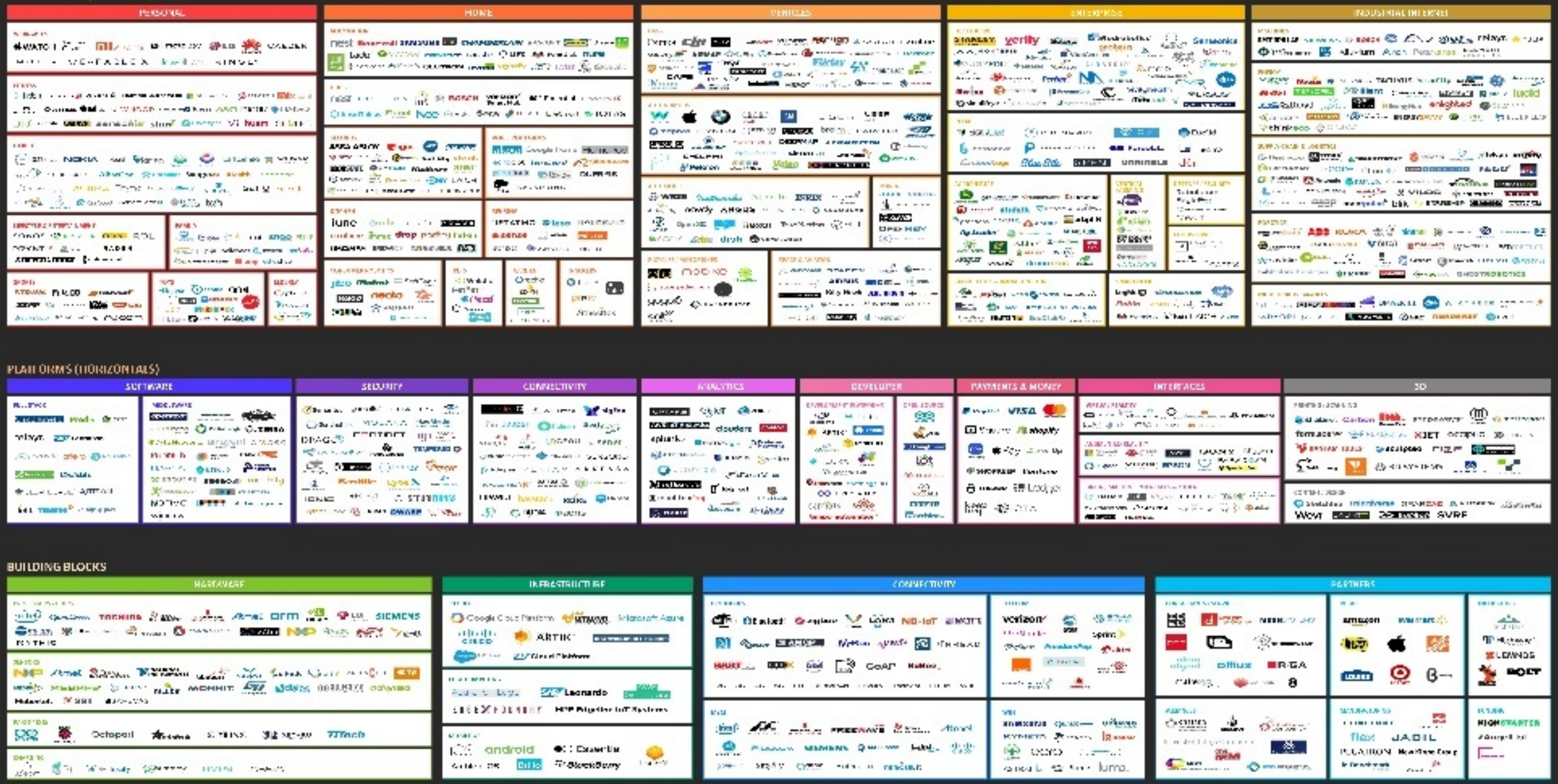
IoT technology enables the concept of a **digital twin** (aka device twin), which is a **virtual model of a physical asset**.

The **state** of an asset (sensor readings) and its **capabilities** (actuators) are **exposed via APIs** on top of an object-oriented programming model.

The virtual model can be used for **analytics and simulations**, and changes made to it can be **propagated to the physical world**.

# Digital Twin Example: Drones

# Internet of Things Landscape 2018



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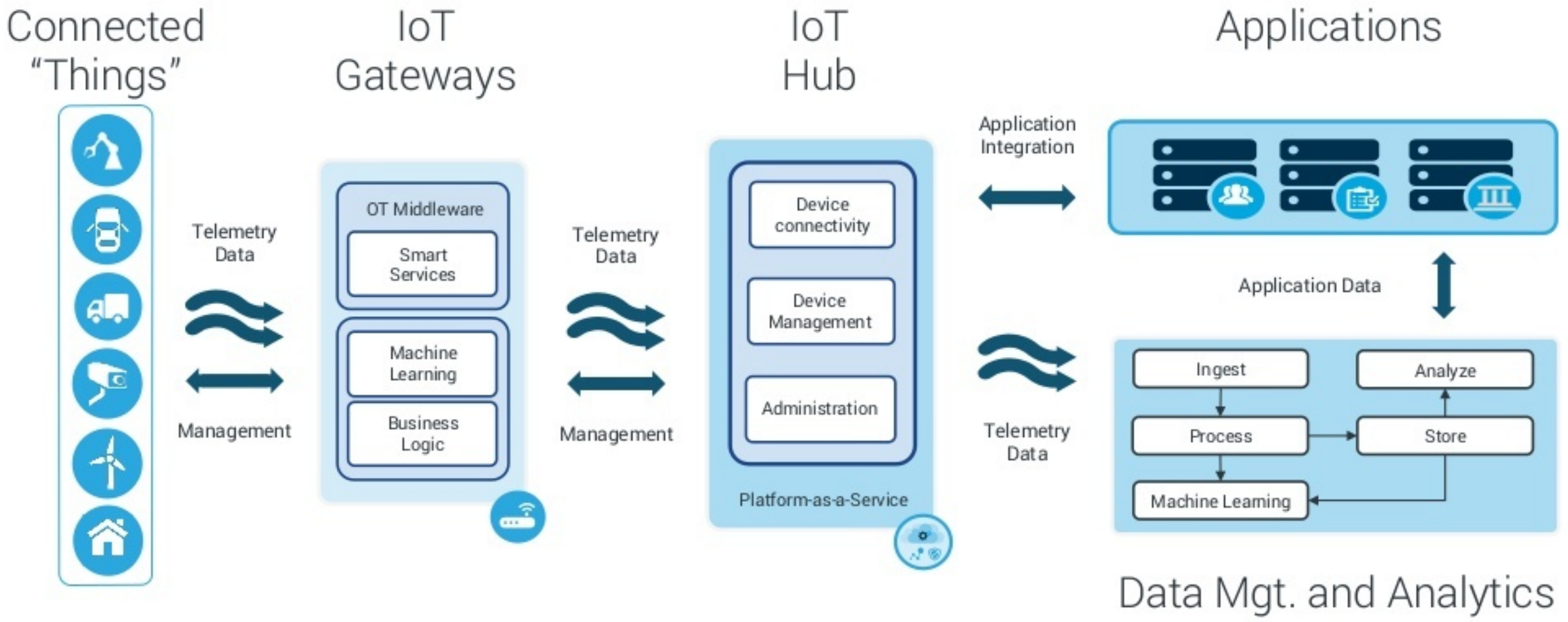
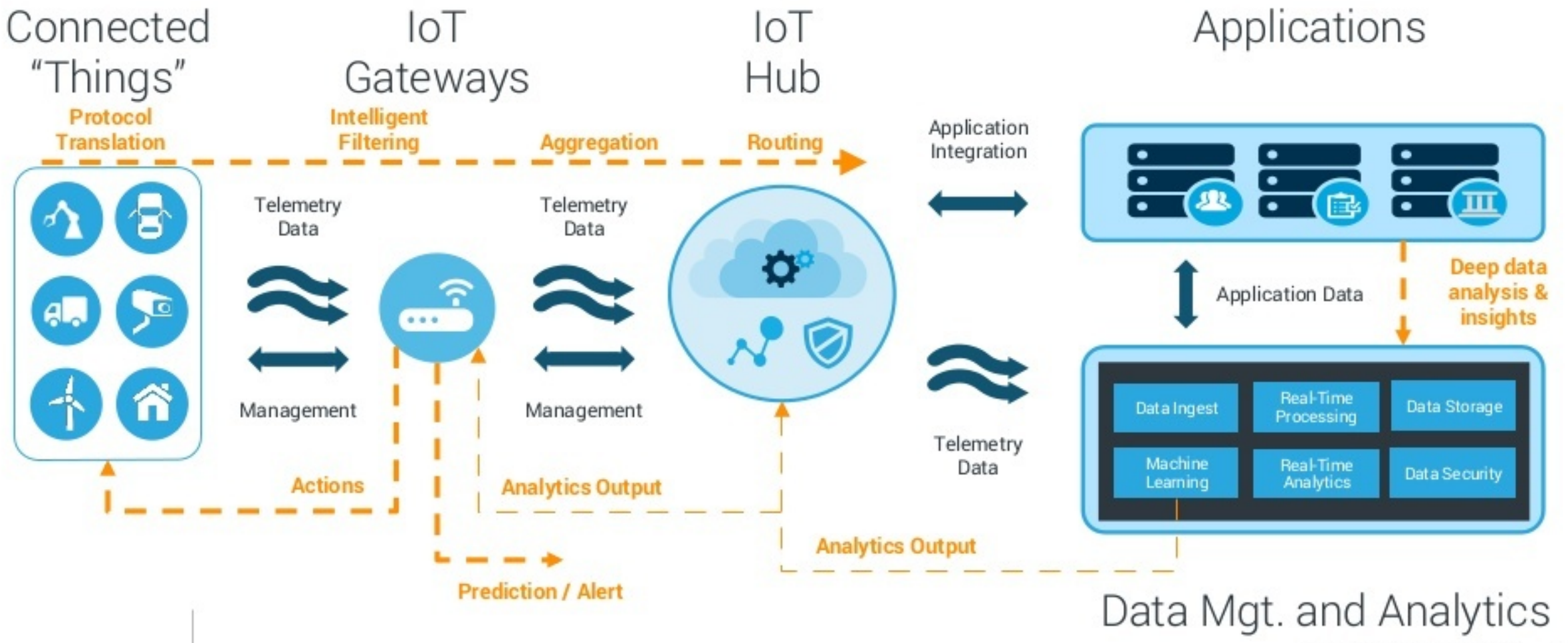
# End-to-End IoT Architecture: Functional



# End-to-End IoT Architecture: Overview

Integrating IoT Operating Technology, Data Management, Analytics, and Applications



# Thank you

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